PUBLIC DOCUMENT . . . . No. 31.

THIRTY-SEVENTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

1899 - 1900

JANUARY, 1900.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1900.

·VETERINARY·LABORATORY·AND·HOSPITAL·STABLE·
·AT·THE·MASS.·AGRICULTURAL·COLLEGE·
·AMHERST·MASS.
·E·A·ELLSWORTH·ARCH'T. HOLYOKE·MASS·

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Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Jan. 4, 1900.

To His Excellency W. Murray Crane.

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

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

CALENDAR FOR 1900–1901.

1900.

January 3, Wednesday, winter term begins, at 8 A.M.

March 22, Thursday, winter term closes, at 10.15 A.M.

April 4, Wednesday, spring term begins, at 8 A.M.

June 16, Saturday, Grinnell prize examination of the senior class in agriculture.

June 17, Sunday, { Baccalaureate sermon. Address before the College Young Men's Christian Association.

June 18, Monday, { Burnham prize speaking. Flint prize oratorical contest. Class-day exercises.

June 19, Tuesday, { Meeting of the alumni. Reception by the president and trustees.

June 20, Wednesday, commencement exercises.

June 21–22, 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.

September 4–5, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.

September 6, Thursday, fall term begins, at 8 A.M.

December 20, Thursday, fall term closes, at 10.15 A.M.

1901.

January 2, Wednesday, winter term begins, at 8 A.M.

March 21, 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.

Changes in the faculty during the past year have been few. Ralph E. Smith, for the past few years instructor, has been made assistant professor of botany. Edward R. Flint, assistant professor of chemistry, resigned at the opening of the present college year to pursue a course in medicine, and his place has been filled by the appointment of Samuel Francis Howard, a graduate of the college in 1894, and who has since continued his studies at Johns Hopkins. A fellowship, under the title of "instructor in chemistry," is now offered to some recent graduate who desires, in connection with his regular duties as instructor, to carry on advanced work for one or more years. The advantages of this are apparent. It increases the force of instructors, and thereby increases the efficiency of the department; it offers an incentive to one young man annually to carry on advanced studies; and it furnishes candidates well prepared to fill assistants' positions in the experiment department, as well as places in other colleges, experiment stations or high schools. The position has been held by Bernard H. Smith, a graduate in 1899. The advantages to both instructor and pupils are so obvious that it is hoped the same course may be adopted in other departments. I would call particular attention in this respect to those of botany and entomology. Dr. Henry T. Fernald, a graduate of the Maine Agricultural and Mechanical College in 1885 and of Johns Hopkins in 1890, has been appointed professor of entomology to the college and assistant entomologist to the experiment station.

This addition to the force makes it possible to offer a more extended course of instruction to those students electing entomology, and to undertake a wider system of help to the fruit growers and farmers of the Commonwealth.

Requirements for entrance have been slightly modified by dropping descriptive geography and the metric system from the list, and substituting an increased amount of English. Candidates will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present, at the examination in 1900, evidence of a general knowledge of the subject matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics, to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will call for only a general knowledge of the substance of the books. In place of a part or the whole of this test, the candidate may be allowed to present an exercise book, properly certified by his instructor, containing compositions or other written work done in connection with the reading of the books. The books set for this examination in 1900 are: "The Sir Roger de Coverley Papers," in "The Spectator;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Cooper's "The Last of the Mohicans;" Whittier's "Snow Bound."

In the regular curriculum, to allow of advanced work in French and German, which languages are especially necessary on all matters of science, provision has been made for both, as required studies in the freshman and sophomore years respectively, and as electives in the senior year. Book-keeping has been dropped from the studies of freshman year and is continued in the short winter courses.

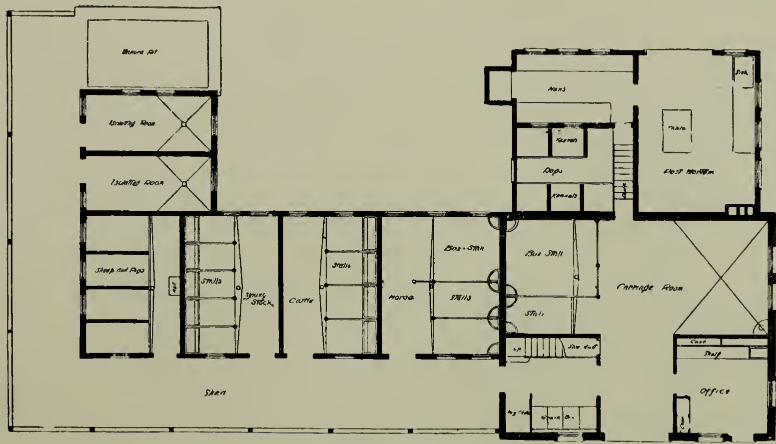
The new rule that went into effect at the June examination, by which candidates could be received without examination, on certificates from the principals of schools of approved course and training, resulted in the entrance of a larger class than usual. Sixty-five presented themselves at the time appointed, and fifty-four were admitted. With few exceptions, the scholarship was quite up to the average and the results were highly gratifying. The history of education shows, the world over, that there can be no such thing as a satisfactory system of education for the masses of the people unless it be fed by a large and liberal provision of higher education. The higher education is to the common schools as the ocean to the mountain spring, — continually sending back the dew and the rain to supply them; it is as the tree to the fruit; it is as the sun to the planets, — holding all in their appointed course. From the higher institutions come not only the teachers to lead and guide the lower, but that great body of learning and intelligence which creates, moulds and enriches the public sentiment that supports the common schools. Our educational system can never be fully worthy of the name till there shall be in every Massachusetts village and country town the foot of a ladder, the topmost rung of which shall reach to the top of the Massachusetts Agricultural College; and the time must come when it will be quite as natural for a pupil to look forward from the high school to work in the college, as to look forward from the grades or grammar schools to work in the high.

The appropriation made by the Legislature of 1898 for the establishment and maintenance of a veterinary plant at the college has been judiciously expended by the committee having the matter in charge. The contractors, Henry Mellen & Son of Worcester, selected as the lowest bidders out of sixteen competitors, have completed their work in the most thorough and satisfactory manner, and we take pleasure in testifying to the faithful fulfilling of their contract. Outside of Cambridge and Boston there are no buildings of similar construction and purpose in the State; and it seems fitting, therefore, to insert the following report and description prepared by the professor in charge: —

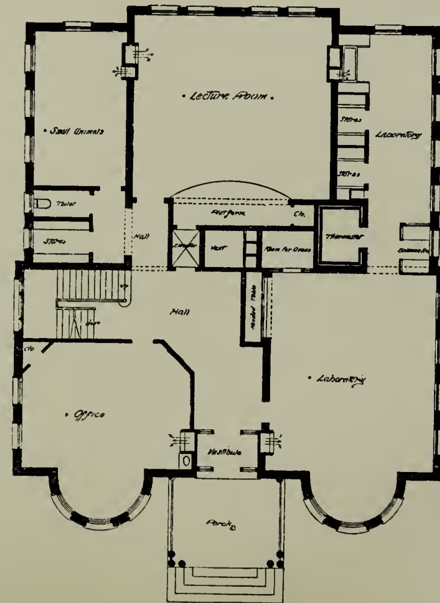
The frontispiece and accompanying drawings give a general view and floor plan arrangement of the new veterinary laboratory and hospital stable, for the erection of which the Legislature of 1898 appropriated the sum of $25,000.

The buildings are located on the west side of the road, south of the drill hall, nearly on the site of the old farm buildings. Both are of brick, with brownstone trimmings. The laboratory is a two-story building, with basement. The style of architecture is colonial. From the foundation to the water table the walls are of brownstone broken ashlar work. On the ground floor are the student laboratory, lecture room, office and private laboratory, small animal room and storerooms. The general laboratory occupies the entire floor on the north side, to the right of the hall. It is provided with fume chambers, incubator room, store closets, balance room and a large brick incubator with close-fitting iron door. The latter is to be used for the preparation of large quantities of cultures, or of tuberculin, mallein and such other bacterial products as may seem desirable. To avoid as far as possible the vibration usually occurring on floors constructed in the ordinary manner, rendering satisfactory work with the microscope impossible, to protect the occupants from dangers of infection and to provide for easy and effective disinfection, the floor in this part of the building has been built of masonry and asphalt, supported upon rolled steel I beams. Opposite each window on the north side and in the bay window in front there are tables of special design for microscopic work, each of which will accommodate two students. To the left of the main entrance is a large office and laboratory for the use of the professor of the department. In the rear of the hall is the lecture room, being of sufficient size to seat about forty students. Adjoining this on the south side are the small animal room and storeroom. These have asphalt floors similar to that in the laboratory. The interior walls of the laboratory, class room and animal room are of enamelled brick, permitting easy cleaning and perfect disinfection. On the second floor are private laboratories, the museum, a photographing room and dark room. An elevator runs from the basement to the attic, facilitating the transportation of material from the museum to the class room. The building is provided with a combination heating and ventilating system. A continual current of warm, fresh air is brought into the rooms through vertical wall ducts connected with the stacks in the cellar in which are the steam radiators. The impure air escapes through floor registers which lead into horizontal ducts in the cellar, connected with a large ventilating stack. Every room has been piped for sewage, water and gas, and wired for electricity.

Fifty feet in the rear of the laboratory stands the hospital stable. It consists of three parts, — a central portion one and one-half stories in height, a single-story L on the south side of the main part, and a one-story addition on the west side. On the


Manure Pit
Isolating Room
Isolating Room
Sheep and Pigs
Stalls
Young Stock
Cattle
Stalls
Horse
Box Stall
Stalls
Box Stall
Stall
Carriage Room
Post Mortem
Table
Sink
Dogs
Kennels
Office
Shelf
Shed

FLOOR·PLAN·


• Small Animals
• Lecture Room •
Laboratory
Stores
Toilet
Platform
Hall
Hall
Vestibule
• Office
• Laboratory
Porch

right of the main entrance of the central building is an office and pharmacy, on the left the grain room. In the rear is the operating floor. Only animals free from disease are kept in this part of the stable. The upper floor is used for storage purposes.

The L extending to the south and west of the main building has a total length of one hundred and five feet, and a width, including the porch, of twenty-nine feet. It is divided into six sections by brick wall partitions, extending from the floor to the ceilings. There is one section for horses, two for cattle, one for sheep and swine, and two isolation rooms for the confinement of animals suffering from contagious diseases. There exists no means of communication between the different sections except by way of the doors which open into the covered passageway outside. Each apartment is provided with water, heat and electric light, and each has a separate cupola for ventilation. The dog kennels, dissecting and post-mortem rooms and section for poultry are located in the addition to the rear of the main stable.

Throughout, the idea has been to provide a hospital stable, in which animals suffering from disease might be kept, limiting as far as possible the spread of infection from one to another, and providing for easy and thorough disinfection. To this end all floors have been made of artificial stone laid directly upon the ground, the ceilings have been plastered, and walls and ceilings made perfectly smooth and non-absorbent by means of paint. The mangers for cattle are of brick, made water-tight by the use of Portland cement. Cast-iron stall floors, mangers and hay racks of different patterns for horses have been put in, to afford the students an opportunity of comparison.

The erection of the buildings was begun the last of August, 1898, and completed about July 1, 1899. They have been occupied by the department since the opening of the college year in September, and have been found to be well adapted for the purposes for which they were intended. The appropriation for their construction has been sufficient for their completion according to the original plans and specifications, besides allowing for the purchase of a portion of the equipment.

Having now at our command every facility for the study of animal diseases, the department invites every one in the State interested in animal husbandry to send specimens from diseased animals for examination, and, in case of outbreak of obscure diseases among domestic animals, to communicate with the undersigned regarding the same.

Respectfully submitted, JAMES B. PAIGE, D.V.S.

The finances of the college require the most careful consideration. The assets may be divided into two classes, those that may be used for maintenance for the current expenses of the college, and those donated for special purposes and which cannot be used for maintenance. We find the income from the maintenance funds amounting to $44,601.78, while the liabilities, on the basis of expenditure for the year 1899, foot up to $46,554.16, or an excess of $1,952.38 over the receipts. We find the income from the non-maintenance funds reaching the sum of $30,000. Of the available funds for maintenance, the United States furnishes $23,966.66 and the State $19,135.12.

STATEMENT OF RESOURCES AND LIABILITIES ON THE BASIS OF RECEIPTS AND EXPENDITURES FOR THE YEAR 1899.

Liabilities.

Salaries,	$28,104 16
Farm appropriation,	3,000 00
Horticultural appropriation,	2,600 00
Dairy school,	1,000 00
Expense, labor,	2,500 00
repairs,	700 00
apparatus and material,	300 00
reading room,	150 00
fuel,	2,000 00
water,	400 00
incidentals,	2,000 00
electric equipment,	2,500 00
insurance,	600 00
advertising,	700 00
	$46,554 16

For Maintenance.

Income from Morrill fund, U. S.,	$16,666 66
from endowment fund, U. S. and State,	11,435 12
from scholarship fund, State,	10,000 00
from maintenance fund, State,	5,000 00
from rents,	1,500 00
	$44,601 78

Funds used for Special Purposes, but not Maintenance.

Labor fund, State,	$5,000 00
Experiment station, State,	10,000 00
Experiment station, U. S.,	15,000 00
	$30,000 00

The college was founded in 1862, by act of Congress, donating 360,000 acres of the public lands, the income derived from the sale of which was to be used inviolably for teaching. In 1863 the Commonwealth accepted this grant with all its conditions: *i. e.*, the establishment of a college where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the Legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.

In 1863 the income was divided, giving one-third to the Institute of Technology and two-thirds to establishing and maintaining a college of agriculture. The amount realized by the sale of lands was $219,000, and to this in 1871 the State added $141,575.35, creating a perpetual endowment fund of $360,575.35, two-thirds of the income of which is paid to this college. It yields from $10,500 to $11,400. In 1890 the United States government further increased the funds of the college by an annual appropriation of $16,666. Tuition having been made free to citizens of Massachusetts in 1886, the State granted $10,000 annually for scholarships. In 1896 it continued for four years a grant, made originally in 1889, of $5,000 for the purpose of establishing certain chairs of instruction.

The condition of the grant of 1862 was that a *college* — not a military or trades school — should be established and maintained. The great founder of all these national institutions of agriculture and the mechanic arts, the Hon. Justin S. Morrill of Vermont, thus interprets his own bill: —

Obviously not manual, but intellectual, instruction was the paramount object. It was not provided that agricultural labor in the field should be practically taught, any more than that the mechanical trade of a carpenter or blacksmith should be taught. It was a *liberal education* that was proposed. The act of 1862 proposed a system of broad education by *colleges* not limited to a superficial and dwarfed training, such as might be supplied by the foreman of a workshop or by a foreman of an experimental farm. If any would have only a college with equal scraps of labor and instruction, or something other than a college, they would not obey the national law. Experience in manual labor, in the handling of tools and implements, is not to be disparaged, — in the proper time and place it is most essential; and generally something of this may be obtained either before or after the college term, but should not largely interfere with the precious time required for a definite amount of scientific and literary culture, which all earnest students are apt to find far too limited.

In his far-sighted policy, the author of the above statement saw that laboratory work would take the place of manual labor, — for the laboratory is the pivot on which the modern college wheels. The principles laid down in the lecture room are verified and proved true by the student himself in the laboratory. There, whether in physics, chemistry, entomology, botany, agriculture or any other science, he grapples with the problems offered and seeks for their solution. Whether it be the feather scale of some destructive insect, or the atomic weight of some material, all alike must go to the laboratory to be determined. In this respect the colleges of 1900 differ radically from the colleges of 1862. In the latter, principles and facts were given on the authority of the teacher, and accepted as such without comment; in the former, these same principles and facts are given to the student to demonstrate and elucidate for himself. This necessarily proves an increasing item of expense, for the reason that to renew the materials expended and to furnish the delicate apparatus needed requires an annual outlay and expenditure.

The requirements of a college in this year of grace 1900 are infinitely greater than one in 1862, and the funds necessary for its maintenance must be proportionally greater. The college opened in 1867 with four buildings. They now number twenty-seven. The expenses for heat, light, water, care and wear and tear have immensely increased, and must necessarily continue to increase as the buildings grow older. In 1867 there was no equipment and no library. The demands of modern science now require costly apparatus and material renewed each year. The library now numbers twenty thousand volumes. Up to this time it has been cared for by the president; it has now outgrown his care, —

a librarian is necessary. An annual appropriation for binding books and for the purchase of new ones is required, for a college without a library would be like a carpenter's shop without its tools. Books are the tools of both teacher and pupil. A library is perhaps the most important adjunct of instruction. It is open to all and is used by all. During the past year more than thirty thousand volumes were taken out for study, — not for pleasure, for, in the twenty thousand volumes found upon the shelves, scarcely two hundred are works of fiction. In every department of science throughout the world the keenest intellects are at work, seeking for solutions to the unending series of problems that present themselves in the physical and natural world. "Light, more light," said the dying philosopher, and the longing of the world is but the echo of his last faint cry. To do our duty and to give reply to the many demands made upon us requires all the light and all the experience of other minds, wheresoever they may be found.

In our barn we keep one hundred head of stock, carrying out an experiment for the benefit of the farmers of this Commonwealth. We keep pure types of the different breeds. It is not economy to do this, but it is necessary for educational purposes. In the greenhouses and on the horticultural grounds, in a similar manner, types of plants and fruits are kept for educational purposes which do not yield any great income. In a word, the expenses have increased in a greater ratio than the income.

The labor fund, established by the Legislature of 1889 for four years and continued by the Legislatures of 1892 and 1896, expires by limitation in 1900. In order to make it operative in January, 1901, it is necessary to ask for its renewal this year. The same is true of the $5,000 maintenance fund, established the same year and continued in similar manner.

The experience of the last ten years shows that the labor fund has solved the problem how wisely to assist deserving students who must have pecuniary aid to enable them to secure the education the college offers. A truer remark was never made than that of President Hadley in his inaugural address, when he said: "Aid in education, if given without exacting a corresponding return, becomes *demoralizing*. If it is earned by the student as he goes, it has just the opposite effect." Money is not given as a charity, which a self-reliant man might refuse to accept, but is paid out in wages as a fair compensation for services rendered. By means of it the students are employed in labor which is necessary to keep the several departments of the college in efficient action, and which, at the same time, educates the students in the practical use of the principles set forth in the class room. To hold their own against the intense competition of to-day, Massachusetts manufacturers in self-defence have established with State aid the Lowell Textile School, where the man who guides the machine shall be so trained that he shall be the peer of any operative in the world. In like manner, if the agriculture of the State shall maintain itself, no young man who is willing to work for it should be denied the education and training the college gives, because neither he nor his relatives have the money to pay the necessary expenses. Every dollar spent in setting such a man to work returns a three-fold interest on the principal invested: first, in the permanent improvement of college property; second, in the equipment of the student himself; and third, in the work such a trained producer of wealth must do for the agriculture and the agriculturists of the State. During the last five years the number of students helped in this way has been: —

In 1895,	80	In 1898,	86
In 1896,	77	In 1899,	100
In 1897,	75		

We ask, therefore, for a renewal for four years of the grant of $10,000, made by the Legislatures of 1889, 1892 and 1896, for the creation of a labor fund, and to provide the theoretical and practical education required by the charter of the college and the law of the United States relating thereto. And we further ask for an additional annual appropriation for four years of $8,000, for the following purposes, to wit: $2,000 for the support and maintenance of the library; $3,000 for instruction in drawing, French, German and geology; $1,000 for furnishing equipment and instruction in the dairy school; $1,000 for renewing the annual waste and destruction of material and equipment; and $1,000 for the expense account of the college.

In addition to the customary reports, I have the honor to submit a special paper, on "The Grass Thrips," by W. E. Hinds.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 4, 1900.

THE CORPORATION.

	TERM EXPIRES.
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,	1906
J. HOWE DEMOND of Northampton,	1907
ELMER D. HOWE of Marlborough,	1907

Members Ex Officio.

His Excellency Governor W. MURRAY CRANE,
President of the Corporation.

HENRY H. GOODELL, *President of the College.*

FRANK A. HILL, *Secretary of the Board of Education.*

JAMES W. STOCKWELL, *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.*

ELMER D. HOWE. 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 H. BOWKER.
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.

JOHN BURSLEY (*Chairman*), . of West Barnstable.
C. K. BREWSTER, . . . of Worthington.
WESLEY B. BARTON, . . . of Dalton.
GEORGE P. SMITH, . . . of Sunderland.
ALVAN BARRUS, ... of Goshen.

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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.

HENRY T. FERNALD, Ph.D.,
Professor of Entomology.

HERMAN BABSON, M.A.,
Assistant Professor of English.

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.,
Assistant Professor of Botany.
(Instructor in German.)

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

JOHN ANDERSON, Captain, U. S. A.
Professor of Military Science and Tactics.

BERNARD H. SMITH, B.Sc.,
Instructor in Chemistry.

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

E. FRANCES HALL,
Librarian.

ELISHA A. JONES, B.Sc.,
Farm Superintendent.

Graduates of 1899.*

Armstrong, William Henry (Boston Univ.),	Cambridge.
Beaman, Dan Ashley (Boston Univ.),	Leverett.
Chapin, William Edward (Boston Univ.),	Chicopee.
Dana, Herbert Warner (Boston Univ.),	South Amherst.
Hinds, Warren Elmer (Boston Univ.),	Townsend.
Hooker, William Anson (Boston Univ.),	Amherst.

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* 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 1899.

Hubbard, George Caleb (Boston Univ.),	Sunderland.
Maynard, Howard Eddy (Boston Univ.), ...	Amherst.
Merrill, Frederic Augustus (Boston Univ.), ...	Boston.
Pingree, Melvin Herbert (Boston Univ.), ...	Denmark, Me.
Smith, Bernard Howard (Boston Univ.), ...	Middlefield.
Smith, Samuel Eldredge, . . .	Middlefield.
Turner, Frederick Harvey (Boston Univ.), ...	Housatonic.
Walker, Charles Morehouse, . .	Amherst.
Total, ...	14

Senior 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.
Gilbert, Ralph Davis, ...	Gilead, Conn.
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.
Monahan, Arthur Coleman, . .	South Framingham.
Morrill, Austin Winfield, . . .	Tewksbury.
Munson, Mark Hayes, . . .	Huntington.
Parmenter, George Freeman, . .	Dover.
Saunders, Edward Boyle, . . .	Southwick.
Stanley, Francis Guy, . . .	Springfield.
West, Albert Merril, ...	Brookville.
Total, ...	25

Junior Class.

Barry, John Cornelius,	Amherst.
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.
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.
Henry, James Buel,	Scitico, Conn.
Howard, John Herbert,	Littleton Common.
Hunting, Nathan Justus,	Shutesbury.
Jones, Cyrus Walter,	Amherst.
Leslie, Charles Thomas,	Pittsfield.
Macomber, Ernest Leslie,	Taunton.
Ovalle Barros, Julio Moises,	Santiago, Chili.
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,	32

Sophomore Class.

Ball, George Treadwell,	Holyoke.
Belden, Joshua Herbert,	Newington, Conn.
Blake, Maurice Adin,	Millis.
Bodfish, Henry Look,	Tisbury.
Carpenter, Thorne Martin,	Foxborough.

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.	
Paul, Herbert Amasa,	Lynn.	
Peabody, Harry Eldridge,	Stoneham.	
Smith, Samuel Leroy,	South Hadley.	
West, David Nelson,	Northampton.	
Total,		32

Freshman Class.

Allen, Lilly Bertha,	Amherst.
Bacon, Stephen Carroll,	Leominster.
Barrus, George Levi,	Goshen.
Blake, Ernest Edward,	Gill.
Bowen, Howard Chandler,	Rutland.
Bowler, Patrick Henry,	Bondsville.
Brooks, Philip Whitney,	Cambridge.
Carmody, John Francis,	Bondsville.
Cheever, Herbert Milton,	West Boylston.
Cook, Joseph Gershom,	Clayton.
Dillon, James Henry,	Belchertown.
Franklin, Harry James,	Bernardston.
Harris, Frederick Arnold,	Amherst.

Higgins, Willis Elmore, . . .	Winchester.
Hood, William Lane, ...	Vandiver, Ala.
Jones, Gerald Denison, . . .	South Framingham.
Kelley, Herbert Thomas, . . .	Amherst.
Martin, Henry Thomas, . . .	Amherst.
Monahan, Neil Francis, . . .	South Framingham.
Nersessian, Paul Nerses, . . .	Marash, Turkey.
O'Hearn, George Edmund, . . .	Pittsfield.
Parsons, Albert, ...	North Amherst.
Parsons, Josiah Waite, . . .	Northampton.
Peebles, William Warrington, . .	Washington, D. C.
Perkins, Edward Lamson, . . .	Roxbury.
Phelps, Arthur Augustus, . . .	Boylston.
Phillips, Lee, ...	West Hanover.
Poole, Elmer Myron, ...	North Dartmouth.
Potter, Roland Daniel, . . .	Rutland.
Proulx, Edward George, . . .	Hatfield.
Richardson, Harlan Lewis, . . .	Boxborough.
Robertson, Richard Hendrie, . .	Malden.
Snell, Edward Benaiah, . . .	Lawrence.
Thompson, Leslie Irving, . . .	Middleborough.
Tinker, Clifford Albion, . . .	West Tremont, Me.
Tinkham, Charles Samuel, . . .	Roxbury.
Tottingham, William Edgar, . .	Bernardston.
Tower, Winthrop Vose, . . .	Melrose Highlands.
Vance, Phillip Gifford, . . .	Stow.
Webster, Frank Wallace, . . .	Bay State.
West, Myron Howard, . . .	Belchertown.
Wollheim, Ernest, ...	Jersey City, N. J.
Total, ...	42

Short Winter Courses.

Adams, John Dwight, . . .	Westfield.
Blair, Curtis Merritt, ...	Blandford.
Buckley, Clarence Eaton, . . .	Dorchester.
Carlson, Axel Gottfried, . . .	Shirley Centre.
Carrington, Edward Seymour, . .	Monterey.
Frost, George Howard, . . .	West Newton.
Goodfield, William Raymond, . .	Gilbertville.
Jejeian, Gabriel Solomon, . . .	Roomdigen, Turkey-in-Asia.
Krikorian, Karakin Krikor, . .	Tarsus, Turkey.
Morton, John Bardwell, . . .	Amherst.

Nourse, Arthur Henry,	Bolton.
Nye, Vaile Elliott,	Westfield.
Randall, Earle Adams,	Hadley.
Sullivan, Thomas Francis,	Amherst.
Tallberg, Claes Alfred,	Uxbridge.
Total,	15

Graduate Course.

For Degree of M.S.

Adjemian (B.Sc., M. A. C., '98), Avedis Garrabet,	Kharpoot, Turkey.
Babb (Bates College), George Francis,	Spencer.
Baker (Mt. Holyoke College), Grace B.,	South Hadley.
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.
Hinds (B.Sc., M. A. C., '99), Warren Elmer,	Townsend.
Hooker (B.Sc., M. A. C., '99), William Anson,	Amherst.
Knight (B.Sc., M. A. C., '92), Jewell Bennett,	Belchertown.
Pingree (B.Sc., M. A. C., '99), Melvin Herbert,	Denmark, Me.
Walker (B.Sc., M. A. C., '99), Charles Morehouse,	Amherst.
Total,	11

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, M.S., Edward Bertram,	Amherst.
Jones, B.Sc., Benjamin Kent,	Middlefield.
Mossman, B.Sc., Fred Way,	Westminster.
Smith, Jr., B.Sc., Philip Henry,	South Hadley Falls.
Thomson, B.Sc., Henry Martin,	Monterey.
Wiley, B.Sc., Samuel William,	Amherst.
Total,	9

Summary.

Graduate course :—		
For degree of M.S.,	11	
Four-years course :—		
Graduates of 1899,	14	
Senior class,	25	
Junior class,	32	
Sophomore class,	32	
Freshman class,	42	
Winter course,	15	
Resident graduates,	9	
Total,		180
Entered twice,		4
Total,		176

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. German, — 3.	- -	- -
Winter, .	- -	Laboratory work, — 4.	Lectures and practice, — 4.	Anatomy and physiology, — 4.	Mechanics, — 3.	English, — 3. German, — 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. German, — 3.	- -	- -

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).*								
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. French, — 5.
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. French, — 5.
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. French, — 5.

* 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 affect 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 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.

ENGLISH.

The aim of this department is to secure: (*a*) ability to give oral and written expression of thought in correct, effective English; (*b*) acquaintance with the masterpieces of American and English literature; (*c*) ability to present, logically and forcibly, oral and written arguments on propositions assigned for debate. The following subjects are studied: —

1. *Rhetoric.* — The course in rhetoric comprises a study of the choice of words, the theory of phraseology, special objects in style, the sentence, the paragraph, the whole composition in its plan, arrangement and development. This is followed by lectures on invention, in which the elements and underlying principles of literature are discussed. The students are expected to give practical illustration of the principles taught in written exercises, themes and compositions that are required throughout the course.

Required during freshman year and two terms of sophomore year: —

2. *Elocution.* — Individual drill in declamation, first in private and then before the class, is given during freshman and sophomore years. The choice of speakers for the Burnham prizes is based upon this work. In the junior year at least two orations are written, and delivered before the class by each student. Each oration is criticised in private before it is committed to memory. Private rehearsal prepares the student for his appearance before the class. The choice of speakers for the Flint prizes in oratory is based upon this work, in part, and in part upon general proficiency in the studies of the English department.

3. *Literature.* — American literature is studied in the third term of sophomore year, and English literature in the three terms of junior year. The *history* of literature is made secondary to the literature itself; and an attempt is made to secure familiarity with authors through their writings, rather than through what others have written about their writings. In the elective English of senior year attention is given to poets and prose writers of the eighteenth and early part of the nineteenth centuries. At least one essay on each author studied is read before the class, and frequent themes on subjects suggested by the text are required.

4. *Argumentation.* — The required English of the senior year is a course in written and oral argumentation. The principles of the subject are studied by the aid of text-books, and their practical illustration and use are secured by written briefs and forensics and by oral debate.

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, including description of the several parts of our complex system, the history of its development, comparison with modern and ancient European governments, and discussion of current questions of governmental reform.

VETERINARY.

To give a general idea of the principles of veterinary science in such simple and comprehensive manner as to enable one to give animals under his supervision such care and treatment as will tend to secure and maintain a healthful condition, thereby preventing the occurrence of disease among them, is the aim of the course of study in this department. (*a*) The hygiene of farm animals; (*b*) the anatomy and physiology of the bony, muscular, circulatory, respiratory, genital and digestive systems; a study of the more common pathological processes and the general causes, symptoms and effects of disease; (*d*) the consideration of the diseases of the different organs, particularly as regards causes, effects and prevention; (*e*) 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.

Senior Entomology. — During the senior year such members of this class as elect advanced entomology take a course of lectures on the external and internal anatomy of insects, and on the various methods by which the injurious forms are destroyed or held in check. The laboratory work consists of a critical study of the external and internal anatomy of members of the different groups, followed by the determination of insects of each group. In connection with this work a careful study of the literature is made, and familiarity with the analytical keys and the more important articles on injurious species is obtained. During the spring term much of the time is spent in the field, where the student is taught how to look for and find injuries caused by insects, to recognize the species by the nature of the injuries, and how best to deal with each case, either by the use of insecticides or other methods. 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 occupation he intends to follow after graduation, and is then advised to prepare his thesis on those insects with which he will have most 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.

Graduate Entomology. — 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 to do 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.

A three-years course, leading to the degree of Doctor of Philosophy, is in active operation, three subjects — botany, chemistry and entomology, arranged as a major and two minors — being required. In those cases where entomology is chosen as the major subject, the course consists of lectures and laboratory work, some of the topics treated being the following: —

General morphology of insects: embryology, life histories and transformations, histology, phylogeny and relation to other arthropods; hermaphroditism, hybrids, parthenogenesis, pædogenesis and heterogamy; colors, — chemistry of color in insects; luminosity; deformities of insects; variation; duration of life.

Œcology of insects: dimorphisms; polymorphisms; mimicry, warning coloration; insect architecture; fertilization of plants through the agency of insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects; insects as disseminators of disease; enemies of insects, vegetable and animal, including parasitism.

Economic entomology: general principles; insecticides; apparatus; special cases (borers, etc.); photography of insects and their work; methods of drawing for illustrations; field work on insects; insect legislation.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and in existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

In connection with these topics, corresponding laboratory work is given as far as possible, and, in addition, investigations on subjects not previously studied are made, and the results published in the form of graduation theses.

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 — "Landscape Gardening." John Wiley & Sons, 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.

VOORHEES — "Fertilizers." Macmillan & Co., New York.

ROBERTS — "The Fertility of the Land." Macmillan & Co., New York

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

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.

ARMSBY — "Manual of Cattle Feeding." John Wiley & Sons, New York.

WING — "Milk and its Products." Macmillan & Co., New York.

NEWTH — "Text-book of Inorganic Chemistry." Longmans, Green & Co., New York.

REYCHLER and MCCRAE — "Outlines of Physical Chemistry." Whittaker & Co., New York.

NOYES — "Qualitative Analysis." Macmillan & Co., New York.

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

TALBOT — "Quantitative Chemical Analysis." Macmillan & Co., New York.

FRESENIUS — "Quantitative Chemical Analysis." John Wiley & Sons, New York.

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

REMSEN — "The Compounds of Carbon." D. C. Heath & Co., Boston.

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

VULTÉ and NEUSTADT — "Inorganic Preparations." G. G. Peck, New York.

COHEN — "Practical Organic Chemistry." Macmillan & Co., New York.

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

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." D. C. Heath & Co., Boston.

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

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

PHILLIPS and STRONG — "Elements of Trigonometry." Harper & Brothers, New York.

NICHOLS — "Analytic Geometry." D. C. Heath & Co., Boston.

SEARLES — "Field Engineering." John Wiley & Sons, New York.

MERRIMAN — "A Text-book on the Mechanics of Materials." John Wiley & Sons, New York.

CARHART — "University Physics." Allyn & Bacon, Boston.

OSBORNE — "An Elementary Treatise on the Differential and Integral Calculus." D. C. Heath & Co., Boston.

MERRIMAN — "A Text-book on Roofs and Bridges." John Wiley & Sons, New York.

YOUNG — "A Text-book of General Astronomy." Ginn & Co., Boston.

PHILLIPS 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.

BRADFORD — "The Lesson of Popular Government." Macmillan & Co , New York.

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.

ROLFE — "Standard English Classics." Ginn & Co., Boston.

MACEWAN — "Essentials of Argumentation." D. C. Heath & Co., Boston.

CHARDENAL — "Complete French Course." Allyn & Bacon, Boston.

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. 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.

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.

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

FOUR-YEARS COURSE.

Admission.

Candidates for admission to the freshman class will be examined orally and in writing upon the following subjects: English, United States history, physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography" or its equivalent), arithmetic, algebra (through quadratics), geometry (two books) and civil government (Mowry's "Studies in Civil Government"). A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject-matter of the books named below, and to answer simple questions on the lives of the authors. The form of examination will usually be the writing of a paragraph or two on each of several topics, to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will call for only a general knowledge of the substance of the books. In place of a part or the whole of this test, the candidate may be allowed to present an exercise book, properly certified by his instructor, containing compositions or other written work done in connection with the reading of the books. The books set for the examination in 1900 are: "The Sir Roger de Coverley Papers" in "The Spectator;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Cooper's "The Last of the Mohicans;" Whittier's "Snow Bound." The standard required is 65 per cent. on each paper. Examinations in the following subjects may be taken a year before the candidate expects to enter college: English, 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 21 and 22, and on Tuesday and Wednesday, September 4 and 5; 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 21 and 22, 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 open 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 1899.

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

Arithmetic.

1. Find the value of $\left(\frac{31\frac{1}{3}}{8} + \frac{6\frac{3}{4}}{2\frac{1}{12}}\right) \div 4.23$.

2. A board is 15 feet long, 20 inches wide and 1 inch thick. What length may be cut from the board so as to leave 15 board feet?

3. Bought 128 tons of coal at $5.12½ a ton, and sold it at a profit of 22 per cent. What was the entire profit?

4. Required the bank discount and proceeds of a note for $1,615, due in 90 days, at 7 per cent.

5. Find the square root of .001225.

6. Describe the standard unit of weight in the metric system.

7. How many hectolitres in a box whose length is 2.25 metres, width 1.75 metres, depth 1 metre?

8. How many kilograms of mercury will the box contain, if mercury weighs 13.5 times as much as water?

Algebra.

1. A cask (a) contains 12 gallons of wine and 18 gallons of water. Another cask (b) contains 9 gallons of wine and 3 gallons of water. How many gallons must be drawn from each cask so as to produce by their mixture 7 gallons of wine and 7 gallons of water?

2. $\left.\begin{array}{l}\frac{5}{x}+\frac{16}{y}=79\\ \frac{16}{x}-\frac{1}{y}=44\end{array}\right\}$ Solve for x and y.

3. $\frac{\sqrt{7}+\sqrt{2}}{9+2\sqrt{14}}$ Rationalize the denominator.

4. $\frac{y}{x^{n}}\sqrt{\frac{x^{2n+a}}{y^{3}}}$ Express as an entire surd and reduce to lowest terms.

5. $\frac{1}{x+\sqrt{2-x^2}}+\frac{1}{x-\sqrt{2-x^2}}=\frac{x}{2}$ Solve for x.

6. $\left.\begin{array}{l}\frac{1}{x^2}+\frac{1}{y^2}=\frac{481}{576}\\ \frac{1}{x}+\frac{1}{y}=\frac{29}{24}\end{array}\right\}$ Solve for x and y.

Geometry.

1. How many degrees in the complement and in the supplement of an angle equal to $\frac{7}{12}$ of a right angle?

Prove the following: —

2. If two parallels are cut by a secant line, the alternate interior angles are equal.

3. Any point in the bisector of an angle is equally distant from the sides of the angle.

4. 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.

5. The angle between two secants, intersecting without the circumference, is measured by one-half the difference of the intercepted arcs.

United States History.

1. Discuss any two of the early colonial wars.
2. The condition of our country immediately after the close of the revolution.
3. A brief composition upon the war of 1812.
4. Jackson's struggle with the national bank.
5. (*a*) The Missouri compromise. (*b*) The Dred-Scott decision. (*c*) The relation of the Mexican war to the civil war.
6. Causes, dates, and battles of the recent Spanish-American war.

Geography.

1. Name the continents, and draw as well as you can *outline maps* of each.
2. Write short accounts of the following countries, giving distinctive facts with regard to each: (*a*) Europe; (*b*) Africa; (*c*) Australia.
3. Name and locate twenty cities of Europe.
4. Contrast the North Atlantic States with the South Atlantic States, as follows: (*a*) class of people in each; (*b*) productions; (*c*) climate.
5. Name the principal colonies of Great Britain, and describe the two largest.

Physical Geography.

1. Give Laplace's nebular theory.
2. What are stratified, igneous and metamorphic rocks?
3. Describe the mariner's compass. What is meant by magnetic declination?
4. How may mountains be classified? Give examples of each sort.
5. How are the great forms of relief arranged in each of the continents? What general rule does the location of the predominant mountain system follow? How do continents and islands differ? Is Australia a continent, or an island?
6. What are bores? Give several causes of ocean currents.
7. What was the glacial period? What was the probable extent of the ice cap in North America? What evidences have we that the glacial theory is true?
8. Name three important factors which influence climate.
9. Name some of the principal animals and plants native to North America.

10. What is ethnology? Name the principal races of man, giving their characteristics and some idea of their geographical distribution.

(Based upon Warren's " Physical Geography.")

Civil Government.

Note. — Penmanship, punctuation and spelling are considered in marking this paper.

1. Define the following: *civil government*, *municipal government*, *military government*, a *franchise*, a *charter*, a *tax*.

2. What is meant by an *executive* officer? What is the official title of the chief executive officer of the United States? of Massachusetts? of the city or town in which you live? How is the chief executive officer of the United States elected?

3. By whom and in what city are the laws for the State of Massachusetts made? How often do these law makers meet? By whom are they chosen?

4. By whom and in what city are the laws for the United States made? How many men from the State of Massachusetts have part in making these laws? Who represents the district in which you live in the national House of Representatives?

5. Of how many members does the United States Senate now consist? Who is its presiding officer? Name the United States senators from Massachusetts.

6. How does the government of a Territory differ from that of a State? Name the Territories of the United States.

7. What is the government of Cuba? What is its relation to the government of the United States? What is the government of Porto Rico? of the Philippines?

8. What is a republic? Give reasons why a republican form of government is to be desired.

Physiology.

1. Describe a cell, naming its parts. How may cells vary in form? What is the intercellular substance? What do you mean by physiological division of labor?

2. How are the chemical compounds existing in the body classed? Name the principal constituents under the first class. What are the four principal elements found in the body?

3. Locate and describe the sacrum. Name and describe the first two cervical vertebræ. What are the intervertebral discs, and what is their function?

4. Describe the three orders of levers, and illustrate from the body.

5. Name and describe the successive steps or processes between that of reception of food and that of the excretion of bodily waste.

6. Give the use of the gastric juice in digestion, naming its active principles. What becomes of the fats taken into the body as food?

7. What is lymph? What is its use, and what its origin?

8. What is reflex action? Give an illustration, describing fully what takes place.

9 and 10. Describe carefully the ear, especially the inner ear, and tell how the ear is capable of distinguishing sounds, especially those varying in pitch.

(Based on Martin's "The Human Body," briefer course.)

English.

Note. — Penmanship, punctuation and spelling are considered in marking this paper.

1. Write a composition of at least two hundred words upon one of the best-known American writers. (Allow fifteen minutes.)

2. Change the following piece of blank verse into plain, grammatical and modern English prose. Add nothing in the line of new thought, and leave out nothing that is herein expressed. (Allow fifteen minutes.)

"A level, treeless waste, with rugged shore
Extending boldly 'gainst the roaring surf,
With patches here and there of storm-swept grass
Whereon were fishers' huts, and hard by these
A lighthouse built of stone, — this was the isle
Where many years ago a barque from France
Cast all her lives and freight. The fishers said
It was a dreadful wreck; and from that day
They called it by the name of Frenchman's Isle."

3. Define and illustrate: (*a*) a sentence; (*b*) a clause; (*c*) a phrase; (*d*) a paragraph.

4. What is the difference between grammar and rhetoric? What is literature?

5. Criticise the following: —

"I was placed in a sleigh, and as the horse sprang away, the clear sleigh-bells rang out, and a gun from the ramparts was fired to give the noon hour, I sank into unconsciousness."

6. State briefly the work you did in the high school in rhetoric and literature.

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

* Free to citizens of the United States.

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 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 Middle Yorkshire, Chester White, Poland China, Berkshire, Tamworth and Belted 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 material 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 relating to agriculture. 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 thirty-six compound microscopes, representing Leitz', Reichert's, Bausch and Lomb's, Beck's, Queen's and Tolles' patterns, 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 arcauxanometer, 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.

Zoölogical Laboratory. — This very necessary adjunct to zoölogical teaching is a large, well-lighted room, situated in the old chapel building, and fitted with the necessary tables, trays and general apparatus, besides sixteen Zentmeyer microscopes, two dissecting microscopes, hand lenses and the like. There have lately been added aquaria, one the gift of Mr. Kellogg of the class of 1900, in which the various types studied may be seen in, as nearly as may be, their natural environment.

A reference library is kept in the laboratory, or in the museum when the former is not in session, and the students are urged to become familiar with the best zoölogical literature by constant use of the books.

Zoölogical Lecture Room. — An ample lecture room is situated in South College, adjacent to the museum. It is supplied with a set of Leuckart charts and many special ones as well, and with a complete set of Auzoux models illustrative both of human and comparative anatomy. A special set of typical specimens are being set apart for class illustration, although the more extensive museum collection is drawn upon for the same purpose.

Museum of Zoölogy. — The museum, of course, is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as fully as possible the fauna of the Commonwealth and those types which show the evolution and relationship of the members of the animal kingdom. A department of ethnology has lately been established, and already one case is full to overflowing with articles of human interest, mainly from the Island of Yezzo, collected by the late Colonel Clark. The museum is open to the public during a portion of each afternoon, and at present is in charge of Mr. Clarence E. Gordon of the class of 1901. The interest of the students in the museum is attested by the gifts which are continually being received from them, numbering in the past year no less than fifty-six specimens, mainly of birds.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glassware, and one portion is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of over forty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject, and this is supplemented by the library of Amherst College and by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room in the laboratory is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. The laboratory being directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room, fitted up for the analysis of insecticides and other chemico-entomological work; and the greenhouse, where plants infested by injurious insects are under continual observation, and the subject of experimental treatment, — are all available to the student, and in addition several private laboratory rooms and a photographing room and outfit are provided. The large hothouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for the study of the attacks of injurious insects, under natural conditions.

Veterinary Department.

With a new and well-equipped laboratory and hospital stable, the department has unsurpassed facilities for the study of animal diseases. The department stands ready to investigate any outbreak of obscure disease among animals in the State, and it cordially invites any one to send specimens from diseased animals for examination, which will be made free of expense to the sender. It will not undertake, however, the treatment of animals suffering from common diseases.

The department can well carry out the course of instruction outlined, as it has been provided with a new laboratory and hospital stable for its special use. The former, 59 feet wide and 63 feet 10 inches deep, contains on the lower floor a large general laboratory, recitation room, office, animal room and store closets. Connected with the laboratory is a large incubator built into the building, an incubator room for portable incubators, fume chambers, balance cabinet, microscope cabinet, etc. The floor is asphalt, laid upon cement work. The walls are of enamelled brick.

The recitation room is sufficiently large to accommodate about forty students. On the second floor are two private laboratories, provided with store closets, fume chamber, water, gas and electric lights, a photographing room with dark room, janitor's rooms and a museum.

The hospital stable, located 50 feet in the rear of the laboratory, is of brick, consisting of three parts. A two-story upright portion, 33 by 30 feet in size, contains on the lower floor an office and pharmacy, an operating room with water-tight floor, a single stall and a large box stall, grain room and closets. The upper floor is used for storage purposes.

Extending from the south and west from the main part is an L, 104 feet in length and 29 feet in width. This L is one story in height, and is divided by brick wall partitions into six sections, affording quarters for horses, cattle, sheep and swine. Each section is entirely independent of every other one, having separate ventilator, water, heat and light. The floors are of Portland cement, laid directly upon the ground. Everything has been arranged in this portion of the building to allow of the stabling of diseased animals, at the same time reducing to a minimum the liability of spreading infection. The floors, walls, ceilings and fixtures have all been so constructed as to allow of easy and complete disinfection.

In the rear of the main stable is an addition, 34 by 22 feet in size. This contains the kennels, a section for poultry and a dissecting room.

The hospital has sufficient capacity for the accommodation of about fifty animals.

The museum is well equipped with the apparatus necessary to illustrate the subject as taught in the class room, and in addition there is the clinical material to be observed in the hospital. The museum contains in part an improved Auzoux model of the horse, 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; five 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 cow; 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.

The laboratory is supplied with the usual apparatus required for work in histology, bacteriology and pathology, consisting of Zeiss, Leitz and Reichert microscopes, Lautenschlager's incubator and hot-air sterilizer, steam sterilizers, etc.

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 geometery 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.*

* 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. — 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 20,040 volumes, having been increased during the year, by gift and purchase, 860 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 from eight o'clock to half-past five in the afternoon, and an hour and a half in the evening.

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 1900 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 1899 were awarded as follows: —

Burnham Rhetorical Prizes: Edward S. Gamwell (1901), first; Nathan D. Whitman (1901), second; Ransom W. Morse (1902), first; Maurice A. Blake (1902), second.

Flint Oratorical Prizes: Arthur C. Monahan (1900), first; Howard Baker (1900), second.

Grinnell Agricultural Prizes: Bernard H. Smith (1899), first; Samuel E. Smith (1899), second.

Hills Botanical Prizes: Charles M. Walker (1899), first.

Prize in Drawing, given by William H. Armstrong, '99 : Hubert C. James (1902).

Dairy Prizes, given by the Massachusetts Society for Promoting Agriculture: greatest improvement, Clarence E. Buckley, first (fifty dollars in gold); Arthur H. Nourse, second (thirty dollars in gold); Curtis M. Blair, third (twenty dollars in gold).

RELIGIOUS SERVICES.

Chapel exercises are held every week-day at 8 A.M. Public worship in the chapel every Sunday at 9.15 A.M. Further opportunities for moral and religious culture are afforded by a Bible class taught by one of the professors for an hour every Sabbath afternoon 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 four hundred 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, 1899, to Jan. 1, 1900.*

	Received.	Paid.
Cash on hand Jan. 1, 1899,	$1,423 38	–
State treasurer, endowment fund,	11,435 12	–
State treasurer, maintenance fund,	5,000 00	–
State treasurer, labor fund,	5,000 00	$4,654 92
State treasurer, maintenance fund, special,	7,500 00	–
State treasurer, scholarship fund,	10,000 00	–
State treasurer, Morrill fund,	16,666 66	–
Gassett scholarship fund, income,	40 00	25 00
Mary Robinson fund, income,	35 84	75 00
Whiting Street fund, income,	60 40	60 00
Burnham emergency fund, income,	102 32	96 66
Grinnell prize fund, income,	40 00	40 00
Hills fund, income,	356 16	194 59
Library fund, income,	416 84	416 84
Salary,	165 00	27,621 77
Extra instruction,	–	406 00
Botanical laboratory,	104 15	130 38
Chemical laboratory,	589 77	320 62
Entomological laboratory,	26 00	18 94
Veterinary laboratory,	1,019 94	718 91
Zoölogical laboratory,	129 26	161 24
Term bill,	3,274 27	876 52
Advertising,	–	376 50
Electric equipment,	734 29	2,802 86
Agricultural department,	555 55	1,296 78
Farm,	8,141 80	13,368 21
Horticultural department,	4,594 57	7,170 20
Expense,	2,146 42	13,021 81
Insurance,	–	1,007 00
Investment,	4 00	–
Burnham emergency fund,	3,000 00	–
Cash on hand Jan. 1, 1900,	–	7,700 99
	$82,561 74	$82,561 74

This is to certify that I have this day examined the accounts from Jan. 1, 1899, to Jan. 1, 1900, 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 seven thousand, seven hundred dollars and ninety-nine cents ($7,700.99), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Dec. 28, 1899.

Cash on Hand, as shown by the Treasurer's Statement, belongs to the Following Accounts:

Gassett scholarship fund,	$26 02
Whiting Street fund,	11 91
Grinnell prize fund,	30 00
Burnham emergency fund,	94 70
Hills fund,	150 56
Labor fund,	661 83
College,	6,725 97
	$7,700 99

Bills Receivable Jan. 1, 1900.

Botanical laboratory,	$22 40
Chemical laboratory,	471 39
Entomological laboratory,	4 00
Zoölogical laboratory,	85 74
Electric equipment,	165 59
Term bill,	421 23
Mary Robinson Fund,	23 56
Farm,	908 79
Horticultural department,	530 46
Expense,	56 18
	$2,689 34

Bills Payable.

Chemical laboratory,	$182 77
Veterinary laboratory,	2 03
Electric equipment,	209 00
Term bill,	10 45
Farm,	61 02
Horticultural department,	272 27
Expense,	683 15
	$1,420 69

Inventory — real estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00
Amount carried forward,		$44,350 00

Amount brought forward,		$44,350 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	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Veterinary laboratory,	22,500 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	
		213,775 00
		$258,125 00

EQUIPMENT.

Botanical department,	$3,610 00
Horticultural department,	12,434 12
Farm,	16,339 95
Chemical laboratory,	2,210 00
Botanical laboratory,	2,456 53
Zoölogical laboratory,	1,910 38
Zoölogical museum,	5,238 25
Veterinary laboratory,	4,619 23
Physics and mathematics,	5,213 00
Agricultural department,	3,250 00
Library,	20,040 00
Fire apparatus,	650 00
Furniture,	500 00
Text books,	251 14
Tools and lumber,	259 40
Electric equipment and supplies,	6,354 60
	$85,336 60

SUMMARY.

Assets.

Total value of real estate, per inventory,		$258,125 00
Total value of equipment, per inventory,		85,336 60
Bills receivable,		2,689 34
Cash on hand,		7,700 99
		$353,851 93

Liabilities.

Bills payable,	$1,420 69	
Burnham emergency fund,	3,955 29	
		5,375 98
		$348,475 95

MAINTENANCE FUNDS.

	Fund.	Income in '99.
Technical educational fund, United States grant,*	$219,000 00	$7,300 00
Technical educational fund, State grant,*	141,575 35	4,135 12
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890,	–	16,666 66
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	60 40
Gassett fund,	1,000 00	40 00
Mary Robinson fund,	858 00	35 84

PRIZE FUND.

Grinnell prize fund,	$1,000 00	40 00

MISCELLANEOUS FUNDS.

Library fund,	$10,546 12	416 84
Investment, N. Y. C. & H. R. R.R. stock,	100 00	4 00
Burnham emergency fund,	4,044 71	102 32
		$49,157 34

* Two-thirds of the income of these funds comes to the college.

FARM REPORT.

The operations on the college farm during the year just past require no extended notice. The expenses during the few years covering and immediately following the erection of the new barns and the slaughter of our old herd of cattle and the purchase of the new, had been large; while the returns from our dairy, as was to be anticipated, had been much smaller than our average. The past year has, therefore, been made one of close economy, the farm operations having been limited for the most part to the ordinary routine work, in the effort to curtail expenses in every possible way.

The results have been highly satisfactory from a financial point of view, the farm having much more nearly met all expenses than during any year in the recent past. This result is due in considerable measure to increasing returns from the dairy, — the consequence in part of increased product, but in large measure also to sales at satisfactory prices, through arrangements which have been made by the superintendent for disposing of the product directly to consumers. To the careful attention also of the superintendent to the many details connected with the purchase of supplies and the disposal of other farm products must be ascribed no inconsiderable share of the credit for our better financial showing. Increasing sales of stock and contracts with seedsmen for new varieties of millet and soy bean seed at profitable prices must also be named as among the factors which have contributed to our success.

The nature of the farm operations and the financial returns from the various crops are sufficiently shown in the following table: —

College Farm Crops, 1899.

CROPS.	Acres.	Total Product.			Cost.		Value.	Net Profit.	Loss.
		Pounds.	Bushels.	Tons.	Manure.*	Labor and Seed.			
Hay,	70	–	–	116.5	$115 88	–	$1,747 50	–	–
Rowen,	–	–	–	15	–	–	225 00	–	–
Corn,	22	–	200	330	154 00	$477 00	1,255 00	$624 00	–
Potatoes,	11½	–	1,958 large 425 small	–	191 19	440 95	966 10	333 96	–
Celery,	2	300†	–	–	78 38	185 02	300 00	36 60	–
Japanese millet,	2	–	125	6½ straw,	–	86 34	300 00	213 66	–
Soy beans,‡	1⅛	–	24	–	18 36	47 24	12 00	–	$53 60
Turnips,	1½	–	425	–	–	37 10	85 00	47 90	–
Carrots,	½	–	–	10.37	7 99	33 40	51 85	10 46	–
Mangels,	½	–	–	16.32	9 74	24 34	48 97	14 89	–

* One-half value manure; three-fourths value fertilizer. † Dozen bunches, estimated. ‡ Badly injured for seed by early frost.

The manure produced is generally spread about as fast as made. It is almost invariably applied after ploughing, and harrowed in if the season permits. Manure applied in the winter lies upon the surface until spring, when it is lightly ploughed or harrowed in. Fertilizers are for the most part spread broadcast after ploughing, though a small portion for corn and about one-half for potatoes is put in the drills. The kinds and amounts of manures used are shown in the following table: —

Manures and Fertilizers for the Several Crops, per Acre, 1899.

	Old Mowings (30 Acres).	Field Corn (22 Acres).	Japanese Millet (4 Acres).	Oats and Barley (1 Acre).	Mangels ($\frac{1}{2}$ Acre).	Soy Beans ($1\frac{1}{8}$ Acres).	Celery (2 Acres).	Carrots ($\frac{1}{2}$ Acre).	Potatoes ($11\frac{1}{2}$ Acres).
Manure, cords per acre,	-	4	-	-	8	6	8	7	2
Plain superphosphate, pounds per acre,	-	-	-	-	200	250	-	200	300
Dried blood, pounds per acre,	-	-	-	-	-	-	500	-	200
Tankage, pounds per acre,	-	-	-	-	-	150	500	-	-
Muriate of potash, pounds per acre,	100	-	-	-	200	-	-	-	-
High-grade sulfate of potash,	-	-	-	-	-	200	350	150	300
Nitrate of soda,	150	-	-	-	100	-	200	100	200

Live Stock.

Our large herds and flock, as well as the horses, have maintained a high average of health for the year, and the breeding increase has been satisfactory. It will soon be possible to discard all except the very best Dakota cows, their places being taken by their descendants, sired by high-bred dairy bulls of the leading breeds, animals many of which give good promise of superior dairy qualities. The kinds and numbers of the various classes are as follows: —

Horses. — French Coach, 1 stallion, 1 mare and 1 foal; Percheron, 1 stallion; French Coach, half blood, 3 colts; Percheron, three-fourths blood, 2 mares; work horses, 4; total 13.

Neat Cattle. — Jersey, 1 bull, 1 cow and 2 heifers; Guernsey, 1 bull; Ayrshire, 1 cow and 1 heifer; Shorthorn, 1 bull and 1 heifer; Holstein-Friesian, 1 cow and 2 heifers; Dakota and grade, 37 cows; grade heifers, 19; calves, 3; total, 71.

Sheep. — Southdowns, males, 3; breeding ewes, 28; ewe lambs, 17; total, 48.

Swine. — Middle Yorkshire, 1 boar, 4 breeding sows and 28 shoats; Tamworths, 1 boar, 2 breeding sows and 12 pigs; Poland-China, 1 boar, 1 breeding sow, 3 shoats and 4 pigs; Berkshire, 2 breeding sows and 9 pigs; Belted, 1 boar and 1 sow; total, 70.

Improvements.

As has already been indicated, this has, in the main, been a year of routine work. Still, a few improvements of considerable prominence have been made. Most important are the provisions which have been completed whereby our breeding sows and growing pigs may be pastured during the summer. This change in plan has enabled us to maintain our large stock of these animals in better condition and at much less expense than ever before. We find the breeding increase much more satisfactory than when the animals are confined in pens.

This change has rendered necessary the erection of a house for shelter and for feeding in the pasture which lies just west of the "ravine." This house has been substantially constructed, and is 25 by 30 feet in size. The area mainly depended upon for pasture, 3¼ acres, has been inclosed with Page fence, a total of 1,600 feet having been strongly put up for this purpose. Besides this, another much-needed improvement has been provided by the erection of 1,000 feet of Page fence on one side of our sheep pasture.

Other minor improvements include a new service stall, a new system of drains under the horse barn and a new body for the Concord wagon, while repairs to machinery and buildings have been carefully attended to.

Financial Outcome.

The cash receipts for the year for stock and produce sold and labor performed for outside parties have in the aggregate amounted (Dec. 15, 1898, to Dec. 15, 1899) to $8,011.93, and there is still due on sundry accounts $908.79, making a grand aggregate of credit transactions of $8,920.72, which it is believed is the largest in the history of the college farm. The cash received has come from the following sources: milk and cream, $3,269.26; cattle, $669.17; horses, $289.50; swine, $105.31; sheep, $139.10; hay, $535.88; potatoes, $823.08; celery, $388.13; team labor, $781.41; millet seed, $536.99; soy beans, $330.19; and sundries, $143.91.

The cash payments of the year have amounted to $9,675.50, which is about $1,000 less than last year, while the credits are $1,699.95 greater. When it is added that the inventory of this year slightly exceeds that of last, it will be seen that the results of the year are very satisfactory.

In conclusion, let me say that to the members of the farm committee of the board of trustees, who have devoted much time to the affairs of the farm, is due much praise. The interest that has been shown and the suggestions made have been exceedingly helpful and stimulating. To the farm superintendent, Mr. E. A. Jones, with whom the execution of plans and in some measure their suggestion have been left, must be ascribed a lion's share of the credit for the result of the year.

WM. P. BROOKS,
Director, College Farm

AMHERST, Dec. 16, 1899.

GIFTS.

From Massachusetts Society for Promoting Agriculture, one hundred dollars in prizes for Dairy School.

Atherton Clark and Mrs. Frank Stearns of Boston, portrait of Pres. Wm. S. Clark.

A. M. Lyman, Montague, one pair Belted swine.

Baker Manufacturing Company, Racine, Wis., one dozen sheep collars.

J. Montgomery Sears, Southborough, one pair Poland-China swine, one Jersey bull.

Nitrate of Soda Syndicate, New York, five tons nitrate of soda.

German Kali Works, New York, three and one-half tons muriate of potash, two and one-fourth tons high-grade sulfate of potash, one-fourth ton low-grade sulfate of potash.

Solomon Fuller, Danvers, one wheel hand cultivator.

J. J. H. Gregory, Marblehead, collection of seeds from India, seeds from individual plants, — carrots, onions, cabbages, corn, etc.

Peter Henderson & Co., New York, seeds from individual plants, — carrots, cabbages, onions, etc.

Chas. Richardson, new seedling camellia.

Gould Manufacturing Company, Seneca Falls, N. Y., one Kerowater spray pump.

George Cruickshanks, Fitchburg, one fine specimen natural graft.

S. Warner, Hatfield, specimen for museum.

Dr. M. North (M. A. C., '89), Cambridge, specimen for museum.

W. A. Snow & Co., Boston, narrow-channel gutters for stall floor.

Expanding Tread Company, New York, sample of "Rough Rider" horseshoe.

C. S. Dickinson, North Amherst, two specimens for museum.

A. C. Wilson (M. A. C., 1901), Boston, red fox (adult).

From W. H. Armstrong (M. A. C., '99), Cambridge, red fox (young).

Wm. P. Brooks (M. A. C., '75), Amherst, weasel.

E. L. Macomber (M. A. C., 1901), Taunton, gray squirrel.

A. M. West (M. A. C., 1900), Brookville, downy woodpecker, red-shouldered hawk, pigeon hawk, meadow lark, two palm warblers, two yellow rumped warblers, ruby crowned kinglet, three American goldfinch, two Phœbe birds, red-winged blackbird, Wilson's thrush, three cowbirds, two white-throated sparrows, three field sparrows, three chipping sparrows, fox sparrow, belted kingfisher.

J. A. Nash, Amherst, hawk.

E. S. Gamwell (M. A. C., 1901), Pittsfield, hawk, two spotted turtles.

James Lewis (M. A. C., 1900), Fairhaven, red-eyed vireo and nest, cowrie shell.

G. F. Parmenter (M. A. C., 1900), Dover, red-tailed hawk, two cowbirds.

Howard Baker (M. A. C., 1900), Dudley, woodcock.

F. H. Brown (M. A. C., 1900), Newton Centre, barn owl.

E. H. Sharpe, Northfield, Cooper's hawk, spread adder, black snake, ring-necked snake, milk snake.

J. B. Knight (M. A. C., '92), Belchertown, white-throated sparrow.

D. A. Beaman (M. A. C., '99), Leverett, flicker.

B. G. Cochrane, Boston, common eel.

Estate of E. Lewis Sturtevant, one hundred and four volumes on subjects pertaining to botany and horticulture.

James H. Webb (M. A. C., '73), New Haven, Conn., twenty volumes, miscellaneous subjects.

Hon. Geo. F. Hoar, Worcester, seven volumes government publications.

E. W. Carpenter and C. F. Morehouse, Amherst, three volumes Amherst Record.

James F. Lewis, Tales of the Malayan Coast.

Chas. S. Plumb (M. A. C., '82), Lafayette, Ind., three volumes Indiana State Dairy Association.

Chas. P. Lounsbury (M. A. C., '94), Cape Town, Africa, reports of government entomologist, Cape of Good Hope.

George E. Stone (M. A. C., '86), Amherst, six volumes Literary Digest.

Wm. H. Caldwell (M. A. C., '87), Peterboro, N. H., Herd Register and Breeder's Journal (Guernsey).

From Sir John B. Lawes, St. Albans, Eng., Rothamsted Memoirs on Agricultural Chemistry, Physiology, etc.

M. L. Ravaz, Effets de la foudre sur la vigne.

Charles Janet, Etudes sur les fourmis, les guêpes et les abeilles.

Machinery loaned for Use in Dairy School.

From Vermont Farm Machine Company, Bellows Falls, Vt., four separators.

DeLaval Separator Company, New York, four separators.

P. M. Sharpless, West Chester, Pa., one separator.

THE GRASS THRIPS.

ANAPHOTHRIPS STRIATA (Osb.).

WARREN E. HINDS, B.S.

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

JANUARY, 1900.

THE GRASS THRIPS.

WARREN E. HINDS, B.S.

Introduction.

The Thysanoptera form a group of insects which, on account of their small size and apparent insignificance, have been much neglected by entomologists. Their position with reference to other groups has accordingly been doubtful, and at various times they have been assigned a place in no less than three different orders. Linnæus considered thrips as having affinities with the Hemiptera, and placed them in a genus immediately following his genus *Coccus*. While some of the followers of Linnæus retained them in this position, others referred them to the Orthoptera and still others to the Pseudoneuroptera. More recently, however, they have been placed in an order by themselves, to which the names Thysanoptera and Physopoda (Physapoda) have been given; but, as the former has priority, it should be adopted.

Although these insects are widely distributed and extremely abundant, being found in profusion in very many flowers, less than one hundred and fifty species have been described, of which about one hundred and twenty are from Europe and less than twenty from the United States. They range in size from one-fiftieth to one-third of an inch in length, the latter size having thus far been found only in Australian species. Undoubtedly the difficulties encountered in studying and accurately interpreting the mouth parts of such small animals have had much to do with the confusion regarding the systematic position of this group of insects.

Their mouth parts (Plate III., figs. 19, 20, 21 and 22) are intermediate in form between those of sucking and of chewing insects, but they probably take their food by suction. The mouth parts and other structures of the head are in part asymmetrical, a fact of considerable interest, as is also the location of the stigmata (Plate I., figs. 1 and 3). These are situated in adults upon the anterior angle of each side of the mesothorax and on each side of the first and eighth abdominal segments. A fourth pair, which is less conspicuous, is found upon the metathorax behind the place of attachment of the hind wings. In the larvæ the abdominal stigmata are found upon the second and eighth segments.

The metamorphosis also is interesting. The larva resembles the adult in form, and has similar mouth parts and food habits. The pupa, however, takes no nourishment, and is enclosed in a transparent skin, which is finally moulted as the insect reaches the adult form. The pupæ of some species possess a slight power of motion, their movements being very sluggish and uncertain ; others are entirely motionless, and appear to have a nearly complete metamorphosis.

The members of this order live in flowers, upon the leaves or under the bark of plants and trees and in turf or fungi. In Australia they are said to form galls upon the leaves of trees, and in our own country they have been frequently reported as inhabiting galls formed by other insects. Several species have long been considered injurious to cultivated plants, especially to cereals. Extensive damage to grass also has been reported from all of the New England States, New York, southern Canada, Ohio, northern Illinois and Iowa. Without doubt the insect causing this damage infests a much larger territory than this, for it is so small that it easily escapes observation, and the damage really done by it is often attributed to other agencies. In order to become familiar with its life history, studies were made upon it at the entomological laboratory of the Massachusetts Agricultural College, under the supervision of Prof. C. H. Fernald, to whom I am much indebted for his able direction and kind encouragement in carrying on this work, the results of which are here given.

History.

In 1875, Prof. J. H. Comstock, in his "Syllabus of a Course of Lectures," mentioned a species of thrips which was doing very great damage to timothy and June grass by working in the upper joints. To this insect, of which he had seen only the larvæ at that time, he gave the name *Limothrips poaphagus;* but he published no description of it previous to the appearance of his "Introduction to Entomology," in 1888.

Five years before this latter date, Prof. Herbert Osborn published, in the "Canadian Entomologist," Vol. XV., page 155, the description of a species of thrips, under the name of *Thrips striata*. The description was made from a single specimen, and the food plant was unknown to Professor Osborn ; but the published description agreed so closely with the "grass thrips" that the two were suspected to be identical. Not knowing whether *Limothrips poaphagus* Comst. and *Thrips striata* Osb. were positively synonymous, I sent some of my specimens to the Division of Entomology at Washington for determination, where they were referred to Mr. Theo. Pergande, one of the highest authorities on this group of insects, who expressed the opinion that the specimens were identical with *Thrips striata* Osb., and placed them in the genus *Anaphothrips* Uzel. This is the only known genus in which some of the species have a distinct oblique suture near the end of the sixth antennal segment. I have made a critical study of the genera in Uzel's "Monographie der Ordnung Thysanoptera," and agree with Mr. Pergande that this insect should be placed in the genus *Anaphothrips*, which is characterized as follows: —

Genus ANAPHOTHRIPS Uzel, Mon. der Ordnung Thys., page 143 (1895).

Ocelli present, body furnished only with short hairs; but there are no long bristles at the end of the abdomen and the hind angles of the prothorax. The antenna has eight segments, both segments of the stylus being moderately long. The species *virgo* has the sixth segment of the antenna broken near the end by an oblique suture, so that the antenna appears to have nine segments. Maxillary palpi with three segments. Prothorax about as long as the head. Legs unarmed. Wings generally present, but the species *virgo* is generally wingless. The cilia in the fringe of the costa of the fore wing are exceedingly short. The bristles on the veins are fine, and generally very short and inconspicuous. The bristles at the end of the abdomen are also very short and fine; but in *virgo* and *sordida* the bristles on the end of the ninth abdominal segment are short and stout. The males generally have two pairs of very short, stout spines on the upper side of the ninth abdominal segment, the anterior pair being much larger than the posterior. The species belonging here have no power to leap.

For the purpose of making a comparative study of the material before me with the types of Professors Comstock and Osborn, Professor Fernald obtained the loan of these types, and I find upon making the comparison that *Limothrips poaphagus* Comst., *Thrips striata* Osb., and the species which I have found in such abundance here in Amherst and upon which I have made the studies given in this paper, are identical; and, as the species was first described by Osborn, his name should hold, and this insect be known by the scientific name of *Anaphothrips striata* (Osb.).

Since Professor Comstock's first mention of the injury done by this species of thrips to June grass and timothy, several economic entomologists have referred to the most conspicuous effects of its work, the dead tops of these grasses, as "silver-top" or "white-top." Many have questioned the agency of thrips in producing this injury, and have ascribed it to some other suctorial insect;

but the majority of writers were inclined to credit thrips with a part, if not all, of this damage. As they had no means of identifying the little pest, they have usually referred to it as the "grass thrips." This name has been very generally used for this species, but not for any other so far as I can learn, and I have therefore adopted it as the common name.

Methods of Study.

It was evident at the beginning of these studies upon the grass thrips that the insects must be brought into the laboratory, where close observations could be made upon individuals through all their stages. For this purpose, large-mouthed, two-ounce bottles were used. In these bottles specimens of the larvæ taken from the stems of "silver-topped June grass" were confined upon the leaves of their usual food plant. The successive stages were observed, and specimens mounted for more critical examination under a compound microscope. In this way generation after generation was followed through the year. It was found that mounts in Canada balsam best preserved the coloration and natural appearance of the insect. The most satisfactory results were obtained by killing and allowing the specimens to stand for a few hours in xylol before mounting in balsam dissolved in xylol. This method, however, does not show the finer details of the external anatomy. For these, the most satisfactory results were obtained by first allowing the specimen to macerate in a ten per cent. solution of potash from twenty-four to thirty-six hours, and then mounting in glycerine. If the natural form of the body is desired, the specimen may be removed from the potash solution and boiled slightly in a drop of glycerine upon a slide. This removes the potash from the interior of the body, and renders it clear. The specimen is then transferred to a cell, with glycerine as the medium.

White zinc cement makes a very satisfactory cell, as it can be built up rapidly, dries quickly, and, if properly finished, is very firm and durable. In mounts made in this way over three years ago the glycerine has had no appreciable effect upon the cement. Zinc cells, however, require a few days to dry before becoming firm enough for use.

Better mounts for use with high-power objectives may be made without a cell. The specimen may be transferred directly from the potash to a small drop of glycerine upon the centre of a slide, and covered with a slip. All surplus glycerine should be carefully boiled out and removed with a small piece of filter paper. This mount should also be finished with a coat of white zinc cement.

Some specimens which were mounted directly in cold glycerine appeared to be very satisfactory at first, but, after standing for some weeks, masses of needle-shaped crystals formed over the exterior of the insect, so as to obscure its outlines and render the mount practically useless. No analysis was made of these crystals, but they may have been phosphates which had been dissolved in the internal juices of the body. The glycerine gradually extracts these juices, and, as the phosphates held by them would be insoluble in glycerine, they immediately formed a crystalline precipitate.

Laboratory results have been verified as far as possible by field observation.

EGG. (*Plate IV., Fig. 29.*)

The females deposit their eggs in the tissue of the leaf, selecting those parts which are fresh and tender, and appear to oviposit as readily during the night as they do in daylight. The process of oviposition is as follows: The female arches her abdomen so as to bring the weight of her body to bear upon the slender four-valved ovipositor (Plate III., fig. 18), which is attached to the ventral side of the eighth and ninth segments (Plate IV., fig. 31). The ovipositor is then slowly worked down through the epidermis of the leaf and into its cell structure, the abdomen being gradually lowered during this operation, though otherwise the insect appears to be perfectly quiet. Then, by successive contractions of the abdomen, the egg is pushed back under the epidermis of the leaf. The complete operation requires about a minute and a half, after which the female usually moves off a short distance and begins feeding. Occasionally the ovipositor becomes so firmly wedged in the leaf as to hold its possessor prisoner for some time, frequently until death results.

The eggs may be readily separated from the tissue of the leaf and mounted for more careful study with the microscope, but care must be taken not to crush or distort them in these operations.

The eggs are reniform, and vary in length from .265 mm. to .33 mm., and in width from .085 mm. to .145 mm. The average dimensions, taken from about twenty-five eggs, are: length, .288 mm.; width, .11 mm. The color is a translucent white. By transmitted light they are seen to be filled with a mass of yolk globules which vary considerably in size.

The hibernated females begin egg laying very soon after the weather becomes sufficiently warm to start the grass. Specimens of these females show from one to eight fully developed eggs within the abdominal cavity. They may live and continue egg laying for four or five weeks. The number of eggs laid by a single hibernated female has not been determined; but, from specimens kept in confinement in the fall, an average of between fifty and sixty was obtained, the highest number recorded being seventy-two.

The length of the egg stage varies much, according to atmospheric conditions. The eggs laid by the hibernated females hatched in from ten to fifteen days, but this period is shortened in the summer generations to from four to seven days.

LARVA. (*Plate I., Fig. 1.*)

As the young larva emerges from the leaf, it works its way up until about four-fifths of its body projects above the surface.

The body is very soft, shiny and nearly white. The eyes are purplish red in color, and the ocelli are wanting in all the larval stages. The antennæ and legs are folded closely against the ventral side of the body, and their outlines and segmentations are very indistinct. The larva remains supported in an upright position by the tip of its abdomen while the body is drying and the legs and antennæ are being separated from the body. After waving these in the air for a short time, the tiny larva falls forward upon its feet and pulls itself entirely free from the tissue of the leaf. It is able to travel immediately, and usually moves a little way from the egg before stopping for a short rest, after which it begins feeding.

The length of the larva very soon after its emergence is about .3 mm., and its width about .1 mm. The body is cylindrical, tapering posteriorly from the eighth abdominal segment. The head is nearly as wide as the thorax. The antennæ are comparatively large, approximate at their base, and composed of seven segments, of which the last four are closely joined and appear almost like a single conical segment. The fourth segment is larger than any other, and is distinctly ringed with whorls of minute setæ, while the second and third are indistinctly ringed. The basal segment bears one small spine on the inner side, the second segment four short spines which are directed forward and one very long spine directed backward toward the head. The third segment bears five short spines, and the terminal part of the fourth and each of the following segments a number of spines which are quite long and stout. The legs are stout, the tarsi one-segmented and terminated by two claws, and the bladder-like expansion of the adult is present. The abdomen is composed of ten segments which are much compressed longitudinally, and, except the tenth segment, are marked with six longitudinal rows of setæ, three pairs to each segment. The four dorsal rows also extend forward along the segments of the thorax and the head. The tenth abdominal segment bears six very long setæ, two dorsal, two lateral and two ventral.

The body of the full-grown larva is fusiform, about 1.2 mm. in length and about .3 mm. in breadth, while the width of the head is about .1 mm. The antennæ (Plate IV., fig. 27) are seven-segmented, somewhat separated at their base and rather thick for their length. Their color is usually darker than that of the body, often nearly black, and the segmentation beyond the fourth segment is more distinct than in the immature larva. The first four segments are nearly equal in thickness, the third and fourth nearly equal in length, and each is as long as the first and second segments together. The last three segments are much smaller, the fifth one being the shortest. The spines are arranged much as in the younger stage. The third segment is distinctly ringed, and without setæ.

Each segment of the body, except the last two, bears setæ, which are short, slightly thickened at their extremities, and are arranged as in the young larva, those of the last two segments being longer and acute. The integument of the body is roughened by transverse rows of clearly defined ridges. The body is marked by dorsal and lateral longitudinal stripes of yellow, which are most distinct upon the thorax, the dorsal stripe being the widest.

Pupa. (*Plate I., Fig. 2.*)

The general form of the young pupa resembles that of the larva. The color of the legs, wing pads and antennæ is a clear white, while the head, thorax and abdomen are very light yellow and the eyes bright red. When the larva first enters the pupal stage the antennæ are apparently three or four segmented, much shortened and directed forward as in the larva, but after a few hours they are laid back upon the head and thorax. The wing sheaths, which are short, are developed outside the body. The legs are rather thick and clumsy, and as the insect advances in the pupal stage its movements become more and more sluggish and uncertain. No food is taken in this stage.

Upon the dorsal side of the ninth abdominal segment, near its posterior margin, are four prominent, stout, recurved, hook-like processes, while the abdominal setæ are slender and acute. In the fully developed pupa, before the final molt, the form of the body more closely resembles that of the imago. The wing sheaths extend backward along the sides of the abdomen to about the sixth or seventh segment, and the fore pair bear a few small spines. The pupal skin is partially separated from the enclosed insect.

The mature larvæ select secluded spots in which to pass the pupal stage. A few may be found transforming within the sheaths of the upper leaves, but the majority go down the stem to the old leaves and sheaths at the base of the stem near the surface of the ground. The duration of the pupal stage varies not only in the two forms of the adult but also at different seasons. In the first generation in the spring it requires from two to three days for the larvæ to transform to the wingless adult form, and from four to five days to the winged adult, but as the weather becomes warmer they transform more rapidly.

Imago. (*Plate I., Figs. 3 and 4.*)

There are two forms of the adult females, one of which possesses wings, while the other has merely the rudiments in the form of short pads. The description of the winged form is as follows: The length varies from 1 to 1.6 mm., the average being about 1.32 mm. and the width of the thorax is about .28 mm. The color is light yellow, with brownish or blackish markings.

The head, which is rounded in front, is marked with transverse striæ and a dusky border posteriorly (Plate IV., fig. 25). The antennæ (Plate IV., fig. 28), composed of eight segments, are approximate, whitish at the base, gradually becoming more dusky toward the apex, where they are nearly black. The sixth segment has an oblique suture toward the terminal end, which gives the antenna the appearance of consisting of nine segments. Segments three to six are distinctly ringed with whorls of small setæ, each segment bearing a number of stout spines, which are most numerous on the last three. Some of these spines are thick and blunt, rounded at the ends and slightly tapering. Unlike the other hairs, they are not brownish, but are thin-walled and transparent. They vary considerably in size and position, the longest one being found upon the inside of the sixth segment. Upon the dorsal side of the third segment and the ventral side of the fourth, two of these spines appear to have united, forming a delicate crescent-shaped appendage, which is attached by a short trunk to a clear, membranous depression near the end of these segments. The function of these structures is not known, but, as they are found only upon the antennæ, they are doubtless organs of sense, and may be called sense cones.

The eyes are large, and of a dark-red color. Three orange-red ocelli are present, arranged in the form of a triangle with the vertex in front, placed near together and well up on the vertex of the head between the eyes. The thorax is of a darker yellow color than the rest of the body, and is marked with elongated dusky patches forming a broken subdorsal stripe on each side, the forward end of which curves outward. The wings (Plate II., figs. 7 and 8) are slender, somewhat sword-shaped in form, unmarked, and each wing is provided with a scale, which is connected by a membrane to the posterior side of the base of the wing. The fore wing has two longitudinal veins, and slight traces of one or two cross veins may sometimes be seen. There is a row of small spines upon the anterior margin and along each longitudinal vein. The hind wing has a single median vein, upon which, near the base, is a pair of rather slender spines directed backward toward the body. Near the base of the costal margin is a row of four or five short spines, hooked at their tips, which in flight engage a membranous fold on the under side of the scale of the fore wing (Plate II., fig. 9), and the surface of both wings is covered with minute setæ. Long fringes occur on both margins of the wings, except on the basal fourth, that on the hind margin of the hind wings being composed of a single row of spiral hairs, while that on the hind margin of the fore wings consists of a double row of spiral hairs.

The legs (Plate III., figs. 23 and 24) are concolorous with the body, and are sparsely set with fine hairs, in addition to which there is a row of five or six stout spines upon the under side of the hind tibiæ. The tarsi (Plate III., figs. 16 and 17) are composed of two segments, the division between them being very oblique. The second segment is terminated by the remarkable bladder-like structure which has suggested the name Physopoda for this order. The bladder cannot always be seen, as it is retracted when the foot is raised in walking and distended when the foot is put down again.

The abdomen consists of ten segments, of which the first seven are dusky on the dorsum, except at the sides, and segment eight has a dusky spot in the centre of the dorsum. The apex of the abdomen is slightly dusky, and surrounded with black spines. The hairs are scattering and fine except on the last two segments, the next to the last segment bearing four short, stout spines near the posterior edge of its dorsal surface.

The wingless female (Plate I., fig. 3) is slightly longer than the winged form, varying in length from 1.1 mm. to 1.65 mm., the average being about 1.47 mm. The description of the winged form applies to this, except that the general color of the body is more yellowish, the dusky markings upon thorax and abdomen are less distinct or wanting, and the dusky posterior border on the head is darker and more prominent. The abdomen is slightly more elongated, which may be due to its distension by eggs rather than to difference in structure. The wing pads are folded back upon the thorax, in which position the fore pads completely cover the hind ones. The fore pads (Plate II., fig. 12) extend nearly to the posterior edge of the thorax, and are marked by longitudinal rows of short, stout spines, which vary in number. These spines are wanting on the hind pads (Plate II., fig. 13), but both pairs are covered with minute setæ.

About 98 per cent. of the adults which pass the winter are of the wingless form, while from 90 to 95 per cent. of the first generation in the spring develop wings; and the wingless form is far outnumbered by the winged until late summer, when the proportion declines, and in October only a small number, about the percentage that hibernates, of winged adults can be found. The females continue to deposit their eggs, and the young larvæ develop and may be taken from the grass upon warm fall days until snow covers the ground; but only the adults survive the winter. I have seen specimens revive after having been exposed to a temperature of 21° below zero. At frequent intervals during the winter I brought in grass from the field taken from beneath snow, or entirely exposed, and in no case did I fail to find females which became lively upon being kept a short time in a warm room. Accidentally I found that these hibernating females could survive for several days though submerged in a weak solution of potassium hydrate, and they have even revived after being frozen solid in a two per cent. solution of potassium hydrate; but, so far as my experiments went, freezing in pure water killed them. The hibernated females become active in the spring as soon as the weather is sufficiently warm to start the grass, and continue to deposit eggs for from four to six weeks. The appearance of a number of winged adults early in May marks the maturity of the first generation; but, as the hibernated females are still active, there can be no distinct line between the generations out of doors after this time. Laboratory experiments show that there may be eight or nine generations in a season. The length of the life cycle varies from thirty days for the first generation to twelve days during the heat of summer.

I have sought in vain for the males of this species, for, although I have mounted over a thousand specimens, have bred many more in bottles in the laboratory, and have taken and examined large numbers of them in the field, I have never seen any that I even suspected were males. A series of experiments, begun in the laboratory July 22, 1898, and continued into December, proved that no males are developed in the fall generations. Experiments were begun this season (1899) by confining hibernating females in bottles before the weather became warm enough for them to move out of doors. These became active and deposited eggs, from which succeeding generations have been bred without the appearance of any males. I conclude, therefore, that this species is parthenogenetic, and reproduces without the intervention of any males, at least for a series of generations, in this locality. The eggs may be seen in the abdomen before being laid, and I have found as many as eight fully developed in a single female.

Feeding Habits.

The adults of this species feed entirely upon the leaves and external parts of the grass. They are very seldom found within the sheath of a leaf, but frequently congregate in numbers within the terminal leaf before it has fully unrolled. They select the fresh, tender parts of the grass, and consequently their work is most apparent upon the upper leaves. The mouth parts (Plate III., figs. 19, 20, 21 and 22) are formed entirely for sucking. The bristle-shaped mandible and the similarly formed lobes of the maxillæ are used to pierce the epidermis of the leaf and the wall of a cell below. As soon as the juices contained in this cell have been extracted, the piercing mouth parts are withdrawn and another cell is punctured, the empty cells presenting a shrunken, whitish appearance. The insects usually feed lengthwise of the leaves, their path being marked by whitish streaks in the tissue of the leaf and by dots of dark excrementitious matter.

The larvæ seek a more protected place in which to feed, and may be found in large numbers within nearly every sheath of June grass (*Poa pratensis*) during the latter part of May and through June. A favorite haunt is in the head, just as it is making its appearance. The minute larvæ work their way down inside the sheath, and some of them, reaching a node where they must stop, continue to feed upon the juices from the very tender stem within until shortly before they enter the pupal stage. The larvæ may be found within any sheath; but it is almost always those that enter the top sheath which cause the "silver-top," as these directly cut off the supply of sap to the head. Examination of affected stems shows that at a point just above the upper node the stem has been sucked dry for about half an inch of its length (Plate I., fig. 6).

While I cannot state positively that this species is ever carnivorous, my observations have led me to suspect that such may sometimes be the case, though normally it is certainly herbivorous. I have seen specimens of this or some other species so closely allied to it as to be indistinguishable to the naked eye, when confined in bottles, carrying around the victims which they had impaled upon their piercing mouth parts, apparently being engaged in sucking the juices from the bodies.

Food Plants.

This minute pest attacks a number of species of grass; but by far the greatest damage is done to June grass (*Poa pratensis*) (Plate I., figs. 5 and 6), few fields of this escaping more or less serious injury. After the first of July, by which time June grass has usually matured, the insect changes to some later species, as timothy (*Phleum pratense*), when this is present. They may be found in abundance upon barn-yard grass (*Panicum crus-galli*) from midsummer till late in the fall. About the middle of July, 1898, I found them quite common upon a field of young corn which was nearly surrounded by grass land, but later in the season they could not be found upon corn. Many other grasses show unmistakable traces of the work of thrips by their whitened heads, and a list of these, with the percentage of "silver-top," estimated on June 29, 1898, is given below; but I cannot positively connect this species with all the injury.

The percentages given were obtained by counting the injured and uninjured heads upon a small area on which the damage appeared to be of average severity. Slight traces of "silver top" are indicated by a dash in the column of percentage.

	Per Cent.		Per Cent.
Poa serotina,	30	*Festuca elatior*,	–
Poa nemoralis,	80	*Festuca ovina*,	95
Poa compressa,	40	*Festuca duriuscola*,	95
Poa arachnifera,	20	*Festuca tenuifolia*,	40
Poa Fletcheri,	10	*Festuca rubra*,	20
Poa aquatica,	35	*Panicum crus-galli*,	–
Poa pratensis,	75	*Panicum sanguinale*,	–
Poa trivialis,	10	*Phleum pratense*,	–
Poa cæsia,	10	*Elymus striatus*,	–
Agrostis alba,	30	*Elymus virginicus*,	–
Agrostis canina,	20	*Bromus erectus*,	–
Agrostis stolonifera,	25	*Bromus inermis*,	–
Agrostis vulgaris,	25	*Avena flavescens-vera*,	–
Festuca Olcoll,	20	*Agropyrum caninum*,	–
Festuca heterophylla,	35	*Arrhenatherum avenaceum*,	–
Festuca pratensis,	–	*Lolium perenne*,	–

Remedies.

A knowledge of the life history of this insect suggests to us a few ways in which it may be most easily combated and its damage lessened. As the females hibernate above ground, burning in early spring must destroy large numbers of them. To be effective, the burning must be close and thorough, and the burned space either quite large or isolated from other infested fields. This must be done before the grass starts, which is usually about the first of April, because the females hibernate very close to the base of the stems, and a close burn after the green blades appear cannot be obtained.

The damage appears to be most severe on worn-out meadows, fields and lawns. This suggests stimulating the plants, to give them additional vigor, and harvesting as early as possible. The June grass should either be cut as soon as the heads begin to turn white, or fed green.

So far as I can learn, the seed of this grass is sold only in lawn mixtures, and is not used for field seeding. The June grass comes in gradually, as the stouter-growing species usually sown run out. Attacks are most severe on fields that have been seeded for several years and have become partially exhausted. This suggests ploughing deeply, and planting for at least one year with some cultivated crop before reseeding.

Literature.

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—— —— Fletcher, Ins. Life, Vol. V., page 124 (1892).
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Explanation of the Lettering of Figures in the Following Plates.

All figures in these plates are drawn from *Anaphothrips striata* (Osb.) except figs. 5 and 6, which show its work.

AF.	Anterior fringe of long straight hairs.
Ant.	Antenna.
BA.	Basal segment of antenna.
BE.	Basal enlargement of the mandible.
Bl.	Bladder terminating the tarsus.
Bs.	Base of stem of *Poa pratensis*, taken from just above the upper node.
C.	Coxa.
CE.	Compound eye.
CL.	Chitinous lever.
CM.	Connective membrane.
CP.	Chitinous plate.
CR.	Chitinous rod, internal.
EG.	Egg groove.
Fa.	Facets of compound eye.
Fe.	Femur.
FL.	Fore leg.
FV.	Fore vein.
FWp.	Fore wing pad.
H.	Head.
HL.	Hind leg.
HV.	Hind vein.
HWp.	Hind wing pad.
L.	Ligule.
LP.	Labial palpi.
LM.	Lobe of the maxilla.
LV.	Left lower valve of the ovipositor.
MF.	Membranous fold near the posterior edge of the scale of the fore wing.
ML.	Middle leg.
MP.	Maxillary palpus.
MS.	Membranous space to which the labial palpi are attached.

Ms.	Mesonotum.
Mt.	Metanotum.
O.	Ocelli.
Op.	Opening in which a muscle is attached to the base of the mandible.
OS.	Oblique suture near the end of the sixth segment.
PF.	Posterior fringe, composed of long, spiral hairs.
Pt.	Prothorax.
R.	Reticulate markings, which are most prominent upon the posterior part of the dorsal surface of the head.
RV.	Right lower valve of the ovipositor.
S.	Stigma.
SC.	Thick, clear sense cones.
Sc.	Scale of wing.
Sp.	Spines upon the veins of the fore wing.
St.	Style of the antenna.
Su.	Suture between the first and second tarsal segments.
Ta.	Tarsus.
TE.	Thickened edge of the ninth abdominal segment.
Th.	Teeth upon the ovipositor.
Ti.	Tibia.
Tr.	Trochanter.
UV.	Tip of right upper valve of the ovipositor.
WE.	Wings extended in position for flight.
WF.	Wings folded at rest.
WS.	Wing sheath.
7.	Seventh abdominal segment.
8.	Eighth abdominal segment.
9.	Ninth abdominal segment.
10.	Tenth abdominal segment.

Explanation of Plate I.

Fig. 1. Full-grown larva. $\frac{62}{1}$.

Fig. 2. Pupa. $\frac{62}{1}$.

Fig. 3. Wingless adult female. $\frac{62}{1}$.

Fig. 4. Winged adult female. $\frac{62}{1}$.

Fig. 5. Head of *Poa pratensis* normally developed. $\frac{1}{2}$.

Fig. 6. Head of *Poa pratensis* arrested in its growth by the attack of *Anaphothrips striata* (Osb), also showing the shrivelled condition of the stem just above the upper node. $\frac{1}{2}$.

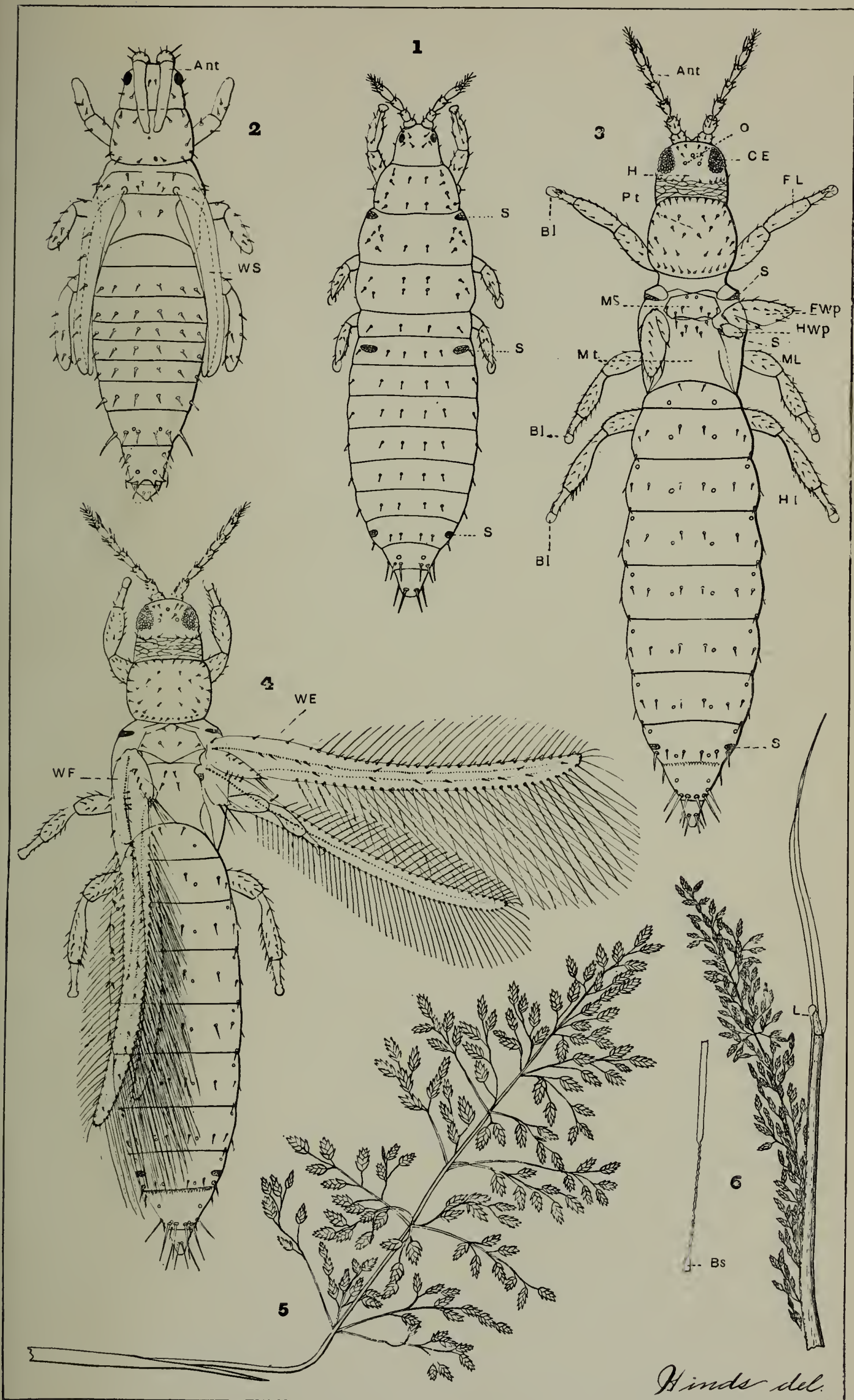
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Plate I.

Explanation of Plate II.

Fig. 7. Right fore wing. $\frac{93}{1}$.
Fig. 8. Right hind wing. $\frac{93}{1}$.
Fig. 9. Bases of wings as joined together during flight. $\frac{162}{1}$.
Fig. 10. Stigma from the second abdominal segment of the larva. $\frac{720}{1}$.
Fig. 11. Stigma from the first abdominal segment of the adult. $\frac{720}{1}$.
Fig. 12. Fore winged pad of wingless female. $\frac{212}{1}$.
Fig. 13. Hind wing pad of wingless female. $\frac{264}{1}$.
Fig. 14. Scale of fore wing, detached. $\frac{212}{1}$.
Fig. 15. Base of hind wing. $\frac{212}{1}$.

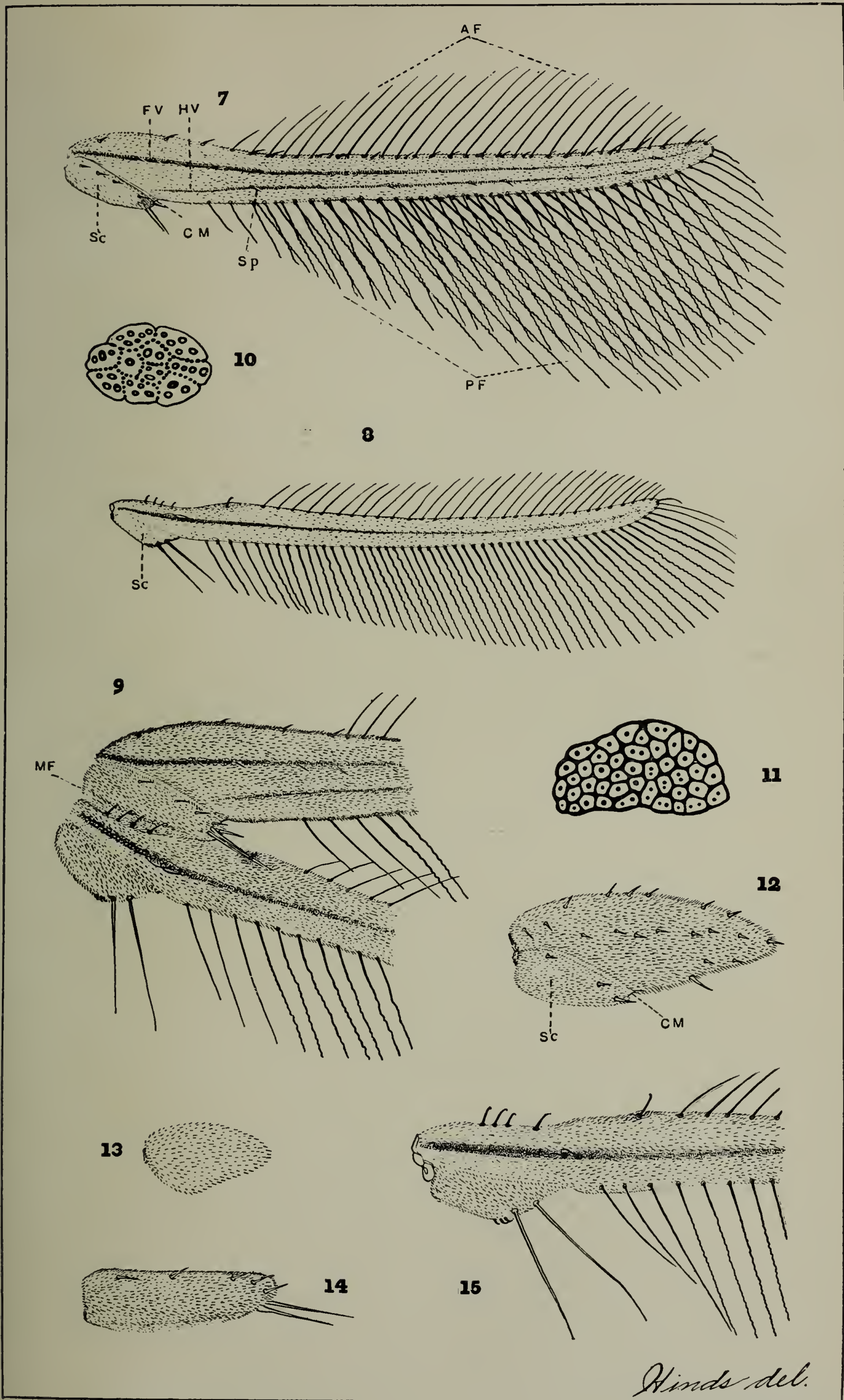

Plate II.

Explanation of Plate III.

Fig. 16. Under side of the tarsus and end of the tibia of the middle leg. $\frac{480}{1}$.

Fig. 17. Side of tarsus and end of tibia of the middle leg. $\frac{480}{1}$.

Fig. 18. Ovipositor. $\frac{370}{1}$.

Fig. 19. Labrum. $\frac{720}{1}$.

Fig. 20. Labium. $\frac{720}{1}$.

Fig. 21. Right maxilla, external view. $\frac{502}{1}$.

Fig. 22. Unpaired mandible. $\frac{720}{1}$.

Fig. 23. Right hind leg. $\frac{212}{1}$.

Fig. 24. Right fore leg. $\frac{212}{1}$.

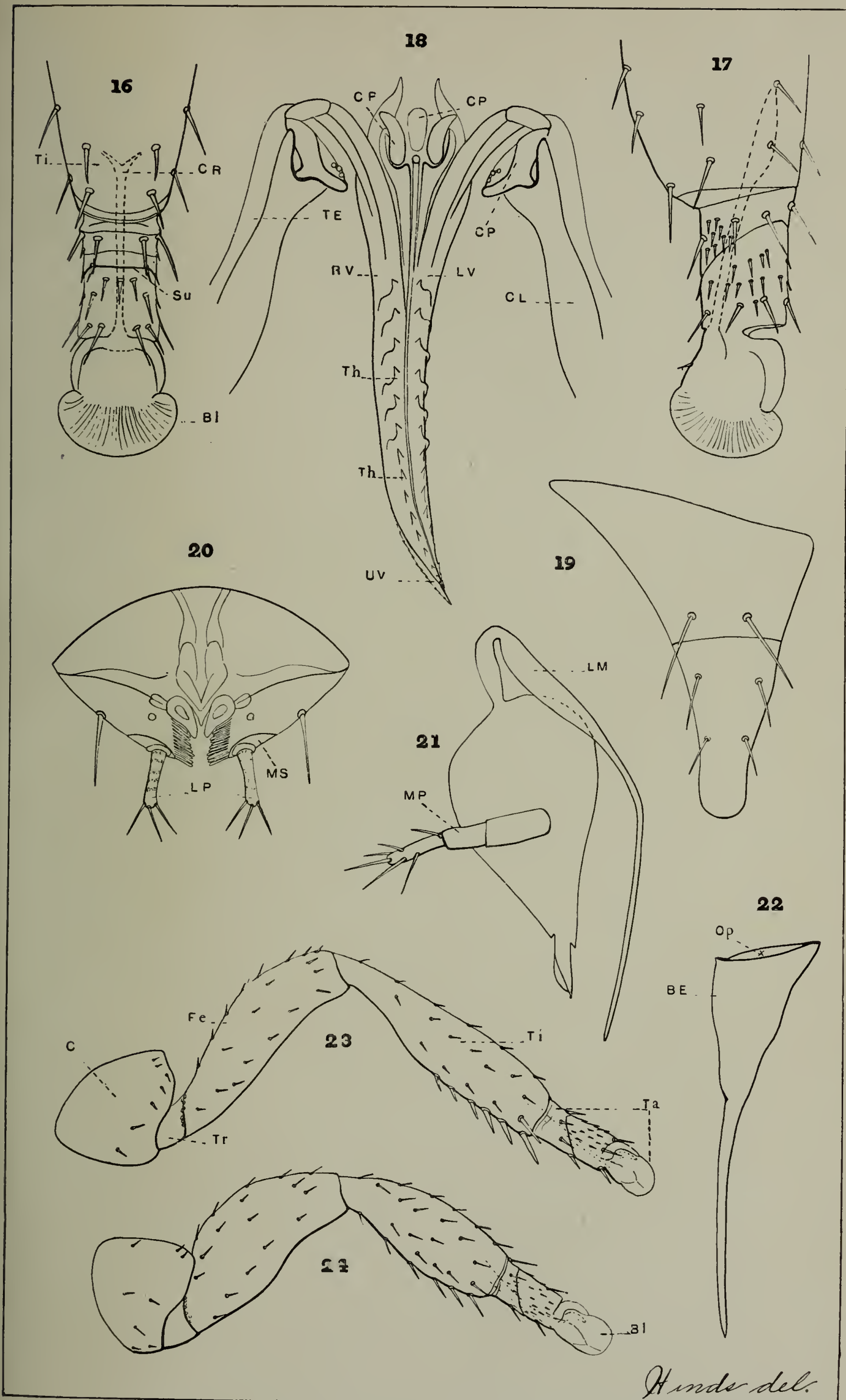
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Plate III.

Explanation of Plate IV.

Fig. 25. Dorsal view of head. $\frac{188}{1}$.

Fig. 26. Left antenna, drawn from the type specimen of *Anaphothrips striata* (Osb.). $\frac{280}{1}$.

Fig. 27. Left antenna of full-grown larva. $\frac{370}{1}$.

Fig. 28. Right antenna of adult female. $\frac{370}{1}$.

Fig. 29. Egg. $\frac{135}{1}$.

Fig. 30. Dorsal view of abdominal segments, 7 to 10. $\frac{145}{1}$.

Fig. 31. Ventral view of abdominal segments, 7 to 10. $\frac{145}{1}$.

Fig. 32. Side view of abdominal segments, 7 to 10, ovipositor hanging down. $\frac{122}{1}$.

Fig. 33. Inside of left lower valve of the ovipositor. $\frac{188}{1}$.

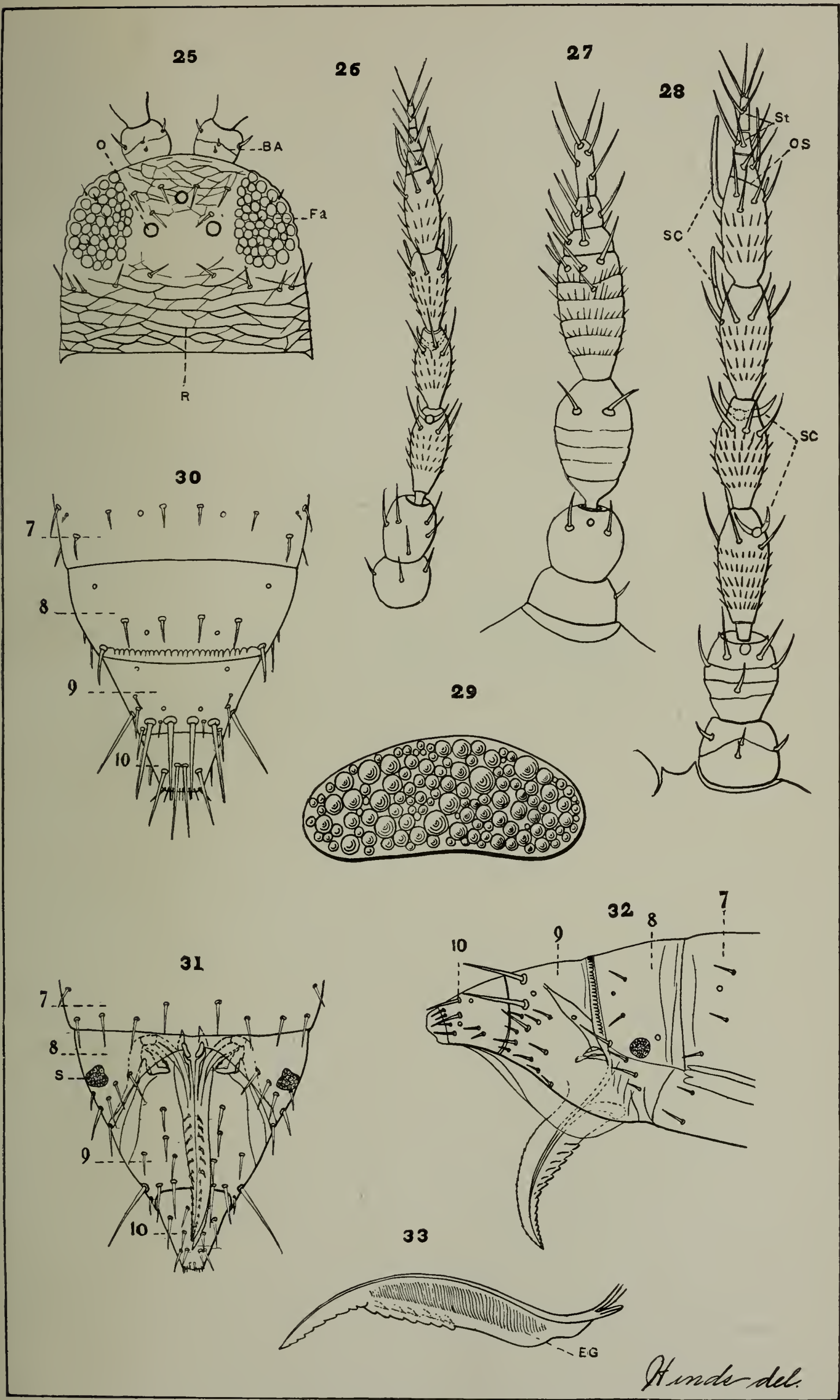
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Plate IV.

TWELFTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1900.

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.*
Henry T. Fernald, Ph.D.,	*Associate 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.*
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. 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. 52. Variety tests of fruits; spraying calendar.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 60. Insecticides; fungicides; spraying calendar.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

The usual variety of problems have presented themselves for solution. In the agricultural division some interesting data have been collected on the use of sulfate and muriate of potash as fertilizers. With the sugar beet the larger yield was secured from the muriate, but the percentage of sugar was greater and the juice was of a higher degree of purity, presenting less difficulties in manufacture, from the sulfate. In sweet and field corn there was no perceptible difference in product, quality or food value, but with cabbages the yield was much greater from the use of the sulfate. In the tests of potatoes the Beauty of Hebron and Early Rose still rank in 94 varieties among the most productive sorts, either for early or late harvests. In feeding poultry a narrow *v.* a wide ration for egg-production, the results seemed to be largely in favor of the wide ration, richer in corn meal and corn, in the following particulars: (*a*) lower cost of feed, (*b*) a gain of 23 to 91 per cent. more eggs, (*c*) a lower cost per egg, (*d*) a greater increase in weight and (*e*) a much earlier moult.

In the meteorological division, besides the usual observation of weather phenomena, the means of the various weather elements for the last ten years have been tabulated, and normal conditions for the period deduced. Observations relating to soil temperature and moisture by electrical methods have been continued, and results from the corn-growing season of the current year have been worked out to serve as basis for comparison in succeeding years.

In the horticultural division, experiments have been carried on in the use of hydrocyanic acid gas under glass as an insecticide, but definite results have not yet been secured.

In the entomological division, the card catalogue to the literature of North American insects now numbers over forty thousand. The inspection of nurseries for the San José scale and the granting of authorized certificates has been added to the work of the division; bulletins on the coccid genera Chionaspis and Hemichionaspis and the grass thrips have been issued, and one on the clover-head beetle and a monograph of the Pyralidæ are ready for publication. The composition of Raupenleim, formerly imported at a high price, has been determined, and it can now be made at a trifling cost.

In the botanical division, interesting observations have been made on the distribution of the asparagus rust in Massachusetts and the relation existing between its outbreaks and the rainfall, together with the physical properties of the soil. There is a marked susceptibility of plants to this disease when grown in soil possessing little water-retaining properties, and a strong relation appears to exist between dry seasons and the occurrence of the summer or injurious stage of the rust.

The chemical division (foods and feeding) has analyzed during the year 2,045 substances, besides carrying on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

The chemical division (fertilizers) has issued 67 licenses to manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals, 38 of whom had offices of general distribution in Massachusetts; 384 samples of fertilizers were collected in the open markets by experienced assistants of the station, and 362 were analyzed and the results published in bulletins.

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, 1899.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,216 31	
for labor,	5,167 16	
for publications,	1,090 45	
for postage and stationery,	242 31	
for freight and express,	122 39	
for heat, light and water,	164 77	
for chemical supplies,	3 45	
for seeds, plants and sundry supplies,	484 58	
for fertilizers,	1,076 40	
for feeding stuffs,	208 55	
for library,	411 65	
for tools, implements and machinery,	718 80	
for furniture and fixtures,	61 45	
for scientific apparatus,	201 90	
for live stock,	95 00	
for traveling expenses,	105 21	
for contingent expenses,	139 25	
for building and repairs,	490 37	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,585 00	
from farm products,	1,641 78	
from miscellaneous sources,	1,906 71	
		$18,333 49
Cash paid for salaries,	$8,127 13	
for labor,	4,275 48	
for publications,	204 00	
for postage and stationery,	211 49	
for freight and express,	162 01	
for heat, light and water,	583 59	
Amount carried forward,	$13,563 70	

Amount brought forward,	$13,563 70	
Cash paid for chemical supplies,	842 90	
for seeds, plants and sundry supplies,	752 76	
for fertilizers,	302 21	
for feeding stuffs,	443 36	
for library,	33 97	
for tools, implements and machinery,	32 75	
for furniture and fixtures,	227 68	
for scientific apparatus,	108 27	
for live stock,	87 22	
for traveling expenses,	272 70	
for contingent expenses,	180 00	
for building and repairs,	1,485 97	
		$18,333 49

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, 1899; 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 $33,333.49, and the corresponding disbursements $33,333.49. All the proper vouchers are on file, and have by me been examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1899.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 11, 1899.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural department of the station has been more extensive during the past year than ever before during its history. Besides the investigations selected for full discussion later in this report, we have carried on a large number of other out-door experiments, among which may be mentioned those having the following objects in view: with potatoes, to determine the best distance for planting; with oats, to determine relative value of equal money's worth of five different phosphates; with corn, to determine relative value of ten leading phosphates when used in quantities furnishing equal amounts of phosphoric acid; with orchard trees, to test the effects of five different systems of manuring; to test the value of employing nitragin for several of the crops of the clover family; to determine the adaptation and value of different grasses, forage and food crops.

We have put up a glass house for use in connection with pot experiments, and have installed a very complete equipment of iron tracks, trucks, pots, etc., for use in such experiments. The house is 23 by 60 feet, and contains six tracks. The track yard adjoining, which is enclosed by fine wire netting, is 28 by 80 feet. It contains seven tracks, on which the trucks carrying the pots stand during good weather, being quickly run into the house in case of rain or storm. It has transfer track, turn-table and an iron water tank. We have partitioned off a room (12 by 30 feet) in the old barn, cemented the floor, and connected the same with the glass house by iron track about 100 feet in length.

This serves as a work room in connection with pot experiments. We have this year carried on experiments with potatoes, onions, soy beans, corn and millet as crops, in which we have used 286 pots. The results are of much value, having assisted toward the solution of a number of important problems; but, as there remains much chemical work to be finished in connection therewith, these experiments cannot be reported at this time. Of the value of this method of experiment, which has so approved itself with European investigators, there can not be the slightest doubt; it will prove a most important adjunct to field work.

We have further carried out a number of experiments in cylinders 4 feet deep and 2 feet in diameter (without bottom), plunged to the rim in the open air and filled with equal amounts of carefully mixed earth. In these experiments we have employed sixty-three such cylinders, dealing with some important problems. This too proves a valuable method of work. Results are not yet sufficiently worked out for publication.

The report will touch in detail only upon experiments the results of which are sufficiently definite to permit practical deductions of value. The report on such experiments follows.

Soil Tests.

Two soil tests have been carried out upon our home grounds during the past season, both in continuation of previous work upon the same ground. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. In addition, each plot in the first test received an application of slaked lime, at the rate of one ton per acre; in the second test, one-half of each plot received an application of lime at the same rate. The lime was spread evenly early this spring, and harrowed in, both fields having been ploughed the previous fall.

Soil Test with Corn. Amherst.

The past is the eleventh 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, corn, 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 having but a single important manurial element, nitrogen, phosphoric acid and potash, — every year the same; three have received each year two of these 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 produced this year an average of 4.6 bushels of shelled corn per acre and 767.5 pounds stover; and even this figure is somewhat misrepresentative, owing to the fact that after this long period two of the nothing plots which adjoin plots which have been yearly well manured begin to feel the effect of the high fertility of their neighbors, although separated from them by strips three and one-half feet wide.

The Effect of the Fertilizers.

The table shows clearly the marked differences undoubtedly due to the variation now eleven years continued in the fertilizer treatment. The fertilizers wherever employed are applied at the following rates per acre; nitrate of soda, 160 pounds (furnishing nitrogen); dissolved bone-black, 320 pounds (furnishing phosphoric acid); muriate of potash, 160 pounds (furnishing potash); land plaster, 160 pounds; lime, 160 pounds; and cow manure, 5 cords. All plots, it must be remembered, received also an application of lime at the rate of 1 ton per acre, in addition to the materials named in the table.

*South Acre Soil Test, 1899.**

Plot.	FERTILIZERS.	Yield per Acre.		Gain or Loss compared with Nothing Plots, per Acre.	
		Shelled Corn † (Bushels).	Stover † (Pounds).	Shelled Corn (Bushels).	Stover (Pounds).
1	Nitrate of soda,	13.75	1,160	9.87	430
2	Dissolved bone-black,	3.50	620	—.38	—110
3	Nothing,	3.88	730	-	-
4	Muriate of potash,	49.75	2,760	45.50	2,000
5	Lime,	7.25	1,100	2.62	310
6	Nothing,	5.00	820	-	-
7	Manure,	75.88	5,350	70.88	4,530
8	Nitrate of soda and dissolved bone-black.	21.38	1,220	15.50	380
9	Nothing,	5.88	840	-	-
10	Nitrate of soda and muriate of potash.	47.88	2,360	42.75	1,573
11	Dissolved bone-black and muriate of potash.	59.88	3,160	55.50	2,427
12	Nothing,	3.63	680	-	-
13	Plaster,	6.63	990	3.00	310
14	Nitrate of soda, dissolved bone-black and muriate of potash.	72.88	4,450	69.25	3,770

* All plots limed at rate of one ton per acre.

† Both stover and ears were driest upon the plots giving the larger yields, viz., 4, 7, 10, 11 and 12, for only on these was growth sufficiently normal to allow natural ripening.

The Results in 1898.

[No lime had been used except on the lime plot.]

For purposes of comparison I here present a statement covering the results of last year (1898), when also the crop, as has been pointed out, was corn. I quote from my last annual report: —

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 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.

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 sulfate 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 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 soil 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 (sulfate 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. . . .

The problems suggested by the results of the year must be

* For example, Plot 6, Field A. See report State Experiment Station for 1896.

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.

Conclusions (based upon Results in 1899).

1. By reference now to the table showing the yields for 1899, it will be seen that what last year was merely a suspicion, supported, it is true, by incidental observations in connection with other experiments, is apparently confirmed by the results of this year after liming, viz.: *that last year the application of potash failed to prove beneficial as in the earlier years when corn was grown, because its continued use in the form of muriate had resulted in depleting the soil of its lime.*

It should be noticed that I say "*apparently* confirmed." I would point out that the results of this experiment by themselves do not furnish absolute proof, for its plan is such that it does not enable us to decide that the superior results of the past season may not have been due to the fact that the lime proved beneficial through indirect effects which might have been exerted equally well by some other alkali, such as an alkaline salt of soda or of magnesia. To determine this point, two series of pot experiments with soil from two plots in this field have been carried out. In these, besides slaked lime, we have employed land plaster (sulfate of lime), carbonate and sulfate of magnesia, and bicarbonate and sulfate of soda. The results are not fully worked up, but they decisively indicate: (*a*) *That the benefit from the use of lime was not due to the fact that it corrected soil acidity.* (Sulfate of lime, a neutral salt, produced a better growth than slaked lime, while neither the carbonate of magnesia nor the carbonate of soda proved distinctly beneficial; the latter, indeed, was highly injurious.) (*b*) That it was not due to indirect action of any other sort. (Substances exercising similar chemical and physical influence upon the soil did not prove equally beneficial with the plaster or the slaked lime.)

2. The yield of each of the plots which has been manured with muriate of potash is largely increased. Alone and in

every combination it proves highly beneficial. *That this soil after eleven years' continuous application of muriate of potash at the rate of 160 pounds per acre annually should be capable after liming of producing corn at the rate of 49.75 bushels of shelled grain per acre, is astonishing.*

3. The crop, amounting to almost 60 bushels shelled corn per acre, on the plot which now for eleven years has yearly received only dissolved bone-black and muriate of potash (lime this year of course excepted) and which in this long period of time has received no addition of nitrogen in the form of manure or fertilizers, illustrates the remarkable extent to which, in our climate, the corn plant can thrive upon the natural stores of this element in the soil and that which it accumulates as a result of the introduction of clover into the rotation.

4. It will be noticed that where the elements nitrogen, phosphoric acid and potash have been yearly supplied, the crop this year, amounting to about 73 bushels per acre, is within three bushels of that produced where manure at the rate of 5 cords per acre has been annually applied. The fertilizers used (nitrate of soda, 160 pounds; dissolved bone-black, 320 pounds; and muriate of potash, 160 pounds per acre) cost about $10; while the manure, if purchased, would cost $25 at least in most parts of the State. It should be pointed out, however, that this soil has almost perfect physical characteristics. On the one hand, its perfect drainage insures freedom from excessive moisture even in wet seasons; and, on the other, the happy mean existing in the proportion of fine and coarse particles insures good water-conducting power (capillarity), and thus prevents injury from drought and injurious crust formation. In such a soil the organic matter furnished by manure is far less necessary than in those which are either more sandy or more clayey. For these reasons, fertilizers have doubtless made a more favorable showing as compared with manure than would usually be the case. The table shows the relative standing of the two plots, 7 (manure) and 14 (complete fertilizer), for the entire period of eleven years. It will be seen that the financial outcome where the fertilizer has been used is much better than for the plot receiving manure.

Increases as compared with Plot receiving no Manure.

Produced by Complete Fertilizer, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn, ...	5	198.05	stover, 12,475	$107 29	$48 00
Oats, ...	1	15.63	straw, 1,720	14 70	9 60
Rye, ...	1	15.36	straw, 2,480	12 10	9 60
Soy beans, ...	1	–	beans, 880; straw, 840	4 61	9 60
Grass, ...	2	–	hay, 3,420; rowen, 1,360	37 56	19 20
Mustard, ...	1	–	5,100	–	19 20*
				$176 20	$115 20

Produced by Manure, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn, ...	5	216.08	stover, 13,990	$117 79	$125 00
Oats, ...	1	18.13	straw, 3,260	22 11	25 00
Rye, ...	1	21.07	straw, 3,200	31 84	25 00
Soy beans, ...	1	–	beans, 1,520; straw, 3,880	77 26	25 00
Grass, ...	2	–	hay, 4,860; rowen, 3,460	64 27	50 00
Mustard, ...	1	–	8,500	–	50 00*
				$313 27	$300 00

* Double application of fertilizers and manure for mustard.

Soil Test with Onions. Amherst.

This experiment occupied a field which has been employed in work of this kind for ten years, the several plots having been every year manured alike, as described under the "Soil test with corn." The previous crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes and onions. The land was ploughed in the fall of 1898 and reploughed early this past spring. Fertilizers were employed this year in the same quantities as last, 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 west half of each plot was limed, as has been stated, at the rate of 1 ton per acre.

The seed was sown in the customary manner, but more thickly, on April 28. Germination was prompt and perfect.

The development upon the several plots and upon the unlimed and limed sections of all the plots exhibited the most remarkable differences.

1. Many of the plants upon the nothing plots soon died, and those remaining made practically no growth. The limed halves of these plots throughout the first half of the season were even worse in these respects than the unlimed.

2. The application of no single element without lime gave a good growth; but the plants upon the dissolved bone-black (without lime) did best. With lime the growth was more feeble than without it on the dissolved bone-black plot. On the plot on which muriate of potash was used without lime most of the plants soon died, while on this fertilizer alone and lime there was a rank growth, though few ripe bulbs were harvested. Nitrate of soda with lime gave better growth than without, but both with and without growth was very feeble.

3. On nitrate of soda and muriate of potash without lime almost all plants died; with lime there was a rank growth; but the bulbs did not ripen well.

4. On nitrate of soda and dissolved bone-black without lime was the best growth on the unlimed portion of the field. As last year, the development upon these two fertilizers alone was much better than on the plot where they were employed in the same amounts with muriate of potash. The growth upon the limed portion of the plot receiving the nitrate and bone-black was not materially improved, while where the muriate of potash was used with these fertilizers liming influenced the growth most favorably.

5. Liming proved highly favorable on the plot where dissolved bone-black and muriate of potash were used, this portion of that plot ranking third in the field in appearance throughout the season, while there was little growth upon the unlimed portion.

The Effect of the Fertilizers.

The tables give the results of the harvest: —

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Pounds, including Tops.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed.	Limed.	Unlimed.	Limed.
Plot 1,	Nothing,	2,950	3,180	-	-
Plot 2,	Nitrate of soda,	4,470	9,700	356.67	5,046.67
Plot 3,	Dissolved bone-black,	2,950	2,570	—2,323.33	—2,836.67
Plot 4,	Nothing,	6,440	6,520	-	-
Plot 5,	Muriate of potash,	3,270	24,740	—2,510	18,467.50
Plot 6,	Nitrate of soda and dissolved bone-black.	17,410	17,380	12,290	11,355
Plot 7,	Nitrate of soda and muriate of potash.	1,440	25,030	—3,020	19,252.50
Plot 8,	Nothing,	3,800	5,530	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	11,090	19,510	7,680	13,815
Plot 10,	Nitrate of soda, dissolved bone-black and muriate of potash.	13,770	22,730	10,750	16,870
Plot 11,	Plaster,	1,550	1,610	—1,080	—4,415
Plot 12,	Nothing,	2,240	6,190	-	-

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Bushels of 52 Pounds of fairly cured Onions.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed.	Limed.	Unlimed.	Limed.
Plot 1,	Nothing,	2.69	4.42	-	-
Plot 2,	Nitrate of soda,	18.65	91.43	15.13	79.77
Plot 3,	Dissolved bone-black,	6.53	12.31	2.17	—6.60
Plot 4,	Nothing,	5.19	26.15	-	-
Plot 5,	Muriate of potash,	3.07	161.75	—1.54	137.90
Plot 6,	Nitrate of soda and dissolved bone-black.	143.10	200.00	139.06	178.46
Plot 7,	Nitrate of soda and muriate of potash.	3.07	145.40	—.39	121.55
Plot 8,	Nothing,	2.88	16.93	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	40.38	183.88	37.21	163.50
Plot 10,	Nitrate of soda, dissolved bone black and muriate of potash.	46.15	224.60	42.69	200.94
Plot 11,	Plaster,	4.04	6.35	.29	—20.68
Plot 12,	Nothing,	4.04	30.39	-	-

The Results and Conclusions based thereon in 1898.

In 1898 also the crop upon this field was onions, and it is desirable to present the leading statements and conclusions published that year for the purpose of comparison. The manuring was the same as this year, save that no lime was used. I quote from my last annual report: —

The results show that this [phosphoric acid, — dissolved bone-black] 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.

Conclusions (based upon Results in 1899).

1. A study of the tables giving the results of this year affords convincing presumptive evidence that the continued use of muriate of potash has so depleted this soil of lime that its use for the onion crop is a necessity. The suspicion of last year, just quoted, is apparently confirmed. The results obtained in two series of pot experiments (not yet fully worked up), in which soil from two plots in this field was used, force me, however, to look upon this conclusion as in a measure tentative; for in the pot experiments other alkalies proved almost, if not quite, as beneficial as lime, indicating that the presence of free acid in the soil may have been the cause of the poor growth upon most of the plots of this field. Even this conclusion cannot, however, be looked upon as final, for the substitution of sulfate for the muriate of potash in the pots resulted in good growth without the addition of any alkali. A full discussion of the subject is reserved for some future article.

2. We are meanwhile justified in the statement that both field and pot experiments show that the muriate is an undesirable form in which to apply potash for this crop, though the bad influence of the chlorine which it contains may possibly be neutralized by application of lime.*

3. The remarks of last year may in conclusion be appropriately quoted: —

The Proper Course as regards Potash Supply.

What, then, in view of our 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 sulfate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulfate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, sup-

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* It is believed that the influence of the lime will be even more marked another year. It was applied, it will be remembered, this spring. Its action, as was anticipated, was not sufficiently prompt to prevent much injury to the onions, because of faulty soil conditions in the early part of the season. We have accordingly failed to produce a good yield on any plot this year.

ply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

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 1890–96, and in 1895 a general summary of the results up to that date was 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 was kept in grass two years, and was manured as usual in 1898. It includes four plots, of one-fourth an acre each. The average results while in grass are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): per acre, hay, 5,662 pounds; rowen, 3,218 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): per acre, hay, 4,540 pounds; rowen, 2,633 pounds.

The sod was turned in the autumn of 1898 and was manured this spring, as shown below: —

Plot 1, manure, 1½ cord; weight, 8,825 pounds.
Plot 2, { manure, 1 cord; weight, 5,880 pounds. high-grade sulfate of potash, 40 pounds.
Plot 3, manure, 1½ cord; weight, 8,840 pounds.
Plot 4, { manure, 1 cord; weight, 5,880 pounds. high-grade sulfate of potash, 40 pounds.

The crop this year has been corn (Sibley's Pride of the North), and its development appears to have been normal in all respects. The crop was a heavy one on all plots.

Yield per Plot.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1,	1,331	1,260
Plot 2,	1,331	1,160
Plot 3,	1,341	1,170
Plot 4,	1,355	1,110

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	66.8	4,860
Plots 2 and 4 (manure and potash),	67.2	4,540

It will be noticed that the crops are of practically equal value, — a little more grain on the manure and potash and a little more stover on the larger quantity of manure alone. The manure and potash used cost per acre nearly $7 less than the larger amount of manure used alone.

We have now grown seven corn crops on this field, and the average yields are at the rate per acre for the two manurings : —

Average of Seven Crops.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone,	61.5	4,562
Lesser manure and potash,	56.7	4,168

At prices which have prevailed during the period covered by this experiment the total manurial application where the manure and potash have been used has cost at the rate of $75 per acre less than on the other plots. The manure alone, however, has produced yields excelling the lesser manure and potash for the entire period at rates per acre amounting to: shelled corn, 33.6 bushels; corn stover, 2,758 pounds ; hay, 2,244 pounds ; and rowen, 1,170 pounds. These products would have been worth $46.50. In using the large amount of manure alone, then, one would in effect, allowing the manure to cost $5 per cord on the land, have expended $75 for products worth but little more than one-half that sum.

When, further, we note that at present the lesser manure and potash is producing the larger crop of grain, the superior economy of the system is evident.

"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

The field was kept in grass for two years, the average yields being at the rates per acre : "Special" fertilizer : hay, 2,730 pounds ; rowen, 1,122 ; fertilizer richer in potash : hay, 2,557.5 pounds ; rowen, 1,149 pounds. The "special," it will be seen, gave yearly 172.5 pounds more hay but 27 pounds less rowen than the other fertilizer. The larger nitrogen application accounts for the excess in hay ; the larger potash application to the other plot produces the more rowen. The stand of clover in the field was poor. It is believed that, had it been good, the differences in yield of rowen in favor of the fertilizer richer in potash would have been larger.

The sod was ploughed in the autumn of last year, fertilizers as usual applied and wheel-harrowed in this spring. The crop this year was corn, which made perfectly normal and good growth on all plots and gave a good yield.

Yield of Corn, 1899.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,257.5	1,090
Plot 2 (richer in potash),	1,141.0	1,140
Plot 3 (lesser potash),	1,168.5	1,120
Plot 4 (richer in potash),	1,200.5	1,120

Average Rates per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	60.7	4,420
Plots 2 and 4,	58.5	4,520

The crops this year are almost equal, — the "special" giving a little more than 2 bushels more grain ; the fertilizer, richer in potash, 100 pounds more stover. The former gives somewhat the more valuable and the more profitable crop. The advantage, however, is insignificant, amounting to only 25 cents per acre.

The experiment has now been in progress nine years, and during seven of these years corn has been grown; on all plots five years and on two only of the plots two years. The averages for the seven years are given in the table: —

Average Yield Corn, Seven Years.

	Shelled Grain (Bushels per Acre).	Stover (Pounds per Acre).
"Special" fertilizer,	57.95	3,760
Fertilizer richer in potash,	50.41	4,033

During two years one-half this field was occupied by Japanese millet (*Panicum Italicum*). The average yields per year are shown in the table: —

Averages, Millet, Two Years.

	Millet Seed (Bushels per Acre).	Straw (Pounds per Acre).
"Special" fertilizer,	63.15	3,522
Fertilizer richer in potash,	66.55	3,735

It will be seen, then, that thus far the two systems of manuring stand nearly upon an equality. The fertilizer poorer in potash ("special") has given the more corn and the more hay. The other fertilizer, richer in potash, has given the more corn stover, rowen, millet seed and millet straw. At present the two stand practically equal, as shown by the corn crop of the past season, It is believed that by the frequent introduction of clover (of which we have not yet had a good catch) the fertilizer richer in potash will prove superior to the other.

Sulfate compared with Muriate of Potash for Various Crops. (Field B.)

This experiment has been in progress in its present essential features since 1893. From 1884 to 1889 the odd numbered plots, 11 to 21, were manured yearly at the rate of 200 pounds per acre of muriate of potash, while the even numbered plots received no potash. From 1889 to 1892 all plots were manured alike. Since 1892 each plot has received yearly bone meal at the rate of 600 pounds per acre, the odd numbered plots muriate of potash at the rate of 400 pounds, and the even numbered plots high-grade sulfate of potash at the same rate per acre. There are eleven plots, numbered 11 to 21. These plots have been used for a wide variety of crops during the seven years that the experiment has been continued. The crops during the past year have been sugar beets, sweet corn, cabbages, field corn and soy beans.

Sugar Beets (Sulfate v. Muriate of Potash).

Sugar beets of four varieties occupied plots 15 and 16. The yield on 15 (muriate of potash) amounted to 3,815 pounds (14.3 tons) per acre; the yield on 16 (sulfate of potash) amounted to 3,708 pounds (13.9 tons) per acre. Each variety was sampled and the value of the beets for sugar manufacture determined. With one exception the beets grown on the sulfate of potash showed considerably higher percentages of sugar and a juice of a higher degree of purity than those grown on the muriate. Though the latter gave a slightly higher yield, the sulfate produced more sugar and a juice offering less difficulties in manufacture. In the case of the one variety where the muriate gave the richer beet, it is believed that this was due to the fact that the sulfate beets selected for analysis were considerably larger than the others. The differences in quality between the beets grown on the two salts were not sufficiently great to materially affect their value for stock feeding.

Sweet Corn (Sulfate v. Muriate of Potash).

This crop (Moore's Concord) occupied plots 11 and 12. Our objects were: first, to study the effect of the two forms of potash on yield; second, to determine whether there was any difference in quality between the product of the two plots which would affect its value for the table; and, third, to determine whether there was any well-defined difference in composition of the entire plant (stalk and ear) which would affect the value for stock feeding.

1. *Product.* — The details concerning product are shown in the table: —

Sweet Corn.

	Weight of Entire Crop (Pounds).	Number of Ears.		Total Ears (Pounds).	Weight of Stover (Pounds).
		Large.	Small.		
Muriate of potash, . .	4,965	1,411	335	929.69	4,035.31
Sulfate of potash, . .	4,965	1,574	377	1,034.36	3,930.64

In the judgment of the men handling the crop, the plants stood slightly thicker on plot 12 than on plot 11, and it is likely that this accounts in large measure, if not entirely, for the greater number of ears on plot 12. It will be noticed that the total product was the same on the two plots.

2. *Quality for Table Use.* — Chemical examination of kernels of corn from the two plots showed no difference which can be regarded as significant; in fact, the differences are probably within the limits of error. It therefore appears that the chlorine of muriate did not exert the depressing effect on sugar formation that is often noticed with other crops.

3. *The Food Value of the Entire Plant.* — Analyses of the product of the two plots revealed no differences in composition which would materially affect the feeding value.

Field Corn (Eureka for the Silo) (Sulfate v. Muriate of Potash).

This crop occupied plots 19 and 20, and on both made a fine growth, averaging 15 feet in height. The ears were small and in the milk when the crop was ensiled, September 28. The yields (obtained by weighing after partial wilting) were: —

Muriate plot, 6,145 pounds, at rate of 23 tons per acre.
Sulfate plot, 5,675 pounds, at rate of 21.2 tons per acre.

Feeding Value. — The crop from both plots was sampled for analysis. The results showed no important differences in the feeding value of the product on the two salts.

Maercker* has quoted Moser to the effect that corn raised on muriate of potash contains more protein, and therefore has a higher food value, than when grown on sulfate. Three experiments here, one in 1898 and the two this year, have not shown this to be the case. It would appear that the muriate of potash is equally as good for the corn crop as the sulfate.

Soy Beans (*Sulfate v. Muriate of Potash*).

Through accident the product of the soy bean plots was mixed; and I can only report that during the early part of the season the beans on the sulfate appeared much better than the others. Later this apparent superiority was lost in large measure, as judged after careful examination.

Cabbages (*Sulfate v. Muriate of Potash*).

This crop (Warren cabbage) occupied plots 13 and 14. The growth on the sulfate of potash was from the start much better than on the muriate, and this superiority was maintained throughout the season. The yield is shown in the table: —

	Number of Hard Heads, November 2.	Total Weight (Pounds).		Loose Leaves (Pounds).
		Hard Heads.	Soft Heads.	
Muriate of potash,	393	4,105	720	750
Sulfate of potash,	502	5,475	255	1,060

It will be noticed that the sulfate of potash plot gave much the larger and more valuable crop. It should be pointed out that, on account of difference of growth due to accidental conditions, the above table has been made to include the yield for only about one-ninth of an acre. The product of plot 14 sold at a price (5 cents per head) which would have made the product of one acre of such cabbages worth about $250, while the product of the other plot was worth only at the rate of about $200 per acre.

* Die Kalidungung, p. 252.

Comparison of Different Potash Salts. (Field G.)

The object in this experiment is to determine the relative manurial value for our various crops of the different prominent potash salts. The experiment was begun in 1898, the crop that year being the soy bean. The results were indecisive and unsatisfactory, the crop where no potash was used in numerous instances being as great as where potash manures were applied. The potash resources of the soil were clearly too large to allow satisfactory deductions to be made. This had, however, been anticipated. From the nature of the problem it was recognized that the experiment must continue for a series of years. We must study not simply the immediate effect upon the crop, but the effect upon the soil of long-continued use of the different salts, — and as well the effect upon the crop of such continued use.

In this experiment the plots are one-fortieth of an acre each, duly separated by dividing strips. There are forty plots, each manuring being five times duplicated. Every plot receives yearly materials estimated to furnish nitrogen and phosphoric acid in liberal amounts. All receive the same materials, save plots 6, 14, 22, 30 and 38, on which the potash salt used is the nitrate, so that the amount of nitrate of soda for these is made only sufficient (.5 pounds) to furnish to these plots the same amount of nitrate nitrogen as to the others. With this exception, the materials applied as sources of nitrogen and phosphoric acid are, per plot: —

	Pounds.
Nitrate of soda,	7.0
Tankage,	7.5
Acid phosphate,	10.0

In order to make certain that there should be no failure through deficiency of lime, the entire field received an application at the rate of one ton to the acre of lime freshly slacked, which was wheel-harrowed in early in the spring of 1898.

The various potash salts where used were applied in amounts intended to furnish an equal quantity of actual potash (K_2O) to each plot, as follows: —

		Pounds.
Plot 1.	No potash.	
Plot 2.	Kainite,	27.75
Plot 3.	High-grade sulfate of potash,	7.50
Plot 4.	Low-grade sulfate of potash,	15.00
Plot 5.	Muriate of potash,	7.50
Plot 6.	Nitrate of potash,	8.25
Plot 7.	Carbonate of potash-magnesia,	20.00
Plot 8.	Silicate of potash,	17.00

Plots 9–16, 17–24, 25–32 and 33–40 are duplicates respectively of plots 1–8.

The crop this year (the second of the experiment) was potatoes, Beauty of Hebron, seed from Maine. It was planted in drills, one set (2–3 eyes) in 14 inches. The tubers were subjected to the formalin treatment, to prevent scab, being soaked two hours in a solution of eight ounces to 15 gallons of water. They were budded in a light room after treatment, before being planted on May 8–9. The crop was well cared for, and sprayed repeatedly with Bordeaux mixture, to prevent blight, of which there was little. The yield was heavy, varying from 297 to 380 bushels of merchantable potatoes per acre on the different potash salts. The results are not entirely conclusive, for the reason that in duplicate plots the yields of the different salts do not occupy the same relative rank. Thus, for example, the various salts made the following relative yields in merchantable tubers : —

Kainite stands : —
1st, once ; 3d, once ; 6th, twice ; and 7th, once.
High-grade sulfate of potash stands : —
1st, twice ; 2d, twice ; and 3d, once.
Low-grade sulfate of potash stands : —
2d, twice ; 3d, once ; 6th, once ; and 7th, once.
Muriate of potash stands : —
1st, once ; 4th, twice ; 5th, once ; and 6th, once.
Nitrate of potash stands : —
Once each : 3d, 4th, 5th, 6th and 7th.
Carbonate of potash-magnesia stands : —
1st, twice ; 3d, twice ; and 5th, once.
Silicate of potash stands : —
4th, twice ; 6th, twice ; and 7th, once.

With such variations in relative standing, it will be agreed we must interpret results with caution. Still, it is believed that the average yield of the different salts should be published as a matter of record: —

Average Yield of Plots.

PLOTS.	POUNDS PER PLOT.		BUSHELS PER ACRE.	
	Large.*	Small.	Large.*	Small.
No potash,	430.70	61.00	287.13	40.66
Kainite,	488.45	52.60	326.83	33.86
High-grade sulfate,	525.70	52.95	350.46	35.49
Low-grade sulfate,	508.20	55.70	338.79	37.13
Muriate,	506.30	61.40	337.53	40.93
Nitrate,	498.20	64.75	332.13	43.16
Carbonate,	518.00	64.80	345.33	43.39
Silicate,	492.40	56.00	328.26	38.39

* Two ounces or over.

Conclusions.

1. It will be noticed that the soil is potash hungry, for every one of the salts used increases the yield.

2. The high-grade sulfate of potash stands first. It has with rare exceptions been found more effective in increasing the yield than the muriate, with which it has been frequently compared, and it gives better quality. We are justified in the conclusion that the application of potash in this form for the potato will give good results. It should be pointed out that our soil is moderately heavy and retentive. On drier sorts the muriate may compare with the sulfate more favorably.

3. The comparatively new carbonate of potash-magnesia ranks second. It is as carbonate that potash exists in wood ashes, which, however, are believed to favor some forms of scab. The fertilizer did not have that effect. This appears to be, then, a very useful form of potash. In mechanical condition it leaves nothing to be desired, being fine and remaining dry under all conditions of weather. The price is at present too high to allow its general use.

4. The low-grade sulfate of potash ranks third; but, as freights cost more per unit of potash for this salt than for the high grade, the latter is generally to be preferred. It is not impossible that in some localities the magnesia of the low-grade sulfate may prove useful; but we have no evidence that such is the case here.

5. The kainite ranks lowest among all the salts employed. Since this, containing only about 13 per cent. of actual potash, can be purchased at a much lower ton price than the purer salts, such as the high-grade sulfate and the muriate, it is sometimes selected by farmers. It should be remembered that the unit of potash on the farm usually costs more in the kainite than in the others. In view of our results, then, I can see no reason for selecting this potash fertilizer.

6. The silicate of potash gives the next lowest crop. It is apparently slowly available. The present cost is high, and it can be kept from caking only by admixture with powdered peat or similar material. It is prepared especially for use on tobacco, for which crop it is under trial in Germany and in this country. I judge it will have no application for ordinary crops; and its usefulness for tobacco is not fully demonstrated, though some favorable results have been obtained.

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, sulfate 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 re-

* 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.

ceived 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), sulfate 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 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 four seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulfate; 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 sulfate of ammonia. The entire field received at the rate of 1 ton per acre of partially air-slacked lime in the spring of 1898, in addition to the usual fertilizers.

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 average in the following order: nitrate of soda, farm-yard manure, dried blood and sulfate of ammonia.

The crop in 1898 was oats. After harvesting them, the land was ploughed and sown to what was supposed to be mammoth red clover in August. The variety appears to be the common red. This went into the winter in excellent condition, but was somewhat winter-killed on all plots, apparently for reasons unconnected with the manures which had been employed. The injury was most severe on plots 0, 5 and 8, and least on plot 5. Between the other plots there was little difference in the degree of injury, if we except plot 6, on which it was greater than on the others. Seed was sown on the surface this spring where needed. This germinated well, but the young plants made little growth, on account of the dry weather. Two crops were cut, the first on July 3. The plants at this time had ceased growth, on account of drought. Not all had blossomed, yet the condition must be classed as mature. The yield was seriously decreased by the dry weather. The second crop was cut August 21, being somewhat mixed with annual grasses, but apparently to equal degree in all plots. The hay was secured in good condition, being cured mostly in the cock. The table shows the fertilizer treatment and the yields of the several plots: —

Nitrogen Experiment, — Fertilizers used and Yield of Clover.

Plots.	FERTILIZERS.	Pounds.	Clover Hay (Pounds).	Clover Rowen (Pounds).	Total (Pounds).
Plot 0,	Barn-yard manure, Potash-magnesia sulfate, Dissolved bone-black,	800.0 32.0 18.0	220.0	288.3	508.3
Plot 1,	Nitrate of soda, Potash-magnesia sulfate, Dissolved bone-black,	29.0 48.5 50.0	200.0	243.8	443.8
Plot 2,	Nitrate of soda, Potash-magnesia sulfate, Dissolved bone-black,	29.0 48.5 50.0	220.0	202.6	422.6
Plot 3,	Dried blood, Muriate of potash, Dissolved bone-black,	43.0 25.0 50.0	120.0	225.8	345.8
Plot 4,	Muriate of potash, Dissolved bone-black,	25.0 50.0	140.0	196.8	336.8
Plot 5,	Ammonium sulfate, Potash-magnesia sulfate, Dissolved bone-black,	22.5 48.5 50.0	140.0	202.1	342.1
Plot 6,	Ammonium sulfate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	140.0	235.6	375.6
Plot 7,	Muriate of potash, Dissolved bone-black,	25.0 50.0	180.0	162.9	342.9
Plot 8,	Ammonium sulfate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	200.0	207.5	407.5
Plot 9,	Muriate of potash, Dissolved bone-black,	25.0 50.0	215.0	206.5	421.5
Plot 10,	Dried blood, Potash-magnesia sulfate, Dissolved bone-black,	43.0 48.5 40.0	215.0	241.5	456.5

It is perhaps questionable whether much weight should be attached to the yields at the first cutting, since full development was not reached on account of drought. The rowen gives a better basis for comparison. Studying these figures, we find the following points bearing upon the problem on which the experiment seeks to shed light: —

1. *The various materials furnishing nitrogen rank in the following order: manure, dried blood, nitrate of soda and sulfate of ammonia.*

2. *The plots receiving no nitrogen approach in average yield much more closely to those getting this element than has been the case with any previous crop on this land. This must be regarded as highly significant, for it will be remembered that this field has been under experiment for eleven years, and in all that time these plots have received no nitrogenous manure or fertilizer of any kind. The clover must, it seems evident, have drawn from the air for this element, in which, as is well known, it is especially rich.*

Fertilizers for Garden Crops. (Field C.)

This series of experiments was begun in 1891, and has for its objects to test the relative value for garden crops: (1) of sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen; and (2) of muriate and sulfate as sources of potash. For full details concerning the methods followed and earlier results, reference is made to my eleventh annual report. It should, however, be pointed out here that partially rotted stable manure has been applied in equal amounts to all the plots for the last two years. The amount of such manure used this year was 7,200 pounds per plot. The fertilizers used were as follows: —

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulfate 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,	Sulfate of ammonia,	38
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulfate 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. For purposes of comparison, I quote from my last annual report:—

Conclusions based on Results up to 1897. (Fertilizers Alone.)

The chief conclusions which seemed justified by the results with fertilizers alone are the following:—

1. Sulfate 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 the muriate or the sulfate of potash.

3. The combination of sulfate 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 1899.

The crops on each plot this year included the following: fruiting strawberries, celery (following the strawberries), cabbages, squashes, spinach, lettuce, table beets, onions and freshly set strawberries. Both manure and fertilizers were spread on after ploughing this spring and harrowed in.

Strawberries:—The vines of the fruiting beds were set in the spring of 1898. They all made good growth, but were somewhat winter-killed, apparently because covered rather too heavily. The injury was not very materially different on the different plots, but was judged to have been somewhat most serious on plots 0 and 2 and least on plot 4. Picking began on June 15 and ended on July 12. Plot 0 (manure alone) much exceeded the others in yield of ripe fruit at first, and in aggregate yield was excelled by but two of the plots. The total yields in pounds per plot were as follows: plot 0, 126.6 pounds; plot 1, 94.7 pounds; plot

2, 96.6 pounds; plot 3, 155.1 pounds; plot 4, 172.3 pounds; plot 5, 108.1 pounds; plot 6, 103.3 pounds.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (plot 0),	126.6
Average of manure and muriate of potash (plots 1, 2 and 3),	115.4
Average of manure and sulfate of potash (plots, 4, 5 and 6),	128.8
Average of manure and sulfate of ammonia (plots 1 and 4),	161.9
Average of manure and nitrate of soda (plots 2 and 5),	102.3
Average of manure and dried blood (plots 3 and 6),	129.2

It will be noticed that but two of the combinations of fertilizers used with the manure excel the manure alone, viz., sulfate of ammonia and sulfate of potash, and dried blood and muriate of potash. Nitrate of soda, which we have found the best source of nitrogen for most crops, makes the poorest showing. Between the muriate and sulfate of potash there seems to be no clearly defined difference. These results were doubtless in part determined by the degree of winter injury.

Celery. — This crop followed the strawberries without extra manuring. The share of the stable manure belonging to the fruiting strawberry area was, however, applied when the strawberry vines were turned in. The yields of the several plots in pounds were as follows: plot 0, 720.8; plot 1, 250; plot 2, 550; plot 3, 510; plot 4, 190; plot 5, 585; plot 6, 550.

The average yields in pounds produced by the different fertilizers were: —

Manure alone,	720.8
Manure and muriate of potash (plots 1, 2 and 3),	436.7
Manure and sulfate of potash (plots 4, 5 and 6),.	441.7
Manure and sulfate of ammonia (plots 1 and 4),	220.0
Manure and nitrate of soda (plots 2 and 5),	567.5
Manure and dried blood (plots 3 and 6),	530.0

* To enable the reader to better make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulfate of potash," etc. It should be remembered that dissolved bone-black was applied to all except plot 0, and that every plot except plot 0 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 141.

It will be noted that the manure alone gave much the largest crop.* Discussion as to the effect of the fertilizers, then, hardly seems called for. It is not without interest, however, to note that the crops where sulfate of ammonia was employed were much the smallest in the field. The result last year was similar in this respect.

Hanson Lettuce. — In harvesting this crop the heads of market size were cut from day to day. The total yields per plot in pounds were: plot 0, 83.1; plot 1, 54.75; plot 2, 129.25; plot 3, 150.50; plot 4, 88.5; plot 5, 148; plot 6, 122.25.

The average yields in pounds on the different fertilizers were: —

Manure alone (plot 0),	83.1
Manure and muriate of potash (plots 1, 2 and 3),	111.5
Manure and sulfate of potash (plots 4, 5 and 6),	119.6
Manure and sulfate of ammonia (plots 1 and 4),	71.6
Manure and nitrate of soda (plots 2 and 5),	138.6
Manure and dried blood (plots 3 and 6),	136.4

The sulfate of potash proves somewhat superior to the muriate; but the most marked result is the highly unfavorable influence of the sulfate of ammonia. This, as in previous years, in combination with the muriate of potash acts as a plant poison.

Spinach. — This, like the lettuce, was cut from time to time as it became ready for market. The yields in pounds of the several plots were: plot 0, 83.8; plot 1, 3; plot 2, 36.8; plot 3, 46.5; plot 4, 42; plot 5, 75.25; plot 6, 56.5.

The averages on the several fertilizers in pounds were: —

Manure alone (plot 0),	83.8
Manure and muriate of potash (plots 1, 2 and 3),	28.8
Manure and sulfate of potash (plots 4, 5 and 6),	57.9
Manure and sulfate of ammonia (plots 1 and 4),	22.5
Manure and nitrate of soda (plots 2 and 5),	56.0
Manure and dried blood (plots 3 and 6),	51.5

It is noticeable that manure alone produces a considerably larger crop than manure with any combination of fertilizers.

* In explanation of this fact, it should be pointed out that plot 0 previous to 1898 had entirely different manuring and cropping from the other plots. See last annual report. It is not believed that the fertilizers were injurious, as a rule.

The most marked effect is the injurious influence of the sulfate of ammonia.

Onions. — The yields of the several plots are shown in the table : —

PLOTS.	Well-cured Onions (Pounds).	Well-formed Onions, but not cured (Pounds).	Scallions (Pounds).
Plot 0,	1,334.5	26.5	13.0
Plot 1,	214.8	108.5	108.3
Plot 2,	1,174.0	75.0	24.0
Plot 3,	761.5	184.0	157.0
Plot 4,	632.7	248.5	93.0
Plot 5,	1,415.8	81.0	17.0
Plot 6,	929.3	243.8	79.8

The averages on the several fertilizers were : —

	Merchantable (Pounds).	Green (Pounds).	Scallions (Pounds).
Manure alone (plot 0),	1,334.5	26.5	13.0
Manure and muriate of potash (plots 1, 2 and 3),	716.8	122.5	96.4
Manure and sulfate of potash (plots 4, 5 and 6),	992.6	191.1	63.3
Manure and sulfate of ammonia (plots 1 and 4),	423.7	178.5	100.6
Manure and nitrate of soda (plots 2 and 5),	1,294.9	78.0	20.5
Manure and dried blood (plots 3 and 6),	845.4	213.9	118.9

It becomes evident from these figures (1) that none of the fertilizer combinations except one (nitrate of soda and sulfate of potash) benefited the crop, (2) that the sulfate is much superior to the muriate as a source of potash, and (3) that the nitrate of soda is much the best source of nitrogen.

Table Beets. — With this crop the manure alone gave much the best yields, and the several fertilizer combinations failed to produce effects sufficiently marked to warrant discussion. The details, therefore, will not be given.

Cabbages. — But one plot in this crop gave a yield excelling the manure alone, and that was the one receiving, in addition to manure, sulfate of ammonia and muriate of potash. The yields in hard heads in pounds were as follows :

plot 0, 375.1; plot 1, 420; plot 2, 377.5; plot 3, 337.5; plot 4, 347.5; plot 5, 207.5; plot 6, 320.

The averages on the several fertilizers in pounds were: —

	Hard Heads.	Soft Heads.
Manure alone (plot 0), ...	375.1	223.9
Manure and muriate of potash (plots 1, 2 and 3), ...	378.3	29.2
Manure and sulfate of potash (plots 4, 5 and 6), ...	291.7	29.2
Manure and sulfate of ammonia (plots 1 and 4), ...	383.7	12.5
Manure and nitrate of soda (plots 2 and 5), ...	292.5	52.5
Manure and dried blood (plots 3 and 6), ...	328.6	22.5

So far as results justify conclusions, it would seem (1) that the muriate shows itself superior to the sulfate of potash for this crop *when used with stable manure*, and (2) that the sulfate of ammonia is the best source of nitrogen for it. That the sulfate of ammonia should prove the most useful form of nitrogen supply with a crop making most of its growth in the latter part of the season we have before observed.*

In other experiments with cabbages this year, where fertilizers alone were used, the sulfate of potash gave much larger yields than the muriate.† Here this is reversed. I have at present no explanation to offer for this difference.

Squashes. — This crop gave much the best yield on manure alone, and the differences apparently produced by the several fertilizers are not significant. The sulfate gives larger yields than the muriate of potash in every case, while the sulfate of ammonia makes the lowest showing among the fertilizers supplying nitrogen. The details will not be given.

Variety Tests with Potatoes.

The number of varieties tested this year was 94. The seed used was all of our own raising. It was produced under conditions similar in every respect and had been similarly preserved. Of each variety, with a few exceptions later noted, 80 sets were planted at the distance of 1 foot

* See eleventh annual report.

† See page 134.

in drills 3 feet apart. One-half of these were harvested at early market maturity (August 1), the balance at full maturity (September 22–23).

The soil was a medium loam, in mixed grass and clover for the two preceding years. It received an application of farm manure at the rate of about 5 cords per acre on the sod early this spring, and was then ploughed. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulfate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were thoroughly mixed and scattered widely in the open furrow before dropping the seed. The seed potatoes were first washed and then treated in formalin solution (8 ounces to 15 gallons water) for two hours. The tubers were budded in a light room after treatment. The planting was done May 4 and 5. The crop was well cared for, and sprayed six times with Bordeaux mixture, to prevent blight, of which, however, there was considerable. The development was normal, save for the blight; and the yields and quality for the most part good. There was practically no scab.

The tables give data for the earlier and the latter diggings: —

Variety Test Potatoes. Record to Aug. 1, 1899.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.*	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Abundance,	June 23,	July 22,	1/16	148.5	24.3
Acme,	June 23,	July 19,	1/2	244.0	24.3
Algoma,	June 28,	July 22,	1/4	154.5	40.9
American Beauty,	June 17,	July 22,	1/4	200.0	10.6
Arizona,	June 17,	July 18,	1/4	224.3	51.5
Bartlett,	June 28,	July 24,	1/16	181.8	36.4
Beauty of Hebron,	June 19,	July 24,	1/8	260.6	40.9

* Fractions indicate proportion of foliage destroyed.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	YIELD AT RATE PER ACRE. Large, Two Ounces (Bushels).	Small (Bushels).
Burpee's Superior,	June 23,	July 22,	⅛	236.4	39.4
Burr's No. 1,	June 19,	July 22,	¼	262.1	45.5
Cambridge Russet,	June 23,	July 18,	¼	166.7	24.3
Carmen No. 1,	June 19,	July 22,	⅝	295.5	30.3
Champion of the World,	June 19,	July 22,	⅛	206.1	31.8
Clay Rose,	June 17,	July 18,	¼	239.4	39.4
Commercial,	June 28,	July 22,	¼	209.1	12.1
Country Gentleman,	June 19,	July 22,	⅛	251.5	33.3
Dakota Red,	June 30,	July 18,	½	184.9	27.3
Dreer's Standard,	June 23,	July 22,	¼	272.8	21.2
Dutton's Seedling,	June 19,	July 22,	⅛	298.5	36.4
Early Kansas,	June 19,	July 22,	⅛	298.5	33.3
Beauty of Hebron,	June 19,	July 24,	Trace.	287.9	31.8
Early Minnesota,	June 28,	July 18,	⅜	190.9	27.3
Early Roberts,	June 19,	July 22,	⅜	300.0	63.6
Early Rochester,	June 19,	July 22,	⅜	230.3	15.2
Early Rose,	June 19,	July 18,	½	263.6	51.5
Early Sunrise,	June 19,	July 18,	¼	221.2	51.5
Extra Early Vermont,	June 19,	July 15,	⅜	266.7	42.4
Empire State,	June 28,	July 22,	¼	148.5	24.3
Enormous,	June 19,	July 22,	⅛	275.8	9.1
Everett,	June 19,	July 15,	½	207.6	45.5
Fillbasket,	June 17,	July 20,	1/16	223.0	51.5
Garfield,	June 19,	July 22,	⅛	193.9	33.3
German Queen,	June 19,	July 22,	¼	213.7	24.3
Good Times,	July 6,	July 29,	Trace.	151.5	21.2
Governor Rusk,	June 28,	July 20,	⅜	236.4	9.1
Green Mountain,	June 23,	July 24,	⅛	127.3	18.2
Howard,	June 19,	July 24,	⅛	275.8	33.3
Hurst,	June 28,	July 15,	¾	–	–
Mill's Longkeeper,	June 23,	July 20,	¼	–	–
Irish Cobbler,	June 17,	July 20,	⅜	260.6	30.3
Joseph,	July 6,	July 24,	¼*	169.7	28.8
King of the Earliest,	–	July 22,	⅜	265.2	24.3
King of Roses,	June 19,	July 22,	¼	209.1	54.6
Lakeside Champion,	June 19,	July 20,	⅜	245.5	39.4

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Late Puritan, . . .	June 23,	July 24,	1/8	224.3	48.5
Lee's Favorite, . . .	June 19,	July 22,	1/4	278.8	47.0
Leonard Rose, . . .	June 19,	July 20,	1/4	239.4	42.4
Lincoln, ...	June 19,	July 29,	1/8	212.1	37.9
Maule's Thoroughbred, .	June 19,	July 22,	3/16	260.6	48.5
Mayflower, ...	-	July 22,	1/4	124.3	42.4
Mill's Banner, . . .	June 23,	July 29,	Trace.	112.1	15.2
Mill's Prize, ...	June 28,	July 22,	Trace.	154.5	18.2
Money Maker, . . .	June 23,	July 22,	1/8	145.5	12.1
Montana Wonder, . .	June 17,	July 22,	3/8	260.6	33.3
New Satisfaction, . .	June 19,	July 22,	1/4	190.9	18.2
Parker's Market, . . .	June 23,	July 22,	1/2	218.2	30.3
Penn Manor, ...	June 19,	July 22,	3/8	284.9	39.4
Pingree, ...	June 23,	July 22,	1/4	190.9	37.3
Prince Bismark, . . .	June 19,	July 22,	3/8	269.7	21.2
Prize Taker, . . .	June 23,	July 22,	1/2	244.0	25.8
Early Potentate, . . .	-	July 20,	1/2	187.9	30.3
Pride of Michigan, . .	June 19,	July 22,	1/4	209.1	50.0
Prolific Rose, . . .	June 19,	July 22,	1/8	257.6	51.5
Quick Crop, ...	June 19,	July 22,	1/8	221.2	54.6
Reeve's Rose, . . .	June 19,	July 22,	1/8	187.9	36.4
Restaurant, ...	June 23,	July 24,	1/16	212.1	36.4
Rochester Rose, . . .	June 19,	July 22,	1/8	212.1	48.5
Rose of Erin, . . .	June 28,	July 22,	1/4	221.2	9.1
Rose No. 9, ...	June 28,	July 22,	1/8	106.1	53.0
Secretary Wilson, . .	June 19,	July 22,	3/8*	266.7	60.6
Seneca Beauty, . . .	June 19,	July 24,	1/8	209.1	24.3
Sir Walter Raleigh, . .	July 6,	July 29,	Trace.	148.5	21.2
Sir William, ...	June 19,	July 22,	3/8	181.8	21.2
Signal, ...	June 19,	July 22,	3/8	251.5	45.5
Somerset, ...	-	July 22,	1/8	169.7	18.2
State of Maine, . . .	June 19,	July 24,	1/8	221.2	24.3
State of Wisconsin, . .	June 19,	July 22,	1/8	121.2	37.3
Table King, ...	June 23,	July 22,	3/8	230.3	25.8
Thorburn, ...	June 19,	July 24,	1/8	218.2	48.5
Tonhocks, ...	June 23,	July 22,	1/8	248.5	37.9

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Uncle Sam, ...	June 19,	July 22,	¼	293.9	12.1
Vanguard, ...	June 19,	July 22,	⅛	277.6	34.9
Vick's Perfection, . .	June 19,	July 22,	⅛	284.9	39.4
Victory, P. and W., . .	June 19,	July 22,	1/16	278.8	36.4
Vigorosa, ...	June 19,	July 24,	⅛	294.0	40.9
Washington, . . .	June 23,	July 24,	1/16	240.9	28.8
White Elephant, . . .	June 19,	July 29,	1/16	218.2	31.4
White Ohio, ...	June 23,	July 22,	¼	230.3	24.3
White Peachblow, . .	June 23,	July 24,	1/16	125.9	42.4
Wisconsin Beauty, . .	June 19,	July 22,	¼	251.5	25.8
Woodbury's White, . .	June 23,	July 22,	1/16	133.3	31.8
Early Andees, . . .	June 23,	July 22,	¼	-	-
Early Dawn, . . .	June 28,	July 20,	¼	-	-
Salzer's Earliest, . . .	June 28,	July 15,	⅞	-	-
Triumph, ...	June 28,	July 15,	15/16	-	-

Variety Test Potatoes. Final Records.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Abundance, ...	-	Sept. 6,	230.3	21.2
Acme, ...	Aug. 12,	Aug. 14,	230.3	18.2
Algoma, ...	Aug. 12,	Aug. 24,	200.0	42.4
American Beauty, ...	Aug. 12,	Aug. 24,	266.7	12.1
Arizona, ...	Aug. 14,	Aug. 24,	236.4	30.3
Bartlett, ...	-	Sept. 5,	330.0	28.8
Beauty of Hebron, ...	Aug. 24,	Sept. 5,	342.5	48.5
Burpee's Superior, ...	-	Sept. 5,	266.7	30.3
Burr's No. 1, ...	Aug. 12,	Aug. 29,	351.5	36.4
Cambridge Russet, ...	Aug. 12,	Aug. 24,	233.4	22.7
Carmen No. 1, ...	Aug. 12,	Aug. 24,	287.9	36.4
Champion of the World, . . .	Aug. 24,	Sept. 5,	269.7	42.4
Clay Rose, ...	Aug. 20,	Aug. 30,	281.8	33.3

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Commercial,	Aug. 14,	Aug. 30,	197.0	3.0
Country Gentleman,	Aug. 20,	Aug. 30,	315.2	51.5
Dakota Red,	Aug. 19,	Aug. 24,	206.1	18.2
Dreer's Standard,	Aug. 20,	Aug. 30,	312.1	18.2
Dutton's Seedling,	Aug. 20,	Aug. 30,	363.7	60.6
Early Kansas,	Aug. 20,	Aug. 30,	330.3	30.3
Beauty of Hebron,	Aug. 24,	Sept. 5,	393.9	39.4
Early Minnesota,	Aug. 20,	Aug. 30,	278.8	12.1
Early Roberts,	Aug. 12,	Aug. 23,	315.2	54.5
Early Rochester,	Aug. 28,	Aug. 30,	278.8	21.2
Early Rose,	Aug. 20,	Aug. 30,	351.5	66.7
Early Sunrise,	Aug. 20,	Aug. 23,	309.1	75.8
Extra Early Vermont,	Aug. 12,	Aug. 23,	327.3	60.6
Empire State,	Aug. 12,	Aug. 30,	206.1	24.3
Enormous,	Aug. 12,	Aug. 30,	397.0	15.2
Everett,	Aug. 23,	Aug. 30,	215.2	66.7
Fillbasket,	Aug 20,	-	416.2	45.5
Garfield,	Aug. 20,	Aug. 30,	236.4	30.3
German Queen,	-	Aug. 30,	275.8	36.4
Good Times,	-	-	229.1	27.3
Governor Rusk,	Aug. 14,	Aug. 23,	275.8	9.1
Green Mountain,	-	-	242.5	24.3
Howard,	Aug. 12,	Aug. 30,	403.1	51.5
Hurst,*	-	Aug. 8,	193.7	38.2
Mill's Longkeeper,†	-	Sept. 5,	177.6	46.7
Irish Cobbler,	Aug. 12,	-	297.0	45.5
Joseph,	Aug. 12,	Aug. 30,	260.6	30.0
King of the Earliest,	Aug. 12,	Aug. 14,	263.6	51.5
King of the Roses,	-	-	327.3	54.5
Lakeside Champion,	-	Aug. 30,	254.6	45.5
Late Puritan,	Aug. 23,	-	336.4	39.4
Lee's Favorite,	Aug. 14,	Aug. 24,	290.9	66.7
Leonard Rose,	Aug. 22,	Sept. 5,	345.6	57.6
Lincoln,	-	Sept. 5,	357.6	30.3
Maule's Thoroughbred,	Aug. 14,	Sept. 5,	321.2	48.5

* Forty-one hills. † Thirty-nine hills.

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Mayflower,	–	Sept. 5,	218.2	18.3
Mill's Banner,	–	Sept. 5,	272.8	10.6
Mill's Prize,	–	Sept. 5,	290.9	12.1
Money Maker,	–	Sept. 5,	287.9	21.2
Montana Wonder,	Aug. 12,	Aug. 23,	347.0	66.7
New Satisfaction,	Aug. 22,	Sept. 5,	297.0	30.3
Parker's Market,	Aug. 12,	Aug. 23,	234.9	30.3
Penn Manor,	Aug. 12,	Aug. 23,	339.4	60.6
Pingree,	Aug. 20,	Aug. 30,	303.0	24.3
Prince Bismark,	Aug. 12,	Aug. 23,	275.8	60.6
Prize Taker,	Aug. 14,	Sept. 5,	275.8	13.6
Early Potentate,	–	Aug. 23,	230.3	36.4
Pride of Michigan,	Aug. 12,	Aug. 23,	303.0	60.6
Prolific Rose,	Aug. 14,	Aug. 30,	351.5	97.0
Quick Crop,	Aug. 23,	Aug. 30,	309.1	66.7
Reeve's Rose,	Aug. 23,	Sept. 5,	345.5	54.6
Restaurant,	–	Sept. 5,	339.4	78.8
Rochester Rose,	Aug. 14,	Sept. 5,	303.0	72.7
Rose of Erin,	Aug. 14,	Aug. 20,	254.6	6.1
Rose No. 9,	Aug. 23,	Aug. 30,	236.4	34.9
Secretary Wilson,	Aug. 12,	Aug. 23,	290.9	54.6
Seneca Beauty,	–	Sept. 5,	345.5	60.6
Sir Walter Raleigh,	Aug. 23,	Sept. 5,	260.6	18.2
Sir William,	Aug. 14,	Sept. 5,	309.1	30.3
Signal,	–	Aug. 23,	284.9	54.6
Somerset,	–	Sept. 5,	278.8	18.2
State of Maine,	Aug. 23,	Sept. 5,	333.4	27.3
State of Wisconsin,	–	Sept. 5,	272.8	15.2
Table King,	Aug. 23,	Sept. 5,	300.0	27.3
Thorburn,	Aug. 12,	Aug. 24,	357.6	48.5
Tonhocks,	Aug. 23,	Sept. 5,	327.3	57.6
Uncle Sam,	Aug. 23,	Sept. 5,	330.3	36.4
Vanguard,	–	–	381.8	69.7
Vick's Perfection,	Aug. 12,	Aug. 30,	306.1	63.6
Victory, P. and W.,	Aug. 23,	Aug. 30,	321.2	48.5

Variety Test Potatoes, etc. — Concluded.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Vigorosa,	Aug. 23,	Aug. 30,	336.4	48.5
Washington,	Aug. 23,	Sept. 5,	404.6	22.7
White Elephant,	Aug. 23,	Sept. 5,	406.1	63.6
White Ohio,	Aug. 12,	Aug. 14,	272.8	48.5
White Peachblow,	Aug. 14,	Aug. 30,	321.2	60.6
Wisconsin Beauty,	Aug. 12,	Aug. 23,	257.6	48.5
Woodbury's White,	Aug. 23,	Sept. 5,	318.2	33.3
Early Andees,*	Aug. 10,	Aug. 14,	509.1	84.9
Early Dawn,*	Aug. 8,	Aug. 12,	509.1	72.7
Salzers' Earliest,*	-	Aug. 8,	434.4	36.4
Triumph,*	-	Aug. 5,	460.7	72.7

* 20 hills only grown.

Thirty-six varieties produce a yield of 55 pounds or over of large potatoes from forty hills when mature, this yield being at the rate of about 333 bushels per acre. These varieties are the following: Burr's No. 1, 351.5; Dutton's Seedling, 363.7; Beauty of Hebron, 393.9; Early Rose, 351.5; Enormous, 397; Fillbasket, 416.2; Howard, 403.1; Late Puritan, 336.4; Leonard Rose, 345.6; Lincoln, 357.6; Montana Wonder, 347; Penn Manor, 339.4; Prolific Rose, 351.5; Reeve's Rose, 345.5; Restaurant, 339.4; Seneca Beauty, 345.5; State of Maine, 333.4; Thorburn, 357.6; Vanguard, 381.8; Vigorosa, 339.4; Washington, 404.6; White Elephant, 406.1; Early Andees,* 509.1; Early Dawn,* 509.1; Salzer's Earliest,* 434.4; Triumph,* 460.7.

Eleven of these varieties gave at the earlier digging 40 pounds or over of large potatoes, which is at the rate of about 240 bushels per acre. These varieties are: Burr's No. 1, 262.1; Dutton's Seedling, 298.5; Beauty of Hebron, 287.9; Early Rose, 263.6; Enormous, 275.8; Howard, 275.8; Montana Wonder, 260.6; Penn Manor, 284.9; Prolific Rose, 257.6; Vanguard, 277.6; Vigorosa, 294.

* Quantity grown less than 40 sets.

There were besides 19 other varieties giving the same or higher yield at the earlier digging. These varieties are: Carmen No. 1, 295.5; Country Gentleman, 251.5; Dreer's Standard, 272.8; Early Kansas, 298.5; Early Roberts, 300; Early Vermont, 266.7; Irish Cobbler, 260.6; King of the Earliest, 265.2; Lakeside Champion, 245.5; Lee's Favorite, 278.8; Maule's Thoroughbred, 260.6; Prince Bismarck, 269.7; Prize Taker, 244; Secretary Wilson, 266.7; Signal, 251.5; Tonhocks, 248.5; Vick's Perfection, 284.9; Victory, P. and W., 278.8; Wisconsin Beauty, 251.5.

It will be noticed that the old Beauty of Hebron and Early Rose are found in both lists, thus ranking still among the most productive sorts, whether for early or late harvest.

There is surely no lack of good varieties of potatoes to choose from, and between many there can be but little difference in value. A single test does not warrant general conclusions. Good northern-grown seed is in my opinion of more importance than name. It is, however, evident that there are a few varieties on our list which seem unworthy of further trial. Among varieties which have made good yields three or more years may be mentioned: Beauty of Hebron, Dutton's Seedling, Early Rose, Enormous, Fillbasket, Prolific Rose, Restaurant, State of Maine, Thorburn, Vanguard and White Elephant.

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 one-half and four 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 21 and 22.

Plot 1, which this year received barn-yard manure, applied Nov. 16, 1898, gave a yield at the rate of 2.095 tons of hay and 0.5 ton of rowen per acre; plot 2, which received bone and potash, yielded 2.289 tons of hay and 0.479 ton of rowen; plot 3, which received ashes this year, yielded 1.58 tons of hay and 0.33 ton of rowen per acre. The field has now been eleven 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 6,630 pounds per acre. The plots when dressed with manure have averaged 7,027 pounds per acre; when receiving bone and potash, 6,568 pounds per acre; and when receiving wood ashes, 6,294 pounds per acre.

Poultry Experiments.

In experiments completed since our last annual report our attention has been confined exclusively to one point, viz., the comparison of a wide nutritive ration with a narrow ration for egg-production; or, in other words, of a ration in which corn meal and corn were prominent with one in which these feeds were replaced with more nitrogenous foods, such as wheat middlings, wheat and oats. So much greater is the cost of wheat than that of corn, that it seemed desirable to obtain as much evidence bearing upon their relative value for egg-production as possible at an early day. If the latter grain should, on further trial, prove so much superior to wheat as our experiments in 1898 indicated, the knowledge of the fact must prove of enormous value. Accordingly, we reared on the scattered colony plan well-bred pullets of the White Wyandotte, Black Minorca and Barred Plymouth Rock breeds, planning to have two houses (one on each feed) with twenty fowls each of each breed. In introducing purchased cockerels for breeding purposes late in the winter we unfortunately carried contagion, and an obscure form of what is commonly called roup broke out in such aggravated form among the Black Minorcas, that, fearing infection of the fowls in other houses, we killed all the Minorcas. The test with this breed was not, therefore, at all conclusive, and details will not be published. Up to the time the test was closed, however, the corn-fed Minorcas had laid about fifty per cent. more eggs than the others.

General Conditions.

The pullets were first evenly divided into lots of twenty each, being matched in sets of two 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 October 15 and ended April 22. 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. At noon a little millet was 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 at intervals of about two months. Sitters 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 60
Oats,	1 00
Millet,	1 00
Wheat bran,	85
Wheat middlings,	85
Gluten feed,	90
Animal meal,	1 75
Cut clover rowen,	1 50
Cabbage,	25
Corn meal,	90
Corn,	90

Narrow v. Wide Ration for Egg-production.

The experiments were in one sense continuous, as the same fowls were used throughout; but it is deemed best to report the results obtained during the cooler months and those of the warmer months separately, one being denominated the *winter experiment*, the other the *summer experiment*. These experiments have for their object testing the correctness of the generally accepted view that the laying fowl should receive feeds very rich in nitrogenous constituents (*i.e.*, should have rations with a narrow nutritive ratio). During the tests of the past year corn has been much more largely used than in 1898. Then it replaced about one-half of the oats and wheat usually fed at night; this year the fowls on the wide ration received at night only corn. The fowls on both rations have received cut clover and animal meal in equal proportions.

The health of the fowls on both rations has been uniformly good through both the winter and summer experiments. As last year, however, it is found to require the exercise of more care to avoid overfeeding and loss of appetite among the corn-fed hens.

Winter Experiment.

This experiment, as has been earlier stated, began October 25. This was much too early to make possible the showing of a good record for total eggs, since the pullets did not begin to lay to any extent until January. The facts that they had been at large until the experiment began, after which they were closely confined, and that, as will be remembered, November and December were very cold and stormy, perhaps in large measure account for this. All details necessary to a full understanding of the experiments and the results, it is believed, will be found in the tables: —

Foods consumed, Narrow v. Wide Ration, October 25 to April 27.

KIND OF FOOD.	White Wyandotte.		Barred Plymouth Rock	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds).
Wheat,	333.00	–	333.00	–
Oats,	55.00	–	60.00	–
Millet,	57.00	56.00	57.50	58.00
Wheat bran,	42.11	42.00	41.30	42.00
Wheat middlings,	42.11	–	41.30	–
Gluten feed,	42.11	–	41.30	–
Animal meal,	42.11	42.00	41.30	42.00
Cut clover rowen,	40.07	40.00	37.80	40.00
Corn meal,	–	111.00	–	111.00
Corn,	–	408.50	–	436.00
Cabbage,	152.38	145.63	152.63	190.75

Average Weights of the Fowls (Pounds).

DATES.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
October 25,	4.3	4.3	4.9+	4.9
January 3,	4.6+	5.0+	5.1	5.6—
March 17,	4.6—	4.7+	5.4—	5.4+
April 27,	4.5—	4.3—	4.9—	4.9+

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

MONTHS.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
October,	-	6	11	7
November,	1	7	18	44
December,	9	33	38	44
January,	50	193	27	83
February,	159	228	57	194
March,	213	177	121	216
April,	179	199	112	168
	611	843	384	755

Narrow v. Wide Ration for Egg-production, Winter Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (pounds),	604.47	635.97	603.13	661.52
Number of hen days, not including males,	3,560	3,560	3,424	3,554
Number of hen days, including males,	3,622	3,622	3,548	3,678
Gross cost of food,	$9 26	$7 30	$9 25	$7 68
Gross cost of food per egg (cents),	1.50	.90—	2.41	1.02
Gross cost of food per hen day (cents),	.26—	.20+	.26	.21
Number of eggs per hen day,	.17+	.24—	.11+	.21+
Average weight per egg (ounces),	1.91—	1.82+	1.76	2.09
Total weight of eggs (pounds),	72.90	95.90—	48.24	98.62
Dry matter consumed per egg (pounds),	.99—	.75+	1.57	.88
Nutritive ratio,*	1:4.80—	1:6.30	1:4.80	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment remained the same as in the winter, 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 the hens in all the houses the same, and (2) the feeding of cabbages was discontinued. The yards, twelve hundred square feet in area for each house, were kept fresh by frequent use of the cultivator and spade. The health of all the fowls was good throughout this experiment. The tables give all details: —

Foods consumed, Narrow v. Wide Ration, May 1 to September 27.

KIND OF FOOD.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds.)
Wheat,	273	-	237	-
Oats,	59	-	52.5	-
Millet,	10	10	8	11
Wheat bran,	56	49	40	42
Wheat middlings,	56	-	40	-
Gluten feed,	56	-	40	-
Meat meal,	56	49	40	42
Corn meal,	-	129.5	-	111
Corn,	-	368	-	300

Average Weights of the Fowls (Pounds).

DATES.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
April 27,	4.50	4.30 —	4.90 —	4.90
June 2,	4.14 —	4.41 +	4.86	4.80
August 11,	4.28	4.68 +	4.88	4.88
September 27,	4.53	4.79	4.70	4.91

Number of Eggs per Month, Narrow v. Wide Ration, Summer Test.

MONTHS.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
May,	162	181	124	177
June,	140	198	156	217
July,	164	213	140	215
August,	158	213	112	128
September (27 days),	107	110	87	76
	731	915	619	813

Narrow v. Wide Ration for Egg-production, Summer Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (per cent.),	510.41	534.22	412.44	446.35
Number of hen days, not including males,	2,945	2,913	2,400	2,555
Number of hen days, including males,	3,245	3,213	2,573	2,735
Gross cost of food,	$7 50	$5 86	$6 14	$4 91
Gross cost of food per egg (cents),	1.03	.64	1.00	.60
Gross cost of food per hen day (cents),	.23	.18 +	.24	.18
Number of eggs per hen day,	.25 —	.31 +	.26 —	.32 —
Average weight per egg (ounces),	1.88	1.90	1.82	1.77
Total weight of eggs (pounds),	85.89	108.70	70.40	89.94
Dry matter consumed per egg (pounds),	.70	.58	.67	.55
Nutritive ratio,*	1:4.20	1:6.30	1:4.40	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that the results of this year's experiments are in every particular similar to those of the experiments carried out in 1898.

The following are the most essential facts: —

1. The wide (rich in corn) ration appears to be much superior to the narrower ration. In all experiments, both summer and winter, the hens receiving corn have laid many more eggs than those receiving wheat.

2. The differences this year in favor of the wide ration, upon the basis of an equal number of hen days, are as follows: —

White Wyandotte, winter test,	41	per cent.
White Wyandotte, summer test,	24	per cent.
Barred Plymouth Rock, winter test,	91	per cent.
Barred Plymouth Rock, summer test,	23	per cent.
Last year the winter difference was	25	per cent.
Last year the summer difference was	33⅓	per cent.

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 dozen eggs the saving amounted to from 4⅔ to 16¾ cents.

4. The fowls on the wide ration gained more in weight than the others. Although laying many more eggs, they averaged at the end of the summer test nearly one-quarter of a pound each more than the others.

At the close of the summer experiment the fowls were most critically examined by a number of different parties, working independently, and all were unanimous in the conclusion that the corn-fed hens were farther advanced in the moult than the others. In my own opinion, the difference amounted to some two or three weeks in time. The corn-fed hens had shed all their old tail feathers, the others but few; the corn-fed hens had a large share of their new body feathers, the others had not shed the old. It was evident that the corn-fed hens were sure to begin laying again before the cold weather, while it seemed that the others were unlikely to do so. This judgment has been verified, for a small number of the corn-fed hens which were purchased by the writer have already laid one litter of eggs since October 1 and are beginning to lay a second, their plumage having been perfect for many weeks (December 20).

The great importance of an early moult in case hens are to be kept over is recognized by all. It makes all the difference between profit and a probable loss.

Our results with both breeds, both summer and winter, are thus greatly in favor of the ration richer in corn meal and corn. On its side we have: (1) lower cost of feed; (2) from 23 to 91 per cent. more eggs; (3) a far lower cost per egg, making possible a saving of from $4\frac{2}{3}$ to $16\frac{3}{4}$ cents per dozen in the food cost of their production; (4) a greater increase in weight; and (5) a much earlier moult.

It may here be remarked, using the words employed by the writer in a recent article, "that nature is generally a safe guide; 'Biddy,' kept healthy and vigorous, will take corn always in preference to wheat. Man conceived the idea that wheat is better for large egg-production. He has been endeavoring to convince the hen that she doesn't know what is good for her; and now it seems that, after all, her instinct and not his supposedly scientific reasoning has been right."

The writer is aware that under different conditions other results might follow. It is here particularly pointed out that our fowls are given plenty of space and fresh air, and that they are made to scratch vigorously for their whole grain.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The work of this division has gone on steadily during the past year, having been almost entirely along the line of vegetable physiology and pathology. A large amount of correspondence has been carried on, along with the work of investigation. A considerable part of the work has been in connection with the growing of green-house crops, as in past years, lettuce, cucumbers and tomatoes receiving especial attention. The investigations outlined in our last report have been continued, and results obtained which in several cases are nearly ready for publication. The only entirely new subject of importance which has been taken up is that of aster diseases, which is referred to more fully later in this report. A bulletin on "The asparagus rust in Massachusetts" has been issued, containing the results of the investigation of this subject up to 1899. A further consideration of the same subject will be found in the present report.

Aster Diseases.

General complaint has been made of late years in all parts of the country of the trouble in growing asters, and at present more or less complete failure is almost universal. We have therefore commenced an investigation of this subject, with a view to ascertaining the exact nature of the trouble, and what may be done to prevent it. A large number of asters were grown during the past season, and, with the experience already gained, it is planned to grow many more next year, under various conditions which have suggested themselves as bearing on the trouble. Some valuable information has already been obtained, and it is hoped that another season's experience will afford considerable insight into the difficulties which now bid fair to prevent the raising of this popular and valuable flower.

Some Prevalent Diseases of the Year.

The following are some rather uncommon diseases which have been unusually prevalent during the past season: —

The Bacterial Cucumber Wilt.

In our last report we gave an account of a wilting of cucumber leaves, due to purely physiological causes. A disease of the same plant, and having a very similar effect, but caused by bacteria, is well known, and appeared in this vicinity in out-of-door cucumbers this year. In this case the bacteria which cause the trouble develop mostly in the ducts of the stem and leaf petioles, multiplying rapidly, and causing a stoppage of the flow of sap and hence a wilting of the leaves. The organisms can be readily seen, oozing out in little drops from the cut ends of affected parts. Pure cultures may be easily obtained from these drops.

No remedy can be given as yet for this disease, other than the removal and burning of affected plants.

A Geranium Disease.

In our annual report for 1897 we described a leaf-spot disease of the cultivated geranium (Pelargonium), which was thought to be caused by bacteria. It appeared at that time in a very wet season, and seemed more a result of the abnormal conditions than a true disease. The same trouble has been abundant during the past season, however, and appears to be a dangerous enemy to the growth of this plant. It causes small yellow and dead spots in the leaves, so that they fall off, and the plant becomes nearly denuded in the worst cases. Examination showed, as before, that the dead spots are full of bacteria, and no other organisms could be found, the former appearing to be the cause of the disease. Attempts were made to isolate the organisms, but thus far without success; apparently it does not flourish under ordinary culture methods and conditions. Nevertheless, we have here, to all appearances, a genuine bacterial disease.

No remedy can be given for this trouble, beyond good cultivation and the production of vigorous plants. Cases have been seen where affected plants lost most of their leaves and produced a new crop, the latter more or less diseased, but still sufficient to present a fairly good appearance. The use of fungicides has no apparent value in such a case as this.

Muskmelon Failures.

Much complaint has been heard during the past season in this and other States of trouble with muskmelons. In our last report we described a disease of this plant caused by a fungus (*Alternaria*). The disease appeared again this year in the same and other places, and some weeks earlier than before, so that spraying experiments which we had planned were begun too late to be of value. Besides this disease, the common anthracnose (*Colletotrichum lagenarium* (Pass.) E. & H.) has been abundant, and very destructive both on muskmelons and watermelons. We saw one field of watermelons of unusually fine appearance completely ruined by this disease within a week. The stems and fruit were the parts most affected. There is every reason to believe that the Bordeaux mixture can be used with profit in these cases; but our experience this year has shown that if the treatment is not begun by July 1 or earlier, before any sign of disease has appeared, it will be entirely useless.

The Maple Leaf Blight. (Phyllosticta acericola C. & E.)

This disease, which affects several species of maple, has been known for some time, but has been much more abundant than usual during the past season. We have received it on sugar maple from several different parties. Large dead spots are produced in the leaves, which become curled and distorted, losing all beauty. Beyond this the actual injury to the tree is probably in most cases very slight.

The Chrysanthemum Rust.

This disease, which we first reported in 1897, appears to be on the decline in Massachusetts. It has been quite common the past season in various places, but in most cases has caused no apparent damage.

Some Experiments in growing Violets in Sterilized Soil.

Some experiments have been made this last year with violets, for the purpose of determining the relation between the production of flowers and the occurrence of leaf spots in sterilized and unsterilized soil respectively. For this purpose cuttings were made in the spring from mature plants and put into sterilized sand, after which they were transplanted into sterilized soil and removed out of doors, where they remained during the summer. In the fall they were transferred to the house and planted in a bed divided equally into two sections, each of which consisted of garden soil of good quality. One section of the bed was sterilized and the other section was not, and, in addition to this, the latter was inoculated with the parasitic nematode *Heterodera* It should be stated, however, that the nematodes were not abundant enough in the inoculated soil to do any harm, as the bed was inoculated some time previous to setting out the violet plants, and, as no host plants were present, they died, or at least they did not gain any foothold upon the violets. The experiment is therefore largely one between sterilized and unsterilized soils.

Sterilizing the soil alone gives rise to beneficial results in the growth of a crop, a fact which we have already called attention to in Bulletin 55, issued from this station, and various experiments on different crops since has demonstrated the same thing.

Both of the beds were under tolerably equal conditions, at least so far as light and moisture were concerned; but a ventilator made some difference in the growth of a few plants in each section. The total number of plants employed in this experiment was fifty-four, and were of the variety known as the Schœnbrun, which is not especially noted as a flower producer.

The following table shows the results of the experiment: —

Table showing the Monthly Production of Violets in Sterilized and Unsterilized Soil.

DATE.	Number of Blossoms picked.		Percentage of Gain.
	Unsterilized Soil.	Sterilized Soil.	
November,	19	38	100
December,	62	101	63
January,	55	125	127
February,	39	72	84
March,	144	250	73
April,	482	510	5
Total,	801	1,096	-
Average,	133	182	36

The results in the preceding table show a considerable increase in the production of blossoms as a result of sterilizing the soil. The percentage of gain of the sterilized plat over that in the unsterilized was 36. It will be observed also that the gain in flower production in general was most marked during the first half of the experiment, and the flower production falls off in the sterilized earths in the succeeding months, until in April, when the experiment was discontinued, the gain was only 5 per cent. over that of the unsterilized. The maximum occurred during the third month (January), although this might not occur in every instance, as a large number of experiments would probably modify these results.

Observations were made in regard to the number of leaf spots in the two plats, with the result that the sterilized plats gave the smallest number, hence showing that vigorous plants are less susceptible to fungi.

The methods employed in sterilizing the soil were the same as those described on page 54 in Bulletin 55, from this station.

In regard to the practice of sterilizing soil for the purpose of growing plants, we will state that, while there is no doubt as to the beneficial results obtained by sterilizing the same soil for two or three crops, it does not necessarily follow that soil will repeatedly stand this treatment and give good crops.

Within the last year sterilized soil has been recommended for home culture purposes, and those who use it claim to have obtained superior results.

The Relationship existing between the Asparagus Rust and the Physical Properties of the Soil.

The past season has been most favorable to the outbreak of the asparagus rust, which has manifested itself in a severe manner in the same localities where it has occurred during the last few years. The unusually dry spring enabled us to predict to asparagus growers the probable occurrence of the rust for last summer; and, as the rust has usually shown itself the season following an outbreak, regardless of the weather conditions, we may expect to encounter the same next summer (1900), at least in those beds which were badly affected and weakened from the attacks of 1899. We have endeavored to point out in Bulletin 61, issued from this station, the relationship existing between dry seasons and the occurrence of the summer or injurious stage of the rust, and also the susceptibility of plants growing in localities possessing soil with little water-retaining properties. Our observations and experiments during the past season have not led us to reverse any of the conclusions set forth in this bulletin, but, on the other hand, we are more strongly convinced of their validity. These conclusions are based upon an extensive study of the localities affected, and the object of the present article is to call attention to additional data relating to the distribution of the rust in Massachusetts, and the relationship existing between the outbreak of the rust and the rainfall, together with the physical properties of the soil. For the past three seasons we have paid attention to the distribution of the rust in Massachusetts, although the regions infected during the past summer (1899) scarcely differ from those infected during previous years.

Attention was first called to the asparagus rust in the fall of 1896. During 1897, although an extremely wet season, the damage by the rust was severe. Its occurrence during this season, however, was merely an after-effect, the primary cause being due to the injury caused by the preceding dry seasons. In 1898 the summer stage of the rust was scarcely perceptible; while in 1899 (the past season) the rust was severe, on account of the want of soil moisture.* The fall stage of the rust (black or teleuto spore stage), which is, according to our estimation, a harmless stage, and not worth paying much attention to, has been universally distributed over the State since 1896. There has, however, been some tendency for it to become less common during the last two years. This stage usually occurs during September and October, about the time when the asparagus plants first commence to lose their green color and turn yellow, the appearance of this stage being associated with the disintegration and death of the plant. The summer stage of the rust (red or uredo stage), which is in every instance an injurious stage, occurs during July and August. It occurs about July 11, or later, on beds from which a crop has been marketed, and spreads very rapidly with the wind, as is evident by those sides of the asparagus plant being first infected which correspond with the prevailing direction of the wind. We have no data as to any earlier appearance of the rust on young plants which have not been cut for the market, and it would not be at all improbable that they become infected earlier than July 11. The summer stage of the rust, however, is limited in its distribution in Massachusetts, and is found only on those soils which are sandy, and possess little water-retaining properties. The sand increases as we approach the sea-coast, and the soils which support asparagus plants affected with the red rust are found with some local exceptions in the eastern part of the State.

The summer stage of the rust has never been observed by us, nor has it been reported (with one exception, which we will refer to later, and which is local) any further west than the towns of Berlin and Northborough, which are east of the

* The amount of rainfall from April 1 to September 1 in 1899, at Amherst, was 14.09 inches; that for the same period in 1898 was 23.97 inches.

meridian 71° 40′. (See map.) These towns would appear to be on the border zone of the uredo spore outbreak, and the occurrence of the rust here is by no means so universal as it is in the sandier region of Cape Cod. Some of the growers situated upon the border zones of infection may have the summer stage badly one season and the next season be free from it. The soil of this region offers sufficient differences in texture from the more sandy coast soils, so that sound, vigorous plants might be expected to be proof against the rust in any season, and the outbreak here might be largely prevented by careful cultivation and feeding of the plants.

An examination of the map (fig. 1) will show those portions of Massachusetts in which the summer stage of asparagus rust has appeared up to the present time. The only region infested with this stage of the rust in Massachusetts west of the meridian 71° 40′ is in the Connecticut valley, in the vicinity of Montague, where the soil is remarkably sandy and dry, while other portions of the Connecticut valley which possess more or less heavier soil have been entirely free from this stage. The affected area shown on the map is characterized by a loose sandy soil, which possesses less water-retaining properties in most instances than the soils of their immediate vicinity. In order, however, to show more definitely the differences existing between the texture of the soils of the eastern part of the State and those of the central and western parts, we have made a number of mechanical analyses of the soils of various regions, which include many from the infected asparagus fields. Any one who has paid special attention to our Massachusetts soils and their influence upon the development of plants would not require a mechanical analysis in order to become convinced of the differences existing between them, as a glance at the soils in the field would be sufficient. Nevertheless, a mechanical analysis will show us the exact differences existing between the textures of the soil of the various regions, and we will moreover be able to demonstrate the amount of difference exhibited in their water-retaining capacity. The following table gives the data of the mechanical analysis*

* The methods of analysis employed are those of Prof. Milton Whitney.

of ten typical surface soils from various parts of the State between the Cape and the New York State line: —

TABLE I. — *Showing the Mechanical Analyses* of Ten Massachusetts Soils, extending from Cape Cod to Western Massachusetts. — Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in 20 Grams of Soil.*

[Diameter of the grains in millimetres (1 millimetre equals about 1/25 inch): gravel, 2–1; coarse sand, 1–.5; medium sand, .5–.25; fine sand, .25–.1; very fine sand, .1–.05; silt, .05–.01; fine silt, .01–.005; clay, .005–.0001.]

SAMPLE.	Water.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Orleans,	1.82	2.20	20.97	31.03	19.70	12.26	6.26	2.77	1.46	1.37
Bridgewater,	1.86	2.10	17.92	28.80	18.85	5.80	19.15	2.85	1.34	.66
Eastham,	1.66	2.00	9.38	27.91	25.09	21.43	8.70	1.40	.77	1.43
Concord,	1.66	4.19	4.24	10.20	12.81	27.93	34.11	1.84	1.73	1.08
Attleborough,	8.13	7.64	9.26	11.15	7.87	11.53	29.50	10.95	2.51	1.42
Worcester,	3.00	9.40	1.65	2.80	4.25	19.85	42.95	4.50	2.95	2.75
Spencer,	3.40	9.80	2.70	4.55	7.30	22.35	29.60	6.65	2.45	3.25
Montague,	.90	1.86	.27	4.39	19.85	43.88	25.75	2.63	.36	.27
Amherst,	2.98	7.31	.95	1.25	1.72	7.28	66.19	6.96	1.33	4.13
Pittsfield,	9.50	11.25	5.50	5.95	5.02	13.87	36.15	6.45	.87	5.40

* Analyzed by A. A. Harmon and Asa S. Kinney.

The first six soils represent typical samples taken from affected fields in locations where the summer stage of the rust has always been present since its occurrence in Massachusetts, and in most instances where it has been severe. The other samples are from towns which have not shown the summer stage of the rust, but in which the fall stage has occurred. All of the samples are so-called surface soils, and represent single analyses. Except in the Amherst soils they represent an average of four analyses, while in the Pittsfield there is an average of two. A careful examination of the table will show considerable difference in the texture of the soils of the various regions. It will be observed that the coarse elements are much more common in the coast soils than in the inland soils, and conversely that the fine elements are greatly increased in the inland soils.

In order to obtain a better idea of the relative amounts of the various constituents found in the different soils, we can arrange them as in Table II., in which the average constituents contained in the four coast soils are shown alongside of four inland soils which are characteristic of the central and western regions of Massachusetts. The four coast soils represent badly infested regions, while the four inland soils represent those in which only the fall stage has occurred.

TABLE II. — *Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in Orleans, Eastham, Concord and Bridgewater (Coast Soils), and Worcester, Spencer, Amherst and Pittsfield (Inland Soils).*

SAMPLE.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Four coast soils, ...	2.62	13.12	24.48	19.11	16.85	16.80	2.21	1.32	1.13
Four inland soils, . . .	9.44	2.70	2.63	4.57	15.83	18.72	6.14	1.90	3.88

The largest amount of gravel as shown by the table is in the Orleans soil from Cape Cod, which is 20.97 per cent.; the average for the whole is 13.12 per cent., against 2.70 per cent. for the inland soils. What holds true in regard to the gravel is also true when we consider the coarse sand, where the proportion is 24.48 per cent. in the coast soil, to 2.63 per cent. in the inland soils; while in the medium sand it is 19.11 per cent. to 4.57 per cent. Only slight differences are shown in the proportion of fine and very fine sand between the two regions, although the coast soils are ahead in the former and the inland in the latter; whereas in both of the silts and clay the largest amounts are found in the inland soils. If we turn to the organic matter, we find that it is also more abundant in the inland soil than it is in the coast soil. This difference is partly accounted for by the fact that some of the samples of inland soil represent highly manured soils, adapted to intensive cultivation. Even making allowances for this fact, the organic matter would seem higher in the inland soils than in the coast soils, inasmuch as various samples of soil taken from inland localities which were not manured gave an average of about 6 per cent., or about three times as much as that shown by the coast soils. This is not true, however, of the coast soils such as are used for general truck farming, — as in the case of Arlington, for example, — in which instance we would find the percentage of organic matter quite large. The amount of water in the soils differs also, which is caused by the analyses of some of the samples being taken at different times, and from not being subject to the same air-drying conditions. It will also be noticed that the Attleborough soil contains an unusually large amount of silt, — a feature which seems to be peculiar to that soil alone. As a rule, the inland soils contain a very large amount of very fine sand, and this appears to be especially characteristic of the Connecticut valley soils. Some analyses which we have made show that this soil sometimes possesses as much as 75 per cent. of this constituent. It is the excessive amounts of this constituent of the soil which renders the Amherst soil compact, and which gives to it an increased water-retaining capacity. The clay, however, shows a gradual increase as we pass inward, and in a less uniform manner is this exhibited by the silt, which can be seen by examining Table III.

TABLE III. — *Showing the Percentage of Gravel-Sand, Silt and Clay in the Soils shown in Table I.*

SAMPLE.	Gravel-Sand.	Silt.	Clay.
Orleans,	90.22	4.23	1.37
Bridgewater,	90.52	4.16	1.13
Eastham,	92.51	2.17	1.43
Concord,	89.35	3.57	1.08
Attleborough,	69.39	13.46	1.42
Worcester,	71.50	7.45	2.75
Spencer,	66.50	9.10	3.25
Montague,	94.15	2.99	.27
Amherst,	77.39	8.29	4.13
Pittsfield,	66.49	7.32	5.40

There are inland soils which contain considerable amounts of sand, such as the Connecticut valley soils, for example, thus offering exception in this respect to the surrounding localities. The Montague soil is one of these, and it will be noticed by examining Table III. that the percentage of sand is very high in this. It is not, however, the coarser varieties but the finer which predominate, thus differing widely from the sandy soil of Cape Cod. Notwithstanding this variation, a large number of analyses show that the clay appears to follow, as a rule, what might be termed a normal amount for each particular region. It is therefore interesting to note in this connection that the increase of clay as we pass inward is fully as characteristic and uniform in the Massachusetts soils as is the decrease of the sand. The differences existing between the texture of the coast and inland soils are sufficient to exert considerable influence upon the growth of plants. This difference is equally perceptible, whether we see the soils in the field or in a table showing their analyses.

Having paid some attention to the physical properties of a few of our State soils, and their effect upon plant development, we are able to ascertain approximately from a mechanical analysis the characteristic properties of the constituents, and what effect they exert upon the development of certain crops. As a rule, we can divide the various constituents directly in the middle; that is, we can consider the four coarser elements and the four finer constituents by themselves. Such an arrangement of the soils is shown in Table IV.

TABLE IV. — *Showing Soils as in Table I., arranged according to the Percentages of Gravel and Coarse, Medium and Fine Sand, the Very Fine Sand, Silt and Clay being omitted.*

Orleans,	83.96	Attleborough,	39.81
Eastham,	83.81	Spencer,	36.90
Bridgewater,	71.37	Pittsfield,	30.34
Montague,	68.39	Worcester,	28.55
Concord,	55.18	Amherst,	11.20

If, for example, a soil is rather low in the constituents represented by the gravel and coarse, medium and fine sand,

and correspondingly high in the remaining constituents, then we possess a soil which is characteristic of the inland types, and will pack down very closely when wet. If, however, the reverse of this is true, we find a loose, pliable soil, such as is found on the coast, which is easily worked and especially adapted for truck farming. The latter soil will not retain much water, it quickly dries out; while the former or inland soil will retain considerable water for a long time, inasmuch as the resistance and relative amount of water maintained by different soils depends upon the volume of space in the soil for the water to enter, which in turn depends upon the number of grains of sand, silt and clay. In sandy soils the space is not divided up as much as in a clay soil; the grains of sand being larger, the spaces between the grains are also larger, there is less friction, and the water moves downward more quickly. The order of arrangement of the soils in Table IV. (which is that relative to the coarse material they contain) follows very closely the water-retaining capacity of the soils, as we shall see when we come to Table V.

These are in part the principal differences existing between the coast and inland soil, with now and then an exception; and the outbreak of the summer or injurious stage of the asparagus rust is always characteristic of those soils which are sandy and porous, and consequently possess little water-retaining capacity, whether they are located near the coast or inland. It should, however, be borne in mind that it is not the percentage of coarse and fine material alone which is responsible for the character of a soil, but the shape and arrangement of its particles exert an influence upon it. Then, again, the organic matter, the depth of the soil and the nature of the sub-soil, as is well known, are important when the question of moisture and dryness is concerned. We have already pointed out that the four soils from the coast contain less organic matter than those from inland soils, and this fact holds good for the Montague sample also. If these soils were richer in organic matter, their water-retaining properties would be increased, and they would become less susceptible to the rust.

In order to test the water-retaining properties of some of these samples of soil, we subjected them to the following treatment. Three hundred grams of the air-dried soils were taken and put into a cylinder three inches wide and six inches high, with a perforated bottom, over which there was placed a layer of filter paper. The cans containing the soil were then weighed, after which the samples were liberally treated with water until they contained all that was possible for them to hold. The cylinders were then set aside, and after the water had stopped dripping they were again weighed, and the additional weight which was due to the amount of water applied was noted. This represented the amount of water which the soils could retain. Other air-dried samples of the same soil were heated in an oven to perfect dryness, and by this means the amount of hygroscopic water was obtained for each. This, being added to the amount of water retained, gave the total water capacity of the soil; and, dividing this sum by the weight of water-free soil, which was obtained by subtracting the hygroscopic water from the original three hundred grams, we obtain the percentage of water which each soil is capable of retaining; or, in other words,

$$\frac{\text{Water retained} + \text{Hygroscopic water}}{\text{Water-free soil}} = \% \text{ of water-retaining capacity.}$$

The following table gives the results of these experiments in the order of water-retaining capacity: —

TABLE V. — *Showing the Retentivity of Soil Moistures in Order of Retaining Capacity.*

SAMPLE.	Water retained (Grams).	Hygroscopic Water (Grams).	Weight of Water-free Soil (Grams).	Percentage of Water retained.
Orleans, ...	103.0	2.10	297.90	35.28
Bridgewater, . . .	99.5	.66	299.34	37.13
Eastham, ...	115.9	.78	299.22	38.99
Montague, ...	144.8	.90	299.10	48.71
Concord, ...	145.3	2.76	297.24	49.81
Attleborough, . . .	168.9	4.20	295.80	58.52
Amherst, ...	200.6	2.82	297.18	68.45

As might be expected, the coast soils show the smallest percentage of water-retaining capacity, and this percentage increases as we pass inland to the heavier soils, as would naturally follow. The smallest percentage is shown by the soils from Cape Cod, where there is a considerable amount of coarse material and small amounts of fine material; while the largest percentage is given by the Amherst soil, which contains a larger amount of fine material and a less amount of coarse material than the coast soils. The Amherst soils show 68.45 per cent. water-retaining capacity, against 35.28 per cent. for the Orleans; or, in other words, the Amherst soil possesses nearly twice the water-retaining capacity of the Orleans soil. Only two determinations were made of the water-retaining properties of the soil west of Worcester, one being at Montague, where the summer stage of the rust is present, and the other at Amherst, where it has never occurred. These two determinations are, however, sufficient for our purpose; inasmuch as the preceding table shows that the water-retaining properties of the soil decrease in loose, sandy soil, and increase in fine, compact soil; and, as the mechanical constituents of such soils as the Worcester, Spencer and Pittsfield are larger in fine material and more closely resemble the Amherst soil than those of the coast, we would therefore find similar water-retaining properties.

The cans containing the soils were left in a room of even temperature, and after five days had elapsed they were weighed again, with the following result: —

Table VI. — *Percentage of Water lost by the Following Soils after Five Days.*

Bridgewater, . . .	75.07	Attleborough, . .	46.95
Orleans, ...	73.78	Montague, . . .	40.33
Eastham, . . .	66.17	Amherst, . . .	23.33
Concord,. . . .	51.75		

These results follow in a general way those shown in Table V. The Bridgewater, however, lost slightly more than the Orleans. As most of these soils were gathered within a few days of each other, it may be of some interest to note the amount of water found in each at the time the samples reached the laboratory. Amherst gave 33.60 per cent. of water; Montague, 11.26 per cent.; Orleans, 12.50 per cent.; Attleborough, 15.40 per cent.; Concord, 8.65 per cent.; Eastham, 5.69 per cent.; Bridgewater, 3.74 per cent. These figures do not possess any great value, but in a general way they correspond with those in the preceding table. The variation in the amount of rainfall in different parts of the State of course comes into account here. We will state, however, that the Amherst soil referred to was taken from an asparagus bed which has never had the rust in any stage, — a fact which is not only due to its characteristic texture and the nature of the subsoil, but to the fact that the plants have been thoroughly cultivated and properly fed, and consequently are in a very vigorous condition. According to Professor Brooks, this bed has at times received a heavy dressing of cow manure in the fall, which has been forked in in the spring, and then fertilizer has been put on at the following rate per acre: muriate of potash, 600 pounds; nitrate of soda, 200 pounds; and acid phosphate, 900 pounds.

Asparagus growers have stated that there is a difference as to infection in different parts of a field. Many have stated that the drier places were the most badly infested, while others could notice no difference, or in some instances those parts which they considered the least dry showed the rust the worst. This latter condition does not in any way affect our conclusions that the rust (summer stage) is peculiar alone to those regions that possess sandy soil which has little water-retaining capacity, inasmuch as our conclusions are general, and refer to the State as a whole. That exceptions do occur even in a single bed is not at all strange, so long as plants are endowed with a tendency to vary. There are other factors which have a bearing on the susceptibility of plants to rust other than those of soil and water conditions, among which is the general health condition or vigor of the plant. We have repeatedly observed in the same bed numerous plants that were badly infected, while directly beside them were some which were perfectly healthy. We do not maintain, however, that, in a bed where the plants possess the same amount of vigor and where they are under exactly similar conditions except in regard to moisture, those in the dry place will succumb to the rust quickest and become more severely affected than those located in dry places. The principal feature which we wish to emphasize in connection with these experiments is that the summer stage of the asparagus rust is due to a weakened condition of those plants growing on dry soil during seasons of extreme drought. In other words, the plants suffer for water; and, since this is the case, the rational method of prevention must take the amount of soil moisture into consideration. It will not be out of place here to reflect upon the present status of the rust problem, and consider the methods which should be employed in our endeavors to control it.

The practice of spraying, it would seem, is not likely to give promise of any remarkable results, because the asparagus plants offer difficulties in this respect, and all of the rusts are hard to control. Stewart found, in his experiments on spraying for the carnation rust, which attacks a host largely confined to greenhouses and therefore much better under control, that the best results obtained by spraying were not very promising. Then, again, it is possible that the asparagus rust mycelium may be confined to the plant throughout the year, in which case the value of spraying would be practically useless. We have observed a fungous mycelium in the roots and stems of the asparagus plants below the ground long before any occurrence of the rust showed upon the aerial stems; but whether the mycelium was identical with that of the rust, or of other parasitic fungi frequently found upon the asparagus, we were not able to ascertain. We must therefore turn our attention to other methods of control, — to methods which will enable us to keep the plants under more normal conditions during seasons of drought. These methods will consist, first, of securing the most vigorous plants, — a feature which is dependent upon cultivation and the proper kinds and amounts of plant food with which the plants are supplied. There is considerable difference in the plants of various growers in this respect; the most vigorous and largest plants which we have observed were situated in a dry region, subject to uredo infection, but they have never suffered from the rust till this season. The amount of rainfall between April 1 and September 1 of this year has been the lowest for many years, and many beds have shown the summer stage for the first time this year. It is interesting to note, however, that cultivation and skilful plant feeding alone have enabled some beds to suppress the outbreak of the summer stage.

Then, again, the question of soil moisture during dry seasons must be considered. There are different ways of securing this, such as by irrigation, by increasing the organic matter in the soil, or by mulching. In selecting a site for new beds, they should be started on soil possessing some degree of water-retaining capacity, even if such soil is not adapted quite so well for asparagus during ordinary seasons. We are convinced, however, that soils such as the Montague and Attleborough, which appear to be good asparagus soils, possess enough fine material and sufficient water-retaining capacity to prevent the summer outbreak, provided robust plants are secured. In fact, we are informed that the summer stage of the rust has not appeared on the beds at Attleborough from which this sample was taken previous to this year. It is these extremely light, sandy soils that have been selected for the largest asparagus beds, because they appear to be best adapted for its growth. Numerous inquiries from towns adjoining many of these badly infected regions have failed to show any evidence of injuries from the rust, as the texture of the soil is slightly different.

If the asparagus rust continues to cause as much injury in the future as it has in the past, it may become necessary to resort to those soils of a finer texture for the cultivation of this crop. The matter of irrigation would be expensive and not readily resorted to on many beds, while others that we know of could be very easily irrigated by damming a small stream and properly diverting the course of the water. Since the asparagus rust is brought about by drought, and is therefore not likely to cause much injury except during such seasons, the occurrence of the disease can be anticipated. In this respect it differs from other common plant diseases, inasmuch as we have to spray for them every season, whether we know they are going to make their appearance or not. An annual treatment would therefore not be required. It is hoped that some preventive measures, based upon the retentivity or the supplying of soil moisture, will be employed by those growers who are favorably situated and who have suffered from the rust.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of this division the past year has been principally devoted to the observation of the various weather phenomena, together with the reduction of the records and their arrangement in form for preservation.

The usual monthly bulletins, giving the more important daily records and a review of the character of the weather, have been issued, and the annual summary will be published as soon as the records for the year are complete.

Throughout the year the New England section of the United States Weather Bureau has furnished us daily, except Sunday, with the local forecasts of the weather, and the signals have been displayed from the top of the tower. Arrangements have been made to furnish them the weekly snow reports, as heretofore.

The observations relating to soil temperature and moisture by the electrical method, begun two years ago, have been continued this year. Owing to the unsatisfactory results of the previous years, the temperature cells and moisture electrodes were tested and standardized before using them in the field. The temperature cells were placed in water and the resistances observed. After the resistances became constant for each cell, the temperature of the water was taken by a standard thermometer. The resistance of each cell was thus determined, for temperatures varying by about 10° F., for a range exceeding that which it would be subjected to in the field. The cells were afterward placed in soil in a box, and the resistances observed and the temperature computed by the tables in Bulletin No. 7 of the United States Department of Agriculture, Division of Soils, and checked by using a standard thermometer. The standardization of the moisture electrodes was effected by placing them in soil in boxes so arranged as to provide for a proper diffusion throughout the soil of water as added, taking the resistances and computing the percentage of moisture from the weight. When afterward used in the field these electrodes gave more satisfactory results than had before been attained. The results for the corn-growing season of the current year have been worked out. The observations will be continued next year, for purposes of comparison.

The means of the various weather elements for each month and year, for the ten years from 1889 to 1898 inclusive, have been tabulated, and normal conditions for the period deduced. These results are of especial interest for the purpose of noting departures from normal conditions. The tabulations, together with other data of interest, will be found on the following pages.

Meteorological Observatory of the Hatch Experiment Station, Massachusetts Agricultural College, Amherst.

General Summary, 1889–98.

Latitude of observatory, 42° 23′ 48.5″ N.; longitude, 72° 31′ 10″ W. Elevation of ground at base of observatory above mean low water, Boston harbor, 223 feet, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is 50.5 feet above the ground and 273.5 feet above sea level. The Draper self-recording barometer is 51.5 feet above ground. The cup anemometer, pressure anemometer, anemoscope and sun thermometer are located on top of the tower, 72 feet above the ground. All temperatures are taken in the thermometer shelter on the campus, about 4 feet above ground and 220 feet above sea level. The standard rain gauge is on the campus, about 2 feet above the ground and 218 feet above sea level.

Mean Barometer.

[Readings are reduced to freezing and sea-level.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889,	30.113	30.238	29.843	29.795	29.916	29.960	29.909	30.008	29.999	30.050	30.040	30.139	30.001
1890,	30.191	30.097	29.993	30.098	29.959	29.975	30.019	30.001	30.124	29.880	30.007	30.013	30.030
1891,	29.958	30.041	30.099	29.923	29.983	29.919	29.986	29.965	30.114	30.028	30.117	30.081	30.018
1892,	29.965	30.106	29.895	29.972	29.943	29.923	29.988	30.017	30.103	29.896	29.988	30.010	29.983
1893,	29.951	30.111	30.065	30.086	29.895	30.056	29.968	30.001	30.065	30.126	30.124	30.120	30.047
1894,	30.175	30.160	30.088	30.054	30.000	29.997	30.012	30.033	30.143	30.016	30.081	30.148	30.085
1895,	30.047	29.918	29.998	30.119	30.097	30.172	30.031	30.016	30.097	30.082	30.187	30.151	30.076
1896,	30.158	29.860	29.990	30.143	29.984	29.949	29.974	29.989	30.004	30.011	30.145	30.135	30.028
1897,	30.041	30.056	30.036	30.042	29.924	29.901	29.943	29.943	30.091	30.122	30.034	30.036	30.014
1898,	29.976	30.052	30.203	29.927	29.937	29.947	30.017	29.959	30.012	30.089	30.010	29.963	30.008
Mean,	30.057	30.064	30.021	30.016	29.964	29.980	29.985	29.993	30.075	30.030	30.073	30.080	30.029

Range of Barometer (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889, ...	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890, ...	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891, ...	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892, ...	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893, ...	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894, ...	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895, ...	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896, ...	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897, ...	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898, ...	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
Mean, ...	1.53	1.58	1.30	1.11	.85	.73	.71	.66	.84	1.12	1.27	1.41	1.92

Maximum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,	30.82	30.97	30.66	30.54	30.40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890,	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891,	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892,	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893,	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894,	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895,	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896,	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897,	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898,	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
Mean maximum,	30.70	30.71	30.62	30.56	30.41	30.37	30.36	30.29	30.44	30.55	30.63	30.70	30.86

Minimum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.20
1890,	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891,	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892,	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893,	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894,	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895,	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896,	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897,	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898,	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
Mean minimum,	29.17	29.13	29.32	29.45	29.56	29.62	29.65	29.63	29.60	29.43	29.37	29.19	28.94

Mean Temperature (in Degrees F.).

[Completed from daily maximum and minimum readings.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Mean.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	29.2	32.0	31.0	45.8	56.3	65.3	68.4	67.2	60.4	48.2	37.2	21.8	46.9
1891,	26.4	27.6	32.7	47.5	55.6	65.2	66.3	69.0	64.9	48.7	38.1	36.9	48.2
1892,	23.6	26.1	31.4	45.2	56.0	69.3	69.3	68.9	59.3	48.6	37.8	26.3	46.8
1893,	16.1	22.9	30.4	43.0	55.8	66.9	68.1	69.2	55.8	52.6	38.2	25.5	45.4
1894,	26.4	21.6	39.6	46.7	57.3	67.8	72.9	68.0	65.5	51.5	34.8	26.9	47.9
1895,	23.2	19.5	31.2	45.6	59.7	69.1	67.6	69.7	64.1	45.6	40.7	30.5	47.2
1896,	20.7	25.0	29.2	48.3	61.1	65.0	71.3	68.8	59.5	47.0	42.2	25.6	47.0
1897,	24.7	25.4	33.1	47.1	56.8	62.0	71.6	66.8	60.1	49.8	36.2	28.3	46.8
1898,	21.8	26.1	39.7	42.4	55.3	66.1	70.9	70.2	63.6	51.1	37.5	25.9	47.5
Mean,	23.6	25.1	33.1	45.7	57.1	66.3	69.6	68.6	60.9	49.2	38.1	27.5	47.1

* Records incomplete.

Range of Temperature (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890, ...	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891, ...	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892, ...	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893, ...	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894, ...	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895, ...	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896, ...	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897, ...	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898, ...	65.5	73.0	45.5	54.0	46.0	50.0	56.5	46.5	58.5	59.5	56.0	60.0	115.5
Mean, ...	56.7	60.3	54.1	58.4	55.4	52.2	48.0	49.6	55.9	55.4	55.2	57.7	107.0

* Records incomplete.

Maximum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891,	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892,	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893,	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894,	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895,	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896,	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897,	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898,	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
Mean maximum,	51.2	50.8	58.8	78.3	85.3	91.6	92.8	91.7	88.2	79.2	65.3	53.1	95.4

* Records incomplete.

Minimum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890, ...	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891, ...	—0.5	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892, ...	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893, ...	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894, ...	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895, ...	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896, ...	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897, ...	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898, ...	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
Mean minimum, . .	—5.5	—9.5	4.7	19.9	29.9	39.4	44.8	42.1	32.3	23.8	10.1	—4.6	—11.8

* Records incomplete.

Mean Dew Point (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890, ...	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891, ...	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892, ...	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893, ...	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894, ...	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895, ...	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896, ...	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897, ...	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898, ...	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
Mean, ...	19.5	20.3	26.5	35.6	49.2	58.1	61.6	60.6	54.7	41.4	32.4	22.7	40.2

Mean Relative Humidity.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890,	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891,	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892,	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893,	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894,	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895,	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896,	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.1	82.3	79.8	76.9
1897,	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898,	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
Mean,	77.0	78.9	73.6	65.3	67.0	71.0	71.8	75.5	76.6	73.2	75.2	76.1	73.5

Mean Per Cent. of Cloudiness, from Tri-daily Observations.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	55	40	63	55	42	53	54	43	65	60	68	61	55
1890, ...	52	66	66	50	59	50	56	57	59	64	47	53	57
1891, ...	61	59	55	49	54	47	54	58	50	54	50	51	53
1892, ...	63	55	45	42	66	50	35	53	29	46	58	45	49
1893, ...	52	57	46	55	55	58	44	45	46	40	49	54	50
1894, ...	53	53	55	53	52	54	50	44	53	44	50	44	50
1895, ...	51	39	55	54	46	48	58	44	42	42	61	45	49
1896, ...	43	63	54	39	40	47	50	40	52	63	59	42	49
1897, ...	46	51	56	46	47	47	64	42	39	39	71	68	51
1898, ...	66	64	53	68	65	57	53	60	48	62	60	66	60
Mean, ...	54.2	54.7	54.8	51.1	52.6	51.1	51.8	48.6	48.3	51.4	57.3	52.9	52.4

Hours of Bright Sunshine by Sun Thermometer.

YEAR.	January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours, . . .	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889, ...	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890, ...	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891, ...	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892, ...	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893, ...	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894, ...	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895, ...	153	187	172	188	243	246	192	251	254	197	111	169	2,363
1896, ...	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897, ...	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898, ...	132	138	200	168	200	270	236	201	218	157	105	113	2,159
Mean, ...	134	145	178	211	228	242	238	224	199	161	114	136	2,212
Mean per cent., . .	45.7	49.0	48.0	52.5	50.3	53.0	51.5	52.2	53.4	47.2	39.0	48.1	49.7

Precipitation (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	3.50*	1.46*	1.02*	3.22*	4.18*	5.40*	10.52	2.72	3.17	4.58	6.04	3.57	49.38
1890, ...	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, ...	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, ...	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, ...	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, ...	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, ...	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, ...	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, ...	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, ...	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
Mean, . . .	3.93	3.13	3.12	2.76	4.15	3.73	5.74	4.05	3.73	4.00	4.10	3.56	46.00

* Kindly furnished by Miss S. C. Snell.

Departures from Monthly Normals.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	—.43	—1.67	—2.10	.46	.03	1.67	4.78	—1.33	—.56	.58	1.94	.01	3.38
1890, . .	—1.32	1.07	2.25	—1.03	1.24	—2.20	—.11	.83	2.12	3.13	—2.78	—.70	2.50
1891, . .	2.82	1.10	—.13	—.10	—2.18	1.02	—.46	.13	—1.07	—1.06	—1.11	1.84	.80
1892, . .	1.92	—1.23	—.72	—2.00	2.13	—.27	—1.33	2.42	—1.57	—3.34	.88	—2.55	—5.66
1893, . .	—.60	2.62	.54	1.65	.87	—.41	—3.15	—.56	—.91	.88	—1.29	1.30	.94
1894, . .	—1.77	—1.39	—1.35	—.93	—.15	—.60	—4.19	—3.74	.90	.85	—.96	—.03	—13.36
1895, . .	—.06	—2.08	—.41	2.80	—2.08	—.97	—1.87	—.59	1.31	.77	1.26	.38	—1.54
1896, . .	—2.86	1.54	2.99	—1.44	—1.57	—1.16	—.78	—.21	1.68	—.77	—1.07	—2.69	—6.34
1897, . .	—.93	—.61	.41	—.34	.23	2.92	8.77	.24	—1.79	—3.27	1.75	3.67	11.05
1898, . .	3.22	.67	—1.49	.97	1.46	—.04	—1.65	2.05	—.08	2.27	1.38	—1.26	8.25

Wind Movement (in Miles).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, ...	4,914	4,616	5,395	5,020	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, ...	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, ...	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, ...	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, ...	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, ...	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	5,029	4,156	5,506	46,861
1896, ...	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, ...	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, ...	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
Mean, . . .	4,511	4,630	5,770	5,078	4,530	3,680	3,439	3,262	3,404	4,154	4,385	4,722	51,566

Maximum Wind Pressure (in Pounds per Square Foot).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	26.00	24.0	16.75	15.50	9.00	11.50	10.00	6.5	9.75	12.25	14.50	29.0	29.00
1890, ...	27.75	17.5	13.50	11.50	16.50	10.00	9.25	13.0	5.00	11.00	9.50	24.5	27.75
1891, ...	16.25	13.5	10.50	14.00	10.75	10.50	4.50	2.5	4.00	9.50	15.75	14.0	16.25
1892, ...	10.50	11.5	20.50	16.75	15.75	20.50	11.50	7.5	15.50	12.50	16.00	13.5	20.50
1893, ...	12.00	20.0	18.50	24.50	24.75	9.00	13.00	37.5	14.50	23.00	14.00	18.5	37.50
1894, ...	20.00	22.5	11.50	15.50	14.50	14.00	9.50	9.5	13.00	10.00	18.00	15.0	22.50
1895, ...	13.00	25.0	20.00	10.00	7.00	8.00	8.00	5.5	43.00	14.00	22.00	24.0	43.00
1896, ...	15.00	24.5	19.00	18.00	25.00	7.75	8.50	12.5	19.00	12.00	15.00	12.0	25.00
1897, ...	18.50	10.0	13.50	14.00	22.00	7.00	12.00	14.0	20.00	11.50	20.00	12.0	22.00
1898, ...	22.50	15.5	15.50	10.00	18.00	8.50	17.50	13.0	30.50	12.00	19.00	28.0	30.50
Maximum, . . .	27.75	25.0	20.50	24.50	25.00	20.50	17.50	37.5	43.00	23.00	22.00	29.0	43.00

Maximum Velocity of Wind (in Miles per Hour).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, ...	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, ...	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, ...	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, ...	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, ...	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, ...	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, ...	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, ...	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, ...	67	56	56	45	60	41	59	51	78	49	62	75	78

Snow, Frost and Weather.

YEAR.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days .01 Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889, ...	April 2,	Oct. 13,	26.0	May 26,	Sept. 21,	119	94	110	161
1890, ...	April 8,	Oct. 19,	43.5	May 12,	Sept. 25,	141	137	105	123
1891, ...	May 5,	Nov. 26,	54.2	May 19,	Oct. 12,	112	145	103	117
1892, ...	April 10,	Nov. 5,	42.5	May 10,	Sept. 30,	108	123	109	134
1893, ...	April 21,	Nov. 4,	74.3	May 8,	Sept. 3,	143	101	96	168
1894, ...	April 12,	Nov. 5,	71.5	May 22,	Aug. 22,	125	107	83	175
1895, ...	April 3,	Oct. 20,	61.0	May 17,	Aug. 22,	119	118	110	137
1896, ...	April 7,	Nov. 14,	44.0	May 1,	Sept. 24,	108	132	102	132
1897, ...	April 27,	Nov. 12,	52.8	May 8,	Sept. 22,	127	108	109	148
1898, ...	April 6,	Nov. 24,	69.5	April 27,	Sept. 21,	135	78	138	149

Summary for the Ten Years 1889–98.

Barometer (Pressure in Inches).

Maximum, reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum, reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum, reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum, reduced to freezing and sea level, Feb. 8, 1895, 7 A.M.,	28.560
Mean,	30.029
Total range,	2.410
Greatest annual range, 1895,	2.270
Least annual range, 1892,	1.650
Mean annual range,	1.920
Greatest monthly range, January, 1891,	1.930
Least monthly range, July, 1895,	.510
Mean monthly range,	1.090

Air Temperature (in Degrees F.).

Highest, July 20, 1894, 5 P.M.,	98.000
Lowest, Feb. 3, 1898, 6 A.M.,	—19.000
Mean,	47.100
Total range,	117.000
Greatest annual range, 1898,	115.500
Least annual range, 1891,	100.000
Mean annual range,	107.000
Greatest monthly range, February, 1898,	73.000
Least monthly range, July, 1897,	36.000
Mean monthly range,	54.900
Greatest daily range, Feb. 18, 1892,	52.500
Least daily range, April 5, 1898,	2.500
Mean daily range,	22.100

Humidity.

Mean dew point,	40.200
Mean force of vapor,	.430
Mean relative humidity,	73.500

Precipitation (in Inches).

Total rain or melted snow,	460.000
Total snowfall,	539.300
Greatest annual precipitation, 1897,	57.050
Least annual precipitation, 1894,	32.640
Mean annual precipitation,	46.000
Greatest monthly precipitation, July, 1897,	14.510
Least monthly precipitation, October, 1892,	.660
Mean monthly precipitation,	3.830

Greatest in twenty-four hours, July 12-13, 1897, . . .	5.650
Greatest in one hour, July 30, 1898, ...	1.500
Unusual rains: 1889, June 15, 2.10 inches in four hours; 1896, July 7, 1.10 inches in thirty minutes; 1897, June 9, 4.08 inches in twenty hours; July 13-14, 8 inches in forty-four hours; 1898, July 30, 2.65 inches in two hours; September 10, .95 inch in twenty minutes. Number of days on which .01 inch or more rain or melted snow fell, ...	1,241.000

Wind (in Miles).

Total movement, ...	515,638
Greatest annual movement, 1896, ...	59,198
Least annual movement, 1894, ...	36,257
Mean annual movement, ...	51,566
Greatest monthly movement, March, 1896, ...	8,182
Least monthly movement, July, 1894, ...	1,109
Mean monthly movement, ...	4,297
Greatest daily movement, Nov. 27, 1898, ...	675
Least daily movement, Sept. 29, 1894, and March 7, 1895, .	–
Mean daily movement, ...	141
Maximum pressure per square foot, 43 pounds, = 93 inches per hour, Sept. 11, 1895, 3 P.M.	

Weather.

Mean cloudiness observed, ...	52.40 per cent.
Total cloudiness by the sun thermometer, .	22,400 = 50.30 per cent.
Number hours bright sunshine recorded, .	22,120 = 49.70 per cent.
Number of clear days, ...	1,143
Number of fair days, ...	1,065
Number of cloudy days, ...	1,444

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of experimentation carried on by this division have been kept strictly within the limits of practical horticulture, devoting especial attention to the growth of common fruit and garden crops, and their protection from insect and fungous pests.

New varieties of fruits, vegetables, ornamental trees, shrubs and plants of promise have been obtained and tested under varying conditions, and many new seedlings produced. For the work of testing varieties a large collection of standard varieties from different sections of the country have been obtained, that, when a new variety is to be tested, careful comparison may be made under conditions where the exact value of standard varieties is known. As far as possible, new varieties are grown under many varying conditions, and very careful inquiry is made of their behavior in many localities.

Previous reports have given the number of varieties of the different kinds of fruits, vegetables, flowers, etc., under experiment, to which have been added the following number of new varieties the past season: apples, four; pears, five; plums (domestic), three; plums (Japanese), seven; plums (American), seven; peaches, five; quinces, two; cherries, four; grapes, four, besides numerous seedlings; blackberries, three; red raspberries, two, and a large collection of seedlings; strawberries, twenty, and many seedlings; chestnuts (Japanese, Spanish and native varieties), eight; walnuts (species and varieties), six; several new hardy ornamental trees, shrubs and plants, and many new varieties of ornamental plants for the greenhouse and summer outdoor decoration.

Immediate results are constantly called for in the case of widely advertised new varieties, but such results can be obtained only under a series of seasons and varying conditions of growth. This work of testing varieties is begun at once upon introduction, and is hastened by all possible means.

The experiments under way, in addition to the testing of varieties, are as follows: —

1. The girdling of the grape vine for profit.
2. Spraying fruit trees when in bloom, to change the bearing year.
3. Spraying peach trees during the winter with lime, to protect the flower buds from winter-killing.
4. The use of dilute copper sulfate in place of the ammoniacal carbonate of copper.
5. The testing of insecticides and fungicides.
6. The testing of spraying apparatus.
7. The use of clear kerosene and kerosene and water for the destruction of scale insects and aphides.
8. The protection of young fruit trees from mice.
9. Various kinds of grafting wax.
10. Various methods of grafting.
11. Whole roots and piece roots in apple root-grafting.
12. Different kinds of stocks for the pear.
13. Growing seedling fruit-tree stocks.
14. The use of hydrocyanic acid gas for the destruction of insects under glass.
15. Turf culture *v.* cultivation in growing apples.
16. Amount and kinds of fertilizers needed for best growth of fruits.
17. Green manuring for orchards.
18. Comparative hardiness of varieties of Japanese plums.
19. Growth of lettuce under glass.
20. Growth of tomatoes under glass.

Assistance has been given many horticulturists by visiting their places or answering inquiries by letter, which takes a large share of the time of the head of the division. Assistance has also been given in many places in planning ornamental planting of home and public grounds.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Since my last report the entomological work of the station has proceeded along its usual lines. A large amount of correspondence has been carried on, and many letters of inquiry from residents of this State have been answered. Believing, however, that the opportunities afforded by this division of the experiment station were either not known of by many, or that the way in which to make use of them was not understood, the following note on the work was prepared: —

Free Aid for the People.

Prevention of Loss by Injurious Insects.

The attacks of injurious insects probably cause the loss of several millions of dollars in Massachusetts alone each year. This has not always been the case, but insects are becoming more abundant and consequently more destructive. Much of this destruction, however, could be either in part or wholly prevented if the proper methods of treatment were made use of, and that this is not more frequently done is very unfortunate. It is probable that the reason for the apparent negligence in this regard is due to ignorance as to what the insect is in each particular case, and what to do to prevent its ravages. It is this very uncertainty which results in nothing being done in most cases.

In order to provide this information for residents of the State, the entomological division of the Hatch Experiment Station at Amherst offers its services without charge to all who may desire them. To obtain this assistance, write to the entomologist, Hatch Experiment Station at Amherst, Mass., describing the trouble, and also, if possible, send samples of the injury and the insect causing it, and attention will at once be given to the matter.

As the Hatch Experiment Station of Massachusetts is supported in part by State appropriation, such a use of its facilities by the people of the State is not only justifiable but most desirable, for it was established for just that purpose; and no one who incurs loss by insect ravages can excuse himself for that loss except on the ground of ignorance that such assistance can be obtained.

Over eight hundred of these circulars were sent out to the newspapers, granges and other organizations of the State, with the request that the facts contained therein be given the greatest publicity. As these slips were not circulated till December, 1899, it is not possible to ascertain the results, but a considerable increase in the already large correspondence is anticipated during the coming year.

Last June my assistant, Mr. R. A. Cooley, was appointed professor of zoölogy and entomology at the Montana State College. Mr. Cooley is a careful and thorough investigator, and proved himself a very efficient and valuable assistant to me. The loss of his services rendered necessary the appointment of some one to take his place. As it was advisable for many reasons to obtain a man of large experience, Dr. H. T. Fernald of Pennsylvania, for nine years professor of zoölogy and entomology at the Pennsylvania State College, and for the past two years State entomologist of Pennsylvania, was elected associate entomologist, to take the place made vacant by the resignation of Mr. Cooley.

The San José Scale.

The San José scale is now known to occur in injurious abundance at more than thirty different places in Massachusetts, — in fact, it may be said to be generally distributed over the State. It has probably been introduced from several other States, as there is nothing except the objections of purchasers to prevent its being brought in on every plant purchased. Its presence, however, and the serious destruction it causes, have led a number of States to pass laws excluding all stock from outside their borders unless accompanied by an authorized certificate that the stock had been inspected and no scale found. This action was most inconvenient for Massachusetts nurserymen, who were often thus prevented from filling orders to go to States having such laws. To meet this difficulty, the committee of the trustees of the college, in charge of the experiment station, authorized the entomological division of the station to inspect nurseries when requested to do so by their owners, and to give authorized certificates where no scale is found, charging for this work only the actual expenses incurred. This action was not a required one, and was taken solely for the purpose of accommodating nurserymen, many of whom have already shown their appreciation of the arrangement and have availed themselves of the opportunity thus afforded them.

Bulletin on Chionaspis.

On the 10th of August, 1899, the work of Mr. R. A. Cooley on the different species of *Chionaspis* and *Hemichionaspis* was published in a special bulletin of the station. This bulletin, treating of many of the important scale insects which have recently attracted so much attention because of the injury they do to fruit and other trees, was fully illustrated, and has received high commendation not only in this country but also in Europe.

The Grass Thrips.

Studies on the grass thrips have been continued during the year by Mr. W. E. Hinds, one of the senior students, with most satisfactory results, and are published as an appendix to the college catalogue. As these studies are largely technical, such of the facts as have an economic bearing will also be published in a bulletin for the use of the farmers of the State.

The Clover-head Beetle.

Work on the clover-head beetle (*Phytonomus nigrirostris*) has been continued during the year by Mr. C. M. Walker, and the results are nearly ready for publication. Its life history has been nearly completed, and the best methods of treatment are being investigated. This work will be published as soon as completed.

Raupenleim.

This substance, which is of such value for banding trees liable to the attacks of the canker worms, tussock moth, etc., has heretofore been manufactured by a secret process in Germany. During the past year the chemist of the Gypsy Moth Commission, Mr. F. J. Smith, made experiments at the chemical laboratory of the insectary, to determine its composition. These experiments proved very successful, and in consequence raupenleim can now be manufactured in this country at a low cost. This one discovery has been estimated as worth half a million of dollars to the farmers and fruit growers of the United States.

The Gypsy Moth.

The work of exterminating the gypsy moth, with which I have been connected since 1891, has been carried on during the past year with marked success, and the insect has been reduced to such an extent over almost the entire territory that one who has kept in close touch with the field work for several years past cannot fail to be impressed by the great gain that has been made towards the extermination of this pest.

There is no longer any question, in the minds of those who have made a careful personal investigation of the work throughout the infested territory, that the gypsy moth can be exterminated. Nearly all of the prominent economic entomologists of this country have inspected the work with great care, and have become fully convinced that extermination is possible, if the Legislature each year promptly grants the full appropriation asked for this purpose by the gypsy moth committee. The entire responsibility now rests with the Legislature.

The Brown-tail Moth.

This insect has now become widely distributed in the eastern part of this State, and even extends into New Hampshire; it is therefore believed to be impossible to exterminate this pest with any appropriations that the two States in which it now occurs would be likely to make. When attention was first called to this insect, in the spring of 1897, the matter was laid before Governor Wolcott, who sent a message to the Legislature recommending an appropriation of $10,000 for the extermination of the pest, which then occurred only in a very limited area. It was believed that this amount would be sufficient to stamp out the insect. The Legislature, however, refused to make any appropriation for this purpose, and the inevitable results followed.

In consideration of the failure of the Legislature to prevent the spread of the brown-tail moth over the country, the gypsy moth committee have authorized me, with the assistance of those associated with me, to "collect such information, both in this country and Europe, in regard to the brown-tail moth, and make such experiments with the insect as may be useful to the committee in future dealing with the creature and necessary for the proper enlightenment of the public on the subject, with a view to publish the said information, if it may appear desirable."

In accordance with this action of the gypsy moth committee a large amount of time has already been spent on this work, but it is far from being completed, and it is impossible at present to say just when the work will be ready for publication.

Monograph of the Pyralidæ.

I have been engaged for many years in a critical study of the microlepidoptera of North America, and have already published several monographs on certain families of these insects. I am now at work on a monograph of the Pyralidæ, which will probably be ready for publication some time this year.

The Card Catalogue.

The card catalogue of insects now contains over forty thousand cards, and is continually growing in size, as constant additions are made to it from the new journals and other entomological publications as they are received. Only those insects occurring in North America have been catalogued in the past, but the literature of the scale insects (Coccidæ) of all countries is now being added. This is rendered necessary, as these insects are being imported into our country from different parts of the world without restriction in any State except California.

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 work of the chemical laboratory connected with this department has materially increased during the past year, notwithstanding the prolonged illness of Dr. Lindsey, which necessitated a temporary rearrangement of the staff, leaving the bulk of the analytical work to be carried on by two assistants.

There have been sent in for examination 167 samples of water, 144 of milk, 193 of cream, 36 of pure and process butter, 25 of oleomargarine, 147 of feed stuffs and 52 of miscellaneous substances.

In connection with experiments by this and other divisions of the station there have been analyzed 62 samples of milk, 54 of butter and 429 of fodders and feed stuffs.

In addition to the above, 748 samples of commercial concentrated feed stuffs have been collected under the provision of the feed law, of which 736 samples have been tested, either individually or in composite. This makes a total of 2,045 substances analyzed during the year, as against 1,875 last year and 1,147 in the year previous. There have also been carried on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

Character of Chemical Work.

Water. — Sanitary examinations of water have been carried out, as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for the use of live stock.

Persons whose water supply is other than that of a city or town system should use every possible means to guard it against pollution arising from sinks, vaults and stables, or from the entrance of surface water and animal and vegetable matter. The latter, while not in itself highly injurious to health, is objectionable, as it favors the rapid propagation of bacteria and other micro-organisms. The detection of specific disease germs in water is, however, not a function of the chemist, but of the bacteriologist.

Frequent cases of poisoning result from conducting drinking water through lead pipe, and such a practice cannot be too severely condemned, for the poison, once assimilated, is very difficult to remove from the system. At least five samples examined during the past year have shown its presence. Soft waters as a rule have a much greater solvent action upon lead than hard waters. Wells and springs ought to be thoroughly cleaned at regular intervals.

It is of great importance that the utmost care be exercised in taking the sample for analysis, otherwise the chemical examination, conducted under the most careful and exacting conditions, is of little or no value. The quantity necessary is two to three quarts, collected in a thoroughly cleaned and well-rinsed glass bottle, stoppered with a new cork, over which is to be tied a clean piece of cotton cloth. An air space of about one inch should be left between cork and liquid, to allow for expansion. In case of pond water, the sample should be taken from below the surface, being careful to avoid the surface scum and the sediment at the bottom. The chemist's report upon the character of the water must necessarily be a matter of judgment, based on the analysis and the information furnished by the party sending the sample. Accurate replies to the following questions are necessary to a complete understanding of each case, and are for the interest of the person sending the water: —

1. Sources, whether from spring, stream, pond, reservoir or well.
2. Character of soil in which located.
3. Distance from any possible source of pollution, and character of the same.
4. Kind of pipe used for conducting the water.

Ship samples at once by express, charges prepaid. In making the report of an analysis a printed form is used, which explains the results so as to be readily understood by any one.

The examination of mineral or spring waters for which medicinal properties are claimed, or those intended for commercial purposes, does not fall within the scope of our duties.

Milk. — The samples sent in show a wide variation both in solids and fat, a considerable number falling below the Massachusetts legal standard,* indicating a need on the part of certain milkmen and others of introducing better stock and disposing of inferior animals.

In taking a sample for analysis, mix the entire milking by pouring three or four times from one vessel to another, and immediately fill a pint bottle. Mark each sample, stating kind of milk (whole, skim or buttermilk) and the tests desired, together with the name and address of the shipper; the package to be marked "*Immediate Delivery*," and sent by express, prepaid. Samples sent from a considerable distance should be treated with four drops of forty per cent. formaldehyde (obtained at any apothecary's), to insure the preservation of the sample.

Cream. — Everything said in regard to the sampling and shipping of milk applies equally well to cream.

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* In the months of October, November, December, January, February and March, 13 per cent. solids and 3.7 per cent. fat are required, but during the remainder of the year only 12 per cent. solids and 3 per cent. fat.

Butter. — In connection with the feeding experiments conducted at the barn last season many samples of butter were analyzed, and very thorough examinations of the butter fat, both in regard to its chemical composition and physical properties, were made.

"Renovated" or "process" butter having become of considerable prominence in the market, a law was passed by the last Legislature forbidding its sale except when plainly marked, in one-half inch type, "Renovated butter." Several samples have been identified in this laboratory by means of a microscopical examination, general characteristics of the melted fat and curd, together with the Reichert number; and a much larger number of oleomargarines have been identified by the same methods.

Cattle Feeds. — The feed law passed by the State Legislature, which took effect in July, 1897, is apparently meeting with good success. The work is carried out by this department, the assistants making a semi-annual canvass of the State, taking samples of all the prominent concentrated feed stuffs. The samples so collected are carefully analyzed, and the results published in bulletins from time to time. The purpose of this work is to exclude poor and adulterated feeds, and to maintain products of a uniform grade.

The effect of the law on the quality of cotton seed meal has been very marked. In the earlier collections inferior meals were common, but during the present season but few were found, and the average protein content is many per cent. higher. Low-grade wheat feeds and oat feeds of unknown manufacture still remain in the market, and probably will to some extent until a guarantee is required on all feeds and power given to enforce the same.

Part II.

Feeding Experiments and Dairy Studies.

An investigation was instituted last season to ascertain the effect produced on the quantity and quality of butter fat by feeding ground flax-seed meal containing thirty-six per cent. of oil, as compared with a normal linseed ration.

Following this, a long series of feeding experiments was begun, the object being to demonstrate, if possible, the effect of each of the food components, protein, fat and carbohydrates, as found in different feed stuffs, — linseed meal, gluten meal, cotton seed meal, etc., — upon the composition and physical characteristics of the resulting butter fat. In each case the experiment was compared with a standard ration supposed to be without special effect on the butter fat. It is evident that such a task involves a large amount of careful and long-continued work, but as soon as positive results are obtained they will be published.

Digestion Experiments.

Digestion experiments were conducted last winter and spring in the same careful manner as in previous years, using two or three sheep in each trial. The grains fed were oat feed, Parson's $6 feed, four lots of "Bourbon" distillers' grains (brands X., XX., XXX. and XXXX.), rye distillers' grains, Cleveland flax meal and Chicago gluten meal.

The digestion coefficients, together with complete data, will be reported at a later date.

REPORT OF THE CHEMIST.

DIVISION 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 DURING THE SEASON OF 1899.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 67; of these, 38 have offices for the general distribution of their goods in Massachusetts, 10 in New York, 5 in Connecticut, 3 in Vermont, 3 in Rhode Island, 3 in Canada, 2 in Pennsylvania, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and ninety-one distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

Three hundred and eighty-four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and sixty-two samples were analyzed at the close of November, 1899, representing 289 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 59, March; No. 62, July; and No. 63, November, 1899.

The samples not already analyzed, together with others that may be collected before the first of May, 1900, will be examined with a view of being published in our spring bulletin.

During the season the inspector has caused samples to be taken in the towns and villages distributed throughout the State, and representing each county within the Commonwealth. Wherever more than one sample of a given brand has been collected in different parts of the State, a composite sample has been made up of equal weights of the several samples, and an analysis made of the homogeneous mixture. It is believed that an analysis of this nature more fairly represents the composition of the fertilizer than the analysis of any one sample.

It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

For the readers' benefit the following abstract of the results of our analyses are here inserted: —

	1898.	1899.
(*a*) Where three essential elements of plant food were guaranteed:—		
Number with three elements equal to or above the highest guarantee,	5	16
Number with two elements above the highest guarantee,	17	27
Number with one element above the highest guarantee,	77	73
Number with three elements between the lowest and highest guarantee,	85	88
Number with two elements between the lowest and highest guarantee,	93	84
Number with one element between the lowest and highest guarantee,	54	58
Number with two elements below the lowest guarantee,	19	19
Number with one element below the lowest guarantee,	90	68
(*b*) Where two essential elements of plant food were guaranteed:—		
Number with two elements above the highest guarantee,	5	7
Number with one element above the highest guarantee,	24	32
Number with two elements between the lowest and highest guarantee,	25	20
Number with one element between the lowest and highest guarantee,	17	27
Number with two elements below the lowest guarantee,	2	2
Number with one element below the lowest guarantee,	8	18
(*c*) Where one essential element of plant food was guaranteed:—		
Number above the highest guarantee,	18	10
Number between lowest and highest guarantee,	23	16
Number below lowest guarantee,	15	10

A comparison of the above-stated results of our inspection with the results of 1898 shows, on the whole, a marked superiority in favor of the samples analyzed in 1899.

Wherever a discrepancy has arisen between the results of our analyses and the manufacturer's guarantee, it has been evident that imperfect mixing has been the cause, and not a desire of the manufacturer to place inferior goods on the market. It should be remembered, when purchasing fertilizers, that the responsibility of the manufacturer or dealer ends with furnishing an article corresponding in its composition with the lowest stated guarantee of each of the three essential elements of plant food.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1898 and 1899 (Cents per Pound).

	1898.	1899.
Nitrogen in ammonia salts,	14.00	15.00
Nitrogen in nitrates,	13.00	12.50
Organic nitrogen in dry and fine ground fish, meat, blood and in high-grade fertilizers.	14.00	14.00
Organic nitrogen in fine bone and tankage,	13.50	14.00
Organic nitrogen in medium bone and tankage,	10.00	10.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.50	2.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows an increase, as compared with the preceding year, 1898.

The above trade values are based on the market cost, during the six months preceding March, 1899, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

Sulfate of ammonia.
Azotine.
Cotton-seed meal.
Linseed meal.
Bone and tankage.
Dissolved bones.
Acid phosphate.
High-grade sulfate of potash.
Sulfate of potash and magnesia.
Sylvinite.
Nitrate of soda.
Dried blood.
Castor pomace.
Dry ground fish.
Dry ground meat.
Ground phosphate rock.
Refuse bone-black.
Muriate of potash.
Kainite.
Crude saltpetre.

How to use the table of trade values in calculating the approximate value of a fertilizer: Calculate the value of each of the three essential articles of plant food (nitrogen, phosphoric acid and potassium oxide, including the different forms of each wherever different forms are recognized in the table) in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made: —

Analysis of Fertilizer (Pounds in One Hundred Pounds of Fertilizer).

Nitrogen,	4
Soluble phosphoric acid,	8
Reverted phosphoric acid,	4
Insoluble phosphoric acid,	2
Potassium oxide (as sulfate),	10

	Value per One Hundred Pounds.	Value per Two Thousand Pounds.
Four pounds nitrogen, at 14 cents,	$0.56×20	=$11.20
Eight pounds soluble phosphoric acid, at 4½ cents,	.36×20	= 7.20
Four pounds reverted phosphoric acid, at 4 cents,	.16×20	= 3.20
Two pounds insoluble phosphoric acid, at 2 cents,	.04×20	= .80
Ten pounds potassium oxide, at 5 cents,	.50×20	= 10.00
Value per ton,	. . . . .	$32.40

The following table gives the average analysis of officially collected fertilizers for 1899: —

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.86	2.96	2.82	4.65	3.29	3.19	11.13	8.77	7.94	6.67	5.16	4.92
Ground bones,	5.23	2.99	2.63	-	5.58	18.61	24.19	22.53	5.58	6.67	-	-
Tankage,	5.75	4.88	4.41	-	4.99	14.49	18.66	16.33	5.83	-	-	-
Dissolved bone-black,	14.02	-	-	13.62	2.82	-	16.76	16.00	16.44	15.00	-	-
Wood ashes,	9.50	-	-	-	-	-	1.57	1.00	-	-	6.37	4.50
Cotton-hull ashes,	10.44	-	-	-	6.88	1.28	8.16	8.00	6.88	-	27.74	25.00
Cotton-seed meal,	7.79	7.09	6.96	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.65	15.71	15.36	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	1.94	21.00	20.60	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.17	-	-	-	-	-	-	-	-	-	48.42	48.95
Sulfate of potash and magnesia,	3.93	-	-	-	-	-	-	-	-	-	26.70	25.28
Muriate of potash,	1.43	-	-	-	-	-	-	-	-	-	49.68	50.27

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1899, to May 1, 1900), 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.
- Fruit and Root Crop Special.

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.
- Cotton-hull Ashes.

The American Jadoo Co., Philadelphia, Pa.: —
- Jadoo Liquid.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

The East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Standard Un X Ld Fertilizer.
- Special Complete Strawberry Manure.
- Special Complete Potato Manure.
- Special Complete Cabbage Manure.
- Special Complete Grass and Lawn.
- Complete Manure for General Use.
- Pure Ground Raw Bone.
- Castor Pomace.

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.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Special Fertilizers.
- Bowker's Potatoes and Vegetables.
- Bowker's Fish and Potash, Square Brand.
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Essex County Fertilizer.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.

William E. Brightman, Tiverton, R. I.: —
- Brightman's Potato and Root Manure.
- Brightman's Phosphate.
- Brightman's Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's Dry Ground Fish.
- Bradley's Strawberry Manure.
- Bradley's English Lawn Fertilizer.
- Bradley's New Method Fertilizer.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's Columbian Fish and Potash.

Bradley Fertilizer Co. — *Con.*
Bradley's Circle Brand Extra Fine-ground Bone with Potash.
Bradley's X. L. Phosphate.
Bradley's Potato Manure.
Bradley's Potato Fertilizer.
Bradley's Complete Manures.
Bradley's Fish and Potash.
Bradley's Corn Phosphate.
Bradley's Fine-ground Bone.
Ammoniated Bone Phosphate.
Breck's Lawn and Garden Dressing.
Dissolved Bone-black.
Sulfate of Potash.
Muriate of Potash.
Nitrate of Soda.
Kainite.

Joseph Breck & Sons., Boston, Mass. : —
Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent) : —
Church's B. Special Fertilizer.
Church's C. Standard Fertilizer.
Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass. : —
Clark's Cove Bay State Fertilizer, G. G.
Clark's Cove King Philip Guano.
Clark's Cove White Oak Pure Ground Bone.
Clark's Cove Bay State Potato Manure.
Clark's Cove Great Planet Manure.
Clark's Cove Bay State Fertilizer.
Fish and Potash.
Potato Fertilizer.
High-grade Sulfate of Potash.
Muriate of Potash.
Nitrate of Soda.

Cleveland Dryer Co., Boston, Mass. : —
Cleveland Fertilizer.
Cleveland Potato Phosphate.
Cleveland Superphosphate.
Cleveland Grass Fertilizer.
Cleveland Corn and Grain Phosphate.

E. Frank Coe Co., New York, N. Y. : —
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's High-grade Potato Fertilizer.

E. Frank Coe Co. — *Con.*
E. Frank Coe's Bay State Phosphate.
E. Frank Coe's Fish Guano and Potash.
E. Frank Coe's Gold Brand Excelsior Guano.
E. Frank Coe's Tobacco and Onion Fertilizer.
E. Frank Coe's Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y. : —
Crocker's Vegetable Bone Superphosphate.
Crocker's Special Potato Manure.
Crocker's General Crop Phosphate.
Crocker's A. A. Complete Manure.
Crocker's Potato, Hop and Tobacco Phosphate.
Crocker's Ammoniated Wheat and Corn Phosphate.
Crocker's New Rival Ammoniated Superphosphate.
Crocker's New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass. :—
Cumberland Phosphate.
Cumberland Potato Fertilizer.
Cumberland Concentrated Phosphate.
Cumberland Fertilizer.

Chas. M. Cox & Co., Boston, Mass. : —
Cotton-seed Meal.

L B. Darling Fertilizer Co., Pawtucket, R. I. : —
Potato and Root Crop.
Animal Fertilizer.
Blood, Bone and Potash.
Fine Bone,
Tobacco Grower.
Special Formula.
Nitrate of Soda.
Muriate of Potash.
Farm Favorite.

John C. Dow & Co., Boston, Mass. : —
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass. : —
Imperial Liquid Plant Food.
Imperial Liquid Grass Fertilizer.

Elbert & Gardner, New York, N. Y.: —
Cotton-seed Meal.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Wood Ashes.

T. H. Frowley, Brookline, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Garden Special.
Vegetable, Vine and Tobacco.
Northern Corn Special.
General Fertilizer.
Grass and Oats.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

F. E. Hancock, Walkerton, Ont., Can.: —
Canada Unleached Hardwood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Animal Brand.
Swift's Lowell Potato Phosphate.
Swift's Lowell Market Garden Manure.
Swift's Lowell Fruit and Vine.
Swift's Lowell Lawn Dressing.
Swift's Lowell Tobacco Manure.
Swift's Lowell Ground Bone.
Swift's Dissolved Bone and Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Celebrated Onion Fertilizer.
Lister's Special Tobacco Fertilizer.
Lister's High-grade Special for Spring Crops.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunnville, Ontario, Can.: —
Canada Hardwood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Mapes Bone Manures.
Mapes Superphosphates.
Mapes Special Crop Manures.
Economical Potato Manure.
Tobacco Ash Constituents.
Sulfate of Potash.
Sulfate of Ammonia.
Nitrate of Soda.
Double Manure Salt.

Geo. L. Munroe, Oswego, N. Y.: —
Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
Fine-ground Bone.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hardwood Ashes.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Niagara Wheat and Corn Producer.
Niagara Potato, Tobacco and Hop Fertilizer.

Pacific Guano Co., Boston, Mass.: —
High-grade General Fertilizer.
Soluble Pacific Guano.
Potato Special.
Nobsque Guano.
Grass and Grain Fertilizer.
Pacific Guano with ten per cent. Potash.
Fish and Potash.
Special Potato Manure.

Packers Union Fertilizer Co., New York, N. Y.: —
Animal Corn Fertilizer.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover.
Gardeners' Complete Manure.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Special Strawberry Brand Fertilizer.
Plymouth Rock Brand.
Special Potato Fertilizer.

Parmenter & Polsey Fertilizer Co. — *Con.*
P. & P. Potato Fertilizer.
Star Brand Superphosphate.
A. A. Brand.
Ground Bone.
Muriate of Potash.
Nitrate of Soda.

Prentiss, Brooks & Co., Holyoke, Mass.: —
Complete Manures.
Superphosphate.
Nitrate of Soda.
Muriate of Potash.
Sulfate of Potash.

Quinnipiac Co., Boston, Mass.: —
Quinnipiac Onion Manure.
Quinnipiac Havana Tobacco Fertilizer.
Quinnipiac Dry Ground Fish.
Quinnipiac Phosphate.
Quinnipiac Potato Manure.
Quinnipiac Market-garden Manure.
Quinnipiac Fish and Potash.
Quinnipiac Grass Fertilizer.
Quinnipiac Corn Manure.
Quinnipiac Potato Phosphate.
Quinnipiac Climax Phosphate.
Quinnipiac Pure Bone Meal.
Dissolved Bone-black.
Nitrate of Soda.
Muriate of Potash.
Sulfate of Potash.

The Rogers & Hubbard Co., Middletown, Conn.: —
Hubbard's Pure Raw Knuckle Bone Flour.
Hubbard's Strictly Pure Fine Bone.
Hubbard's Potato Phosphate.
Hubbard's Fertilizer for All Soils and All Crops.
Hubbard's Fertilizer for Oats and Top-dressing.
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.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
Essex Fish and Potash.
Essex Potato Fertilizer.
Essex Corn Fertilizer.
Essex Complete Manure for Corn, Grain and Grass.
Essex Complete Manure for Potato, Roots and Vegetables.
Essex Odorless Lawn Dressing.
Essex Dry Ground Fish.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent): —
Read's Standard.
Practical Potato Special.
Bone, Fish and Potash.
Vegetable and Vine.

Lucien Sanderson, New Haven, Conn.: —
Sanderson's Old Reliable.
Sanderson's Potato Manure.
Sanderson's Formula A.
Sanderson's Blood, Bone and Meat.
Sanderson's Nitrate of Soda.
Sanderson's Dissolved Bone-black.
Sanderson's Sulfate of Potash.
Sanderson's Muriate of Potash.

Standard Fertilizer Co., Boston, Mass.: —
Standard Fertilizer.
Standard Special for Potatoes.
Standard Guano.
Standard Complete Manure.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
Swift Sure Superphosphate for General Use.

F. C. Sturtevant, Hartford, Conn.: —
Sturtevant's Granulated Tobacco and Sulphur.

Edward H. Smith, Northborough, Mass.: —
Smith's Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

The South Sea Guano Co., Boston, Mass.: —
South Sea Guano.

E. A. Tompkins, Jamaica Plain, Mass.: —
Ferti Flora.

Henry F. Tucker Co., Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Imperial Bone Superphosphate.
- Tucker's Special Potato Fertilizer.
- Tucker's Bay State Special.

I. S. Whittemore, Wayland, Mass.: —
- Complete Manure.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

The Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass.: —
- Ammoniated Bone Superphosphate.
- Prolific Crop Producer.
- Potato Phosphate.
- High-grade Special.
- Royal Bone Phosphate.
- Corn Phosphate.

Williams & Clark Fertilizer Co. — *Con.*
- Potato Manure.
- Grass Manure.
- Fish and Potash.
- Onion Manure.
- Bone Meal.
- Dry Ground Fish.
- Muriate of Potash.
- Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
- Superior Truck Fertilizer.
- Havana Tobacco Fertilizer.
- Potato Manure.
- Corn Fertilizer.
- Fruit Fertilizer.
- Royal Wheat Grower.
- Grass and Oats.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
- Fine-ground Bone.

J. M. Woodard & Brother, Greenfield, Mass.: —
- Tankage.

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 and condition of the trade.

1. Analyses of Materials sent on for Examination.

During the past season 225 materials have been received, and the results of our examination have been published in detail in bulletins 59, 62 and 63 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality they come from. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of many industries are of such a nature that their value as manurial substances is unlimited and the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value. A frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements will be made, as in previous years, to attend to the examination of these materials to the full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below is given a partial list of materials received during the past season, which shows the general nature of the work : —

- Wood ashes.
- Sulfate of potash.
- Muriate of potash.
- Nitrate of soda.
- Sulfate of ammonia.
- Acid phosphates.
- Sulfate of potash and magnesia.
- Ground bone.
- Complete fertilizers.
- Minerals.
- Liquid fertilizers.
- Soils.
- Dried pig's blood.
- Lime-kiln ashes.
- Glucose sugar refuse.
- Damaged grain.
- Insecticides.
- Composts.
- Refuse from glass factory.
- Cotton-seed meal.
- Cotton-hull ashes.
- Tankage.
- Wool shoddy.
- Jadoo fibre.
- Plaster.
- Forage crops.
- Soot.
- Spent bone-black.
- Brick-yard ashes.
- Sludge.

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to those who may desire such information.

2. Notes on Wood Ashes.

This subject has engaged our attention for past seasons and has been discussed at length in previous reports.

During the past year (1899) 24.4 per cent. of the materials sent on for analysis consisted of wood ashes, as against 40.1 per cent. the previous year (1898).

The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article. The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to guarantee the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of those two elements is present. 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 volume.

	No. of Samples.	
	1898.	1899.
Moisture below 1 per cent.,	–	2
Moisture from 1 to 3 per cent.,	9	6
Moisture from 3 to 6 per cent.,	6	4
Moisture from 6 to 10 per cent.,	20	11
Moisture from 10 to 15 per cent.,	22	28
Moisture from 15 to 20 per cent.,	16	7
Moisture from 20 to 30 per cent.,	6	1
Moisture above 30 per cent.,	–	1
Potassium oxide above 8 per cent.,	4	4
Potassium oxide from 7 to 8 per cent.,	6	9
Potassium oxide from 6 to 7 per cent.,	8	13
Potassium oxide from 5 to 6 per cent.,	22	7
Potassium oxide from 4 to 5 per cent.,	25	19
Potassium oxide from 3 to 4 per cent.,	11	2
Potassium oxide below 3 per cent.,	3	2
Phosphoric acid above 2 per cent.,	6	4
Phosphoric acid from 1 to 2 per cent.,	60	43
Phosphoric acid below 1 per cent.,	13	10
Average per cent. of calcium oxide (lime),	33.60	34.10
Per cent. mineral matter insoluble in diluted hydrochloric acid: —		
Below 5,	1	–
5 to 10,	16	16
10 to 15,	31	26
15 to 20,	15	7
20 to 30,	13	5
Above 30,	–	2

Cotton-hull Ashes. — This waste product is receiving increased attention from the farmers, and is an article of great merit. The samples received this year analyze from 21 to 29 per cent. of potash, and are especially adapted to tobacco growing on account of the large proportion of carbonate of potash present, this form of potash being the most valuable one known for that purpose.

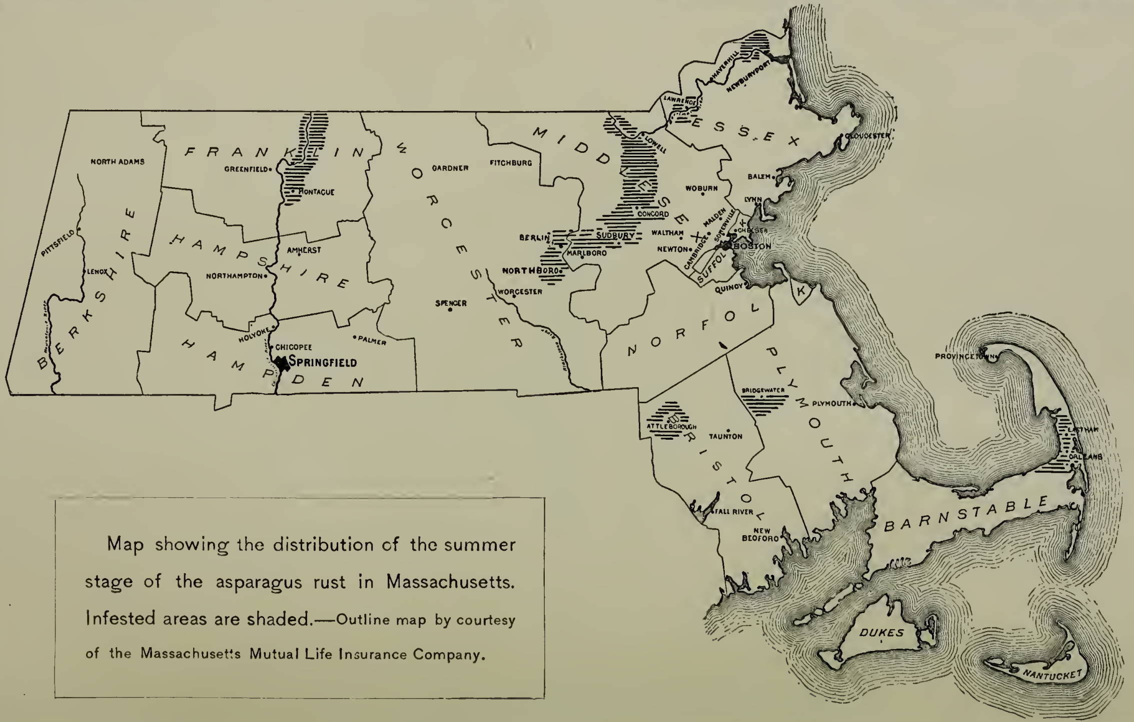
Sludge. — At the present time the larger cities are collecting all waste débris in reservoirs, and subjecting it to chemical treatment for recovery of fertilizing ingredients. This source of plant food is often within easy reach of the farmer, and may be turned to good advantage, as is seen from the average analysis: nitrogen, 1.31 per cent.; potash, .16 per cent.; phosphoric acid, .86 per cent.; lime, 1.13 per cent.

Hen Manure. — In this ingredient we have a very rich fertilizer and a material that is worthy of careful treatment. To save the nitrogen that otherwise might pass into the air a "fixer" is a necessity. Two samples received at the laboratory were analyzed, as follows: —

SAMPLES.	Nitrogen (Per Cent.).	Potash (Per Cent.).	Phosphoric Acid (Per Cent.).
Sample I.,	.46	1.12	.69
Sample II.,	.42	.43	.63

No. I. was treated with kainite, a material analyzing on an average 16 per cent. potash, and a substance capable of fixing the ammonia, thereby saving this element and at the same time supplementing the manure in potash, — the ingredient which it is deficient in. This application of an ammonia fixer may be applied to all animal refuse products, and, as is seen, has a twofold action, — the saving of nitrogen and the supplementing of potash.

Cotton-seed Meal. — This material still holds its own and is a recognized standard article, a source of nitrogen sought by tobacco growers. Its high standard has been maintained as in previous seasons.



Map showing the distribution of the summer stage of the asparagus rust in Massachusetts. Infested areas are shaded.—Outline map by courtesy of the Massachusetts Mutual Life Insurance Company.

PUBLIC DOCUMENT . . . . No. 31.

THIRTY-EIGHTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1901.

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1901.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 2, 1901.

To His Excellency W. MURRAY CRANE.

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

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

CALENDAR FOR 1901–1902.

January 2, 1901, Wednesday, winter term begins, at 8 A.M.
March 21, Thursday, winter term closes, at 10.15 A.M.
April 3, Wednesday, spring term begins, at 8 A.M.
June 15, Saturday, Grinnell prize examination of the senior class in agriculture.

June 16, Sunday,	Baccalaureate sermon. Address before the College Young Men's Christian Association.
June 17, Monday,	Burnham prize speaking. Flint prize oratorical contest. Class-day exercises.
June 18, Tuesday,	Meeting of the alumni. Reception by the president and trustees.

June 19, Wednesday, commencement exercises.
June 20–21, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Sedgwick Institute, Great Barrington; and at Horticultural Hall, Worcester.
September 17–18, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.
September 19, Thursday, fall semester begins, at 8 A.M.
December 19, Thursday, to January 2, 1902, Thursday, winter vacation.
February 5, Wednesday, fall semester ends.
February 6, Thursday, spring semester begins, at 8 A.M.
March 29, Saturday, to April 2, Wednesday, spring recess.
June 18, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

In the year just elapsed, the college has been called to mourn the death of two of its trustees and two of its students.

May 2, 1900, there passed away John D. W. French, for ten years a trustee. Deeply interested in the agriculture and horticulture of his native State, he held many important and prominent offices. He was president of the Ayrshire Breeders' Association, president of the New England Milk Producers' Union, president of the Bay State Agricultural Society, and had seen long service in the American Forestry Association and the Massachusetts Horticultural Society. A man of fine business capacity, he introduced into everything he touched the same order and regularity with which he conducted his own affairs. Strictly conscientious and faithful, he brought to the performance of every duty his best endeavors. A wise counsellor and true friend, he will long be missed on the board of trustees.

September 4 of the same year, after a long and painful illness, there passed away James S. Grinnell, for twenty-two years a trustee of the college, and for many years the presiding officer of its board of trustees. Like his lamented colleague, he was strongly identified with the agriculture of the State, taking an active part in everything that would further its interests. A man of singularly happy and cheerful temperament, he was welcomed at every fireside and was widely known throughout the Commonwealth, an accomplished scholar, a polished gentleman. Loyal to the college and its best interests, he stood stanchly by it in the years of its depression, and lived to see it occupying the honorable position it now holds.

About the usual number of young men presented themselves this year for entrance, and forty were received. With those taking the short winter courses and the additions to our graduate courses, the attendance has considerably increased over the years immediately preceding. The graduate courses for master of science and doctor of philosophy seem to have commended themselves to the popular judgment. We have in attendance graduates of Harvard, Brown, Bates, Smith and Tokyo, besides those from our own college, and applications from the Connecticut College of Agriculture to join the next class. The courses in entomology and botany are unusually complete, and we know of no other institution in the country, or in fact in the world, where a like training and like opportunities in the former are to be found.

By a rearrangement of the work, Dr. Henry T. Fernald takes the elementary work of entomology in junior year as a preparation to advanced elective work in senior year, while Professor Lull offers an elective in advanced zoölogy.

George Francis Babb, a graduate of Bates College in 1891, has been added to the corps of instructors, making it possible to offer to the senior class an elective in advanced French.

It has been deemed advisable to divide the college year into two terms or semesters, for the following reasons: First, the desirability of making the summer vacation longer than it now is. Many of the students depend upon what they earn in the summer for the payment of their college expenses. Some have found it impossible to secure desirable jobs if obliged to leave them the first week in September. If, then, the summer vacation be made longer, the winter and spring vacations must be shortened, so as to leave approximately the same number of weeks as before in the college year. Second, it is believed that the educational interests of the students will be subserved by having two principal examinations during the year, instead of three. Frequent tests will continue to be given, and these two examinations are sufficient for all the advantages that examinations give. Third, the semester plan makes possible a simpler and more effective arrangement of subjects taught in the college. It has frequently been found difficult to adapt the work in some of the departments to the three-terms plan, because the subjects taught in one term overlap into the following term, and it is not an easy problem to arrange the schedule so that the work may be done in succeeding terms. To all this it may be added that other institutions doing similar work to that done in this college have adopted the semester plan, and are pleased with its practical working.

The library, under the efficient management of a trained librarian, is rapidly increasing in value, and taking its place as one of the most important factors in the education of the student. It now numbers 21,655 volumes, divided into ten libraries or classes, as follows: general works, 131 volumes; philosophy, 143 volumes; religion, 234 volumes; sociology, 2,179 volumes; philology, 60 volumes; natural science, 7,882 volumes; useful arts, 8,055 volumes; fine arts, 160 volumes; literature, 1,392 volumes; history, 1,419 volumes. Agriculture in the useful arts naturally leads the list, with 3,438 volumes, followed by botany with 2,108 volumes, entomology with 1,257 volumes, and veterinary with 428 volumes.

A special division has been made for histories of the towns of the Commonwealth, and already over fifty have been contributed. There is no more fascinating way of studying the history of our Commonwealth than through the histories of its towns, and we gladly welcome this new feature in its management.

Under certain prescribed regulations, the privileges of the library are extended outside the college, and thus it is doing its educational work not only among the students, but also among the citizens of the Commonwealth.

The college has been called upon to prepare the agricultural and horticultural exhibit of Massachusetts for the Pan-American Exposition in 1901. It will be largely illustrative, and by comparison rather than by actual specimens.

In horticulture there are five cases, illustrative of its progress during the last hundred years, containing colored models of original fruits and vegetables, side by side with the latest and improved varieties. It is an object lesson of the simplest kind, but of the greatest educational value.

In botany are four exhibits: first, a dozen plates illustrating the structure and development of the nematode worms, so ruinous to the cucumbers, tomatoes and other crops grown under glass, and supplemented by plates showing the methods used for sterilizing the soil and thus killing the nematode foe; second, eighteen types, mounted on glass in glycerin-gelatine, of fungous diseases of Massachusetts, affecting the growth and perfection of the leaf; third, a series of diagrams showing (*a*) the influence of electricity upon plant growth and (*b*) the different kinds of apparatus used for electrically stimulating the germination of seeds; fourth, a set of mounted sections of wood of some sixty specimens of the trees of Massachusetts. There are three sections of the thinness of paper of each specimen, one section being cut perpendicular, another tangential and a third radial, thus showing the grain of the wood from every part of the tree. Accompanying each set of three are two photographs, one of the tree in full foliage and the other bare and denuded of leaves.

In agriculture are a series of charts depicting graphically the acreage of Massachusetts in cereals, root and other crops, compared with the acreage of the same crops in three or four of the great agricultural States of the Union; a second series, comparing the dairy products; and a third, the yield per acre, cost and value of the same. These charts cover a period of forty years, and are exceedingly valuable and instructive.

It is a matter of congratulation that the Morrill annuity of 1890, for the further maintenance and support of the agricultural and mechanical colleges established under the provisions of the act of 1862, and the annuity of 1887, secured by Mr. Hatch for the establishment and maintenance of experiment stations, have been placed upon an absolutely secure foundation. It will be recollected that both were made dependent upon the proceeds of the sale of public lands. Every free homestead measure, by giving away public land, withdrew a like amount from the source of our income. For the past five or six years a measure has been before Congress giving away to bona fide settlers seventy million acres. Beaten in one Congress, it has revived in the next, and was finally passed in the first session of the present Congress, but with the following proviso: "*Provided, however*, that in the event that the proceeds of the annual sales of the public lands shall not be sufficient to meet the payments heretofore provided for agricultural colleges and experiment stations, by an act of Congress approved August thirtieth, eighteen hundred and ninety, for the more complete endowment and support of the colleges for the benefit of agriculture and mechanic arts, established under the provisions of an act of Congress approved July second, eighteen hundred and sixty-two, such deficiency shall be paid by the United States."

It seems proper at this time to speak of the condition of the college buildings and the necessity for certain repairs. A number of them have been in existence for thirty-two years, and require more or less attention to keep them from going to decay and ruin. The drill hall, barn, chemical laboratory, plant houses, botanical museum and president's house are urgently in need of painting. In the drill hall bathing facilities or shower baths are a matter of necessity, that students after exercising may have a chance to properly cleanse themselves before going to their rooms. There are at present only four bath tubs for the use of the college, — a provision entirely inadequate. In the laboratory for vegetable pathology and physiology a small sum is needed to relay the tracks by which those plants under observation can be run in and out of the building, and to provide bottles for specimens. The botanical museum requires shoring up, in order that the delicate instruments used in investigation may have a firm basis on which to stand; and an additional floor requires to be laid, to prevent the coal dust and ashes from coming up and covering everything in laboratory and recitation room when classes are at work. Furthermore, new cases are needed to properly house the growing collections. The most pressing need of the college is a new boarding-house. The old one, built under pressure and against time some thirty years ago, has outlasted its usefulness and should be replaced. It is only the shell of a building, which has been patched up over and over again, till it is hard telling what part belongs to the original structure.

It is dark, cheerless and unsanitary, and to put it in proper condition (and it would then be only an old building) would require nearly as much as a new house.

To provide, then, for these several items, to wit, painting the different college buildings, repairing the laboratory of vegetable pathology and the botanic museum, providing additional bathing facilities and equipment for the museum, and making adequate provision for a boarding-house, the sum of twenty-three thousand one hundred dollars is asked for.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 2, 1901.

THE CORPORATION.

	TERM EXPIRES
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
WILLIAM R. SESSIONS of Springfield,	1905
CHARLES L. FLINT of Brookline,	1905
WILLIAM H. BOWKER of Boston,	1906
GEORGE H. ELLIS of Boston,	1906
J. HOWE DEMOND of Northampton,	1907
ELMER D. HOWE of Marlborough,	1907
NATHANIEL I. BOWDITCH of Framingham,	1908
WILLIAM WHEELER of Concord,	1908

Members Ex Officio.

His Excellency Governor W. MURRAY CRANE,
President of the Corporation.

HENRY H. GOODELL, *President of the College.*

FRANK A. HILL, *Secretary of the Board of Education.*

JAMES W. STOCKWELL, *Secretary of the Board of Agriculture.*

HENRY S. HYDE of Springfield,
Vice-President of the Corporation.

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Committee on Finance and Buildings.*

WILLIAM R. SESSIONS, J. HOWE DEMOND,
HENRY S. HYDE, SAMUEL C. DAMON,
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER, ELMER D. HOWE,
CHARLES L. FLINT, GEORGE H. ELLIS,
WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticultural Department.*

JAMES DRAPER, ELMER D. HOWE,
N. I. BOWDITCH, MERRITT I. WHEELER,
WILLIAM R. SESSIONS, GEORGE H. ELLIS,
ELIJAH W. WOOD, *Chairman.*

Committee on Experiment Department.*

JAMES W. STOCKWELL, ELIJAH W. WOOD,
WILLIAM H. BOWKER, WILLIAM WHEELER,
JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

WILLIAM WHEELER, SAMUEL C. DAMON,
CHARLES L. FLINT, N. I. BOWDITCH,
JAMES DRAPER, *Chairman.*

Board of Overseers.

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ALVAN BARRUS, ... of Goshen.
GEORGE P. SMITH, . . . of Sunderland.

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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, M.A., 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.

HENRY T. FERNALD, Ph.D.,
Professor of Entomology.

HERMAN BABSON, M.A.,
Assistant Professor of English.

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.,
Assistant Professor of Botany.
(Instructor in German.)

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

JOHN ANDERSON, Captain, U. S. A.,
Professor of Military Science and Tactics.

GEORGE F. PARMENTER, B.Sc.,
Instructor in Chemistry.

GEORGE F. BABB, B.A.,
Instructor in French.

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

E. FRANCES HALL,
Librarian.

RICHARD S. LULL, M.S.,
Registrar.

ELISHA A. JONES, B.Sc.,
Farm Superintendent.

Graduates of 1900.*

Master of Science.

Hartwell, Burt Laws,	Kingston, R. I.

Bachelor of Science.

Atkins, Edwin Kellogg,	North Amherst.
Baker, Howard,	Dudley.
Brown, Frank Howard (Boston Univ.),	Newton Centre.
Campbell, Morton Alfred (Boston Univ.),	Townsend.
Canto, Ysidro Herrera (Boston Univ.),	Cansahcab, Mexico.
Crane, Henry Lewis (Boston Univ.),	Ellis.
Felch, Percy Fletcher,	Worcester.
Frost, Arthur Forrester,	South Monmouth, Me.
Gilbert, Ralph Davis (Boston Univ.),	Gilead, Conn.
Halligan, James Edward (Boston Univ.),	Roslindale.
Harmon, Arthur Atwell,	Chelmsford.
Hull, Edward Taylor (Boston Univ.),	Greenfield Hill, Conn.
Kellogg, James William (Boston Univ.),	Amherst.
Landers, Morris Bernard,	Bondsville.
Lewis, James Francis (Boston Univ.),	Fairhaven.
Monahan, Arthur Coleman,	South Framingham.
Morrill, Austin Winfield (Boston Univ.),	Tewksbury.
Munson, Mark Hayes (Boston Univ.),	Huntington.
Parmenter, George Freeman (Boston Univ.),	Dover.
Stanley, Francis Guy (Boston Univ.),	Springfield.
West, Albert Merril,	Brookville.
Jones, Frank Waldo ('82),	South Scituate.
Total,	23

Senior Class.

Barry, John Cornelius,	Amherst.
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.

* 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 1900

† Died April 18, 1900, of diphtheria.

Dawson, William Alucius,	Worcester.
Dickerman, William Carlton,	Taunton.
Gamwell, Edward Stephen,	Pittsfield.
Gordon, Clarence Everett,	Clinton.
Graves, Jr., Thaddeus,	Hatfield.
Greeley, Dana Sanford Bernard,	East Foxborough.
Gurney, Victor Henry,	Forge Village.
Henry, James Buel,	Scitico, Conn.
Howard, John Herbert,	Littleton Common.
Hunting, Nathan Justus,	Shutesbury.
Leslie, Charles Thomas,	Pittsfield.
Macomber, Ernest Leslie,	Taunton.
Ovalle Barros, Julio Moises,	Santiago, Chili.
Pierson, Wallace Rogers,	Cromwell, Conn.
Rice, Charles Leslie,	Pittsfield.
Rogers, William Berry,	Cambridge.
Root, Luther Augustus,	Deerfield.
Schaffrath, Max,	Waterbury, Conn.
Smith, Ralph Ingram,	Leverett.
Tashjian, Dickran Bedross,	Kharpoot, Turkey.
Todd, John Harris,	Rowley.
Whitman, Nathan Davis,	South Boston.
Wilson, Alexander Cavassa,	Boston.
Total,	30

Junior Class.

Belden, Joshua Herbert,	Newington, Conn.
Blake, Maurice Adin,	Millis.
Bodfish, Henry Look,	Tisbury.
Carpenter, Thorne Martin,	Foxborough.
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.
Gates, Victor Adolph,	Memphis, Tenn.
Hall, John Clifford,	Sudbury.
Hodgkiss, Harold Edward,	Wilkinsonville.
Kinney, Charles Milton,	Northampton.
Knight, Howard Lawton,	Gardner.

Lewis, Claude Isaac, ...	Unionville.
McCobb, Edmund Franklin, . . .	Milford.
Morse, Ransom Wesley, . . .	Belchertown.
Paul, Herbert Amasa, ...	Lynn.
Saunders, Edward Boyle, . . .	Southwick.
Smith, Samuel Leroy, ...	South Hadley.
West, David Nelson, ...	Northampton.
Total, ...	25

Sophomore Class.

Allen, Lilly Bertha, ...	Amherst.
Allen, William Etherington, . . .	Winthrop.
Bacon, Stephen Carroll, . . .	Leominster.
Barrus, George Levi, ...	Goshen.
Blake, Ernest Edward, ...	Riverside.
Bowen, Howard Chandler, . . .	Rutland.
Bowler, Patrick Henry, . . .	Bondsville.
Brooks, Philip Whitney, . . .	Cambridge.
Cheever, Herbert Milton, . . .	West Boylston.
Cook, Joseph Gershom, . . .	Clayton.
Dillon, James Henry, ...	Belchertown.
Franklin, Harry James, . . .	Bernardston.
Halligan, Charles Parker, . . .	Roslindale.
Harris, Frederick Arnold, . . .	Amherst.
Higgins, Willis Elmore, . . .	Maynard.
Hood, William Lane, ...	Vandiver, Ala.
Jones, Gerald Denison, . . .	South Framingham.
Kelley, Herbert Thomas, . . .	Amherst.
Martin, Henry Thomas, . . .	Amherst.
Monahan, Neil Francis, . . .	South Framingham.
Nersessian, Paul Nerses, . . .	Marash, Turkey.
O'Hearn, George Edmund, . . .	Pittsfield.
Parsons, Albert, ...	North Amherst.
Parsons, Josiah Waite, ...	Northampton.
Peebles, William Warrington, . .	Washington, D. C.
Perkins, Edward Lamson, . . .	Roxbury.
Phelps, Arthur Augustus, . . .	Boylston.
Phillips, Lee, ...	West Hanover.
Poole, Elmer Myron, ...	North Dartmouth.
Proulx, Edward George, . . .	Hatfield.
Richardson, Harlan Lewis, . . .	Boxborough.
Robertson, Richard Hendrie, . .	Malden.
Snell, Edward Benaiah, . . .	Lawrence.
Thompson, Leslie Irving, . . .	Middleborough.

Tinker, Clifford Albion, . . .	West Tremont, Me.
Tinkham, Charles Samuel, . . .	Roxbury.
Tottingham, William Edgar, . . .	Bernardston.
Tower, Winthrop Vose, . . .	Melrose Highlands.
Webster, Frank Wallace, . . .	Bay State.
West, Myron Howard, ...	Belchertown.
Wollheim, Ernest, ...	Jersey City, N. J.
Total, ...	41

Freshman Class.

Back, Ernest Adna, ...	Florence.
Baker, Perez Raymond, . . .	Amherst.
Barnes, Hugh Lester, ...	Stockbridge.
Collins, Joseph Daniel, ...	Northampton.
Copeland, William Wallace, . . .	Townsend.
Couden, Fayette Dickinson, . . .	Amherst.
Cummings, John Francis, . . .	Brockton.
Ellsworth, Frank Lawrence, . . .	Holyoke.
Elwood, Clifford Franklin, . . .	Green's Farms, Conn.
Esip, Edward Thomas, ...	Amherst.
Fahey, John Joseph, ...	Pittsfield.
Gay, Ralph Preston, ...	Stoughton.
Graves, George Augustus, . . .	Northampton.
Gregg, John William, ...	South Natick.
Griffin, Clarence Herbert, . . .	Winthrop.
Haffenreffer, Adolf Frederick, . .	Jamaica Plain.
Handy, Robert Sylvan, . . .	Bourne.
Haskell, Sidney Burritt, . . .	Southbridge.
Henshaw, Fred Forbes, . . .	Templeton.
Hill, Louis William Barlow, . . .	Greenfield Hill, Conn.
Kelliher, Justin, ...	Brockton.
Kirby, Daniel Webster, . . .	Webster.
Lewis, Clarence Waterman, . . .	Melrose Highlands.
Newton, Howard Douglas, . . .	Stockbridge.
Parker, Sumner Rufus, ...	Brimfield.
Paul, Augustus Russell, . . .	Framingham.
Pease, James Arthur, ...	Greenfield Hill, Conn.
Peck, Arthur Lee, ...	Hartford, Conn.
Pierce, Hervey Cushman, . . .	West Millbury.
Quigley, Raymond Augustine, . .	Brockton.
Raymoth, Reuben Raymond, . .	Goshen.
Richardson, Charles Henry, . . .	Boxborough.
Ryan, Arthur, ...	North Hadley.

Sawin, Ralph Dana, ...	Pembroke.
Staples, Parkman Fisher, . . .	Westborough.
Thompson, Clarence Loomis, . .	South Natick.
White, Howard Morgan, . . .	Springfield.
Witherell, George Albert, . . .	Warwick.
Witt, Henry Herbert, ...	Belchertown.
Total, ...	39

Short Winter Courses.

Burckes, Franklin, ...	Worthington.
Cande, Edwin Henry, ...	Sheffield.
Day, Charles Walter, ...	East Boston.
Eaton, Herbert Benjamin, . . .	North Reading.
French, William Almon, . . .	Athol Centre.
Moore, James Lowell, ...	Wayland.
Sharpe, Edward Hewitt, . . .	East Northfield.
Trow, Charles Warfield, . . .	Buckland.
Valentine, Everett Cyrus, . . .	Northborough.
Total, ...	9

Graduate Course.

For Degrees of M.S. and Ph.D.

Babb (B.A., Bates College, '91), George Francis, ...	Amherst.
Eaton (A.B., Harvard Univ., 1900), Theodore Hildreth, ...	St. Louis, Mo.
Felch (B.Sc., M.A.C., 1900), Percy Fletcher,*	Worcester.
Hemenway (B.Sc., M.A.C., '95), Herbert Daniel, ...	Williamsville.
Hinds (B.Sc., M.A.C., '99), Warren Elmer, ...	Townsend.
Ikeda (A.B., Univ. of Tokyo, '91), Hidezo, ...	Tokyo, Japan.
Knight (B.Sc., M.A.C., '92), Jewell Bennett, ...	Belchertown.
Monahan (B.Sc., M.A.C., 1900), Arthur Coleman, ...	South Framingham.
Morrill (B.Sc., M.A.C., 1900), Austin Winfield, ...	Tewksbury.

* Drowned in Connecticut River, at North Hadley, July 8, 1900.

Parmenter (B.Sc., M.A.C., 1900), George Freeman,	Dover.
Paull (Ph.B., Brown Univ., '97, A.M., Brown Univ., '98), Charles Leslie Fairbanks,	Somerset.
Pingree (B.Sc., M.A.C., '99), Melvin Herbert,	Denmark, Me.
Smith (B.A., Smith College, 1900), Elizabeth Hight,	Amherst.
Walker (B.Sc., M.A.C., '99), Charles Morehouse,	Amherst.
Total,	14

Resident Graduates at the College and Experiment Station.

Brown, B.Sc., Frank Howard,	Newton Centre.
Crane, B.Sc., Henry Lewis,	Ellis.
Drew, B.Sc., George Albert,	Westford.
Halligan, B.Sc., James Edward,	Roslindale.
Haskins, B.Sc., Henri Darwin,	North Amherst.
Holland, M.S., Edward Bertram,	Amherst.
Jones, B.Sc., Benjamin Kent,	Middlefield.
Kellogg, B.Sc., James William,	Amherst.
Mossman, B.Sc., Fred Way,	Westminster.
Smith, Jr., B.Sc., Philip Henry,	South Hadley Falls.
Thomson, B.Sc., Henry Martin,	Monterey.
Wiley, B.Sc., Samuel William,	Amherst.
Total,	12

Summary.

Graduate course: —		
For degrees of M.S., and Ph.D.,	14	
Four-years course: —		
Graduates of 1900,	23	
Senior class,	30	
Junior class,	25	
Sophomore class,	41	
Freshman class,	39	
Winter course,	9	
Resident graduates,	12	
Total,		193
Entered twice,		8
Total,		185

The leading object of the Massachusetts Agricultural College is "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 in the several pursuits and professions in life." That this result may be secured by those for whom it is intended, the college invites the co-operation and patronage of all who are interested in the advanced education of the industrial classes in the Commonwealth.

The instruction here given is both theoretical and practical. The principles of agriculture are illustrated on the extended acres of the farm belonging to the college estate. Nature's work in botany and in horticulture is revealed to the eye of the student in the plant house and in the orchards accessible to all, while the mysteries of insect life, the diseases and the cure of domestic animals, the analysis of matter in its various forms, and the study of the earth itself, "the mother of us all," may engage the attention of the student during the years of his college course.

ADMISSION.

Every candidate for admission must be at least sixteen years of age, and must present a testimonial of good character from the principal of the last school that he attended.

Four-years Course.

Candidates for admission to the freshman class will be received on certificate, as explained below, or on examination in the following subjects: algebra (through quadratics), plane geometry, English, general history, civil government (Mowry's "Studies in Civil Government"), physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography," or its equivalent).

This examination may be oral or written; the standard required for admission is 65 per cent. in each subject. Knowledge of the principles of arithmetic is presupposed, although an examination in this subject is not required. Teachers are urged to give their pupils such drill in algebra and geometry as shall secure accuracy and readiness in the application of principles to practical examples.

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject-matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1901 and 1902 are these: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Cooper's "The Last of the Mohicans;" Lowell's "The Vision of Sir Launfal."

Examinations in one or more of the required subjects may be taken a year before the candidate expects to enter college, and credit for successful examination in any subject will stand for two years after the examination.

Candidates for classes more advanced than the freshman class will be examined in the studies gone over by the class to which they desire admission.

The examinations for admission in 1901 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 20 and 21, and on Tuesday and Wednesday, September 17 and 18, as follows: —

First Day.

8.30 A.M. — Registration.
9 A.M. — English.
11 A.M. — General History.
2 P.M. — Physiology.
3 P.M. — Physical Geography.

Second Day.

9 A.M. — Civil Government.
10 A.M. — Algebra.
2 P.M. — Geometry.

Entrance examinations in June will be held on the same days and in the same order as in Amherst, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston, at Horticultural Hall, Worcester, and at Sedgwick Institute, Great Barrington, but candidates may be examined and admitted at any other time in the year.

Admission on Certificate.

Certificates of schools and academies approved by the faculty of the college are accepted in place of examinations. These certificates must be made out on blanks furnished on application to the registrar, and must be signed by the principal of the school making such application.

A student admitted on certificate may be dropped from college at any time during freshman year, when his work is not satisfactory; and the privilege implied in the acceptance of a certificate may be revoked whenever, in the judgment of the faculty, it is not properly exercised.

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 open 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.

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 and satisfactorily complete a major and two minor subjects. Botany, chemistry or entomology may be selected as the major subject, and the minors available are botany, chemistry, entomology and zoölogy. The amount and quality of work done must be satisfactory to the professors in charge of the respective subjects before the degree will be conferred.

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.

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.

FOUR-YEARS COURSE OF STUDY.

Freshman Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Language and Literature.	Social Science and History.	
Fall semester,	- -	Botany, structural, — 3.	- -	- -	Advanced algebra, — 5.	English, — 3. French, — 4.	- -	Study of military tactics, — 1. Freehand drawing, — 4.
Spring semester,	History of agriculture. Breeds of horses, sheep, cattle and swine, — 4.	Botany, analytical, — 3.	General chemistry, Part I., — 2.	- -	Geometry, — 4.	English, — 3. French, — 4.	- -	- -

Sophomore Year.

Fall semester,	Breeding of live stock, poultry farming, dairy farming, — 3.	Botany, economic and laboratory work, — 4.	General chemistry, Part II., — 4.	Anatomy and physiology, — 3.	Trigonometry and mechanics, — 4.	English, — 3. German, — 3.	- -	- -
Spring semester,	Soils: characteristics, improvement of, drainage, grasses, etc., — 4.	Horticulture, — 3.	Dry and humid qualitative analysis, — 5.	- -	Surveying, — 3.	American literature, — 2. German, — 3.	- -	Mechanical drawing, — 4.

Four-years Course of Study — *Concluded.*

Junior Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Language and Literature.	Social Science and History.	
Fall semester, .	Manures and fertilizers, green manuring, rotation of crops, — 3.	Market gardening, — 3.	Qualitative and quantitative analysis, — 4.	Zoölogy, — 6.	Physics, — 4.	English literature, — 4.	- -	- -
Spring semester,	- -	Landscape gardening, — 3.	Lectures and practice in organic chemistry, — 6.	Zoölogy and entomology, — 6.	Physics, laboratory physics, — 4.	English literature, — 2.	- -	Geology, — 3.

Senior Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Language and Literature.	Social Science and History.	
Fall semester, .	Ensilage, cattle feeding and dairy farming, — 5.	Botany, cryptogamic, — 8. Horticulture, — 8.	Chemical physics and quantitative analysis, — 8.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Mathematics, — 5.	English, — 2. Advanced English, — 5. Latin, — 5. French or German, — 5.	Political economy, — 5. History, — 5.	Military science, — 1. Astronomy, — 4.
Spring semester,	Rural economy, experimental work in agriculture, — 5.	Botany, physiological, — 8. Horticulture, — 8.	Advanced work with lectures, — 8.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Mathematics, — 5.	English, — 2. Advanced English, — 5. Latin, — 5. French or German, — 5.	Constitutional history, — 5. History, — 5.	Law lectures, — 1. Military science, — 1. Geology, — 4.

The studies of freshman, sophomore and junior years are required. English and military science of senior year are required; the other studies are elective, according to the following combinations of senior electives: —

Agriculture.	Agriculture.	Botany.
Political economy.	Chemistry.	Chemistry.
Veterinary science.	German or French.	Veterinary science.
Horticulture.	Chemistry.	Entomology.
Entomology.	Astronomy (one semester).	Botany.
Agriculture.	Geology (one semester).	German or French.
	Horticulture.	
Political economy.	Mathematics.	Veterinary.
English.	Engineering.	Chemistry.
History.	Political economy.	German or French.
English.	Botany.	
Latin.	Horticulture.	
Mathematics.	English.	

The choice of Latin as an elective presupposes at least two years' study of the subject.

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.

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.		*X. Chemistry of the Dairy.*	
1. Introduction,	2	1. Introduction,	2
2. The fourteen elements of agricultural chemistry,	14	2. The fourteen elements of agricultural chemistry,	14
3. Rocks and soils,	8	3. The physical properties of milk,	13
4. The atmosphere,	7	4. Analysis of milk, butter, cheese and other dairy products,	13
5. The chemistry of crop-growing,	8	5. Chemistry of the manufacture of dairy products,	13
6. Fertilizers,	8		
7. Animal chemistry,	8		
Total hours,	55	Total hours,	55

ZOÖLOGY.

XI. Animal Life on the Farm.		*XII. Insect Friends and Foes of the Farmers.*	
Total hours,	22	Total hours,	33

AGRICULTURE.

WILLIAM P. BROOKS.

(*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; the crops of the farm, their characteristics, culture and use; (*d*) farm implements and plans of farm buildings; (*e*) animal husbandry, breeds, stock breeding and feeding; (*f*) dairy farming and dairying. 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.

ANIMAL HUSBANDRY AND DAIRYING.

FRED S. COOLEY.

The required course in animal husbandry and dairying comes into the second semester freshman and first semester sophomore years. After a few introductory and historical lectures, a study of the improved breeds of farm live stock fills the half year. The remainder of the year is divided between the study of the principles of animal breeding and a discussion of dairy farming.

The senior elective course covers one semester, and deals with the subjects of feeding animals and the theory and practice of dairying.

A considerable part of the instruction is given by lectures, of which each student obtains a mimeograph copy. Text-books are used in part, and practical demonstrations with live stock and apparatus are given a prominent place. Live stock judging is also an important feature of the course.

The special teaching facilities consist of charts, plates, pictures, stereopticon slides and library references. Besides these, over forty plaster models of typical farm animals, a large collection of pure-bred and grade live stock, comprising representatives of the leading pure breeds, and a very complete outfit of modern dairy machinery and appliances, including churns, butter workers, separators, pasteurizers, Babcock testers, etc., are used for illustration and demonstration.

We aim to thoroughly acquaint every student with the breeds of farm animals, their management and breeding, and with modern methods of dairying.

BOTANY.

George E. Stone. Ralph E. Smith.

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), which includes a study of germination, seeds, seedlings, different types of roots, rhizomes, stems, leaves, flowers, etc. Seventy-five hours are given to this course, the subject being treated by lectures and class-room work. An essay on some ecological subject, such as the methods and devices of seed distribution, is required as a part of this course.

(*b*) Systematic botany and flower analysis (taxonomy and classification). This includes a study of the types of flowers and plant forms, and their phylogenetic relationship, following in general the natural sequence outlined in Engler and Prantl's "Pflanzenfamilie." Forty-four hours are devoted to this course, including lectures and class-room work. In this course three weeks are devoted to flower analysis, and a herbarium of one hundred named species is required of each student. An ecological essay on the relationship existing between flowers and insects, requiring out-of-door observation, is assigned to each student. Dissecting microscopes, magnifying ten to twenty diameters, are employed in both courses, (*a*) and (*b*).

(*c*) Study of the minute structure (histology) and function (physiology) of a series of typical plants. This course includes ninety-two hours during the sophomore year, and is devoted to lectures and laboratory work. It attempts to give a fundamental knowledge of the chemical constituents, detailed structure and functions of the higher plants, and, to a less extent, of some of the lower plants. A herbarium of one hundred named economic species, representing largely grasses, trees and shrubs, is required. This latter is assigned work, and is a continuation of course (*b*).

Elective Course in the Senior Year.

(*d*) Cryptogamic botany, including a study of the lower forms of plant life and their relationships. Especial attention is given to the study of economic fungi, such as give rise to, or are connected with, plant diseases; their method of reproduction, life histories, mode of dissemination, amount of damage caused by them, together with their remedies and the method of making and applying fungicides for specific diseases. Eight hours per week for one year are given to this subject, which includes lectures, collateral reading and laboratory work. The increasing literature pertaining to plant pathology and the treatment of diseases issued by our experiment stations and the United States Department of Agriculture is freely drawn upon for reference in this course.

(*e*) Experimental plant physiology, a study of the plant's functions, including such subjects as respiration, photosynthesis, metabolism, transpiration, soil nutrition, growth, gravitation, physical and chemical properties of the plant organism, the effect of heat, light and moisture, and their relation to normal and abnormal plant development, etc. Eight hours per week, for two-thirds of a college year, are devoted to this subject by those students who do not elect the whole of course (*d*). The experimental work is supplemented by lectures.

Besides the above course, there is one outlined for post-graduate students, which, besides containing necessarily 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 reference books. 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. 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. There are numerous charts representing the common plant diseases, a considerable number of preserved specimens of pathogenic fungi in formalin, and, for the purpose of consultation, use is made of the station herbarium, which contains over twelve thousand sheets of fungi.

CHEMISTRY.

CHARLES A. GOESSMANN. CHARLES WELLINGTON. SAMUEL F. HOWARD.

It is easy to believe that the country which has the best chemists will be the most prosperous and most powerful. It will have, at the lowest cost, the best food, the best manufactured articles, the fewest wastes and un-utilized forms of matter, the best guns, the strongest explosives, the most resistant armor. Its inhabitants will make the best use of their country's resources; they will be the most healthy, the most free from disease; they will oppose the least resistance to favorable evolution; they will be the most thrifty and the least dependent on other nations. Competition to-day between nations is essentially a competition in the science and application of chemistry.

But the educational force of chemistry is not expended in producing chemists alone. An eminent national writer has said: "The education of the *people* in chemistry and the physical sciences is the most paying investment a country can make." Aside from training chemists and providing an important factor in all liberal courses of education, chemical study performs a special service for still other professions. Engineers, physicians and physiologists often find their success measured directly by the extent of their chemical training.

Accurate observation, logical thinking, systematic and constant industry are absolute requisites for the successful chemical student. And these are the factors which make men of affairs, administrators of large interests and statesmen. A few names from the large number of men in high public service, who were first chemists by profession, may be mentioned. Among presidents of universities and colleges are Eliot of Harvard, Rogers and Crafts of the Massachusetts Institute of Technology, Drown of Lehigh, Morton of Stevens Institute, Dabney of Tennessee, Venable of North Carolina, Clark of our own institution; and, from our alumni, Washburn of Rhode Island and Stone of Purdue; among statesmen, Senator Hill of Colorado, Lords, Prime Minister Salisbury, Playfair and Roscoe of England and J. B. Dumas and Berthelot of France.

Courses adapted to the requirements mentioned are offered at this college. Instruction is given in general and organic chemistry, all kinds of analysis, including that of minerals, and preparations. The needs of students fitting for positions in experiment stations, and those taking courses in entomology, botany and other biological subjects, medicine, veterinary science, dairy work and agriculture, receive special attention.

Instruction is given by lectures, conversations and laboratory exercises, with written and oral examinations.

Eight courses are offered in chemistry. Their time, aim and arrangement are briefly indicated in the following table:—

Chemistry at the Massachusetts Agricultural College (Time stated in Half-years).

COURSES.	B.S.		M.S.		PH.D.		SPECIAL.	
	Major.	Minor.	Major.	Minor.	Major.	Minor.	Agriculture.	Dairy.
Freshman, .	1	1	1	1	1	1	–	–
Sophomore, .	2	2	2	2	2	2	–	–
Junior, . .	2	2	2	2	2	2	–	–
Senior, . .	2	–	2	–	2	–	–	–
Graduate, .	–	–	4	2	6	3	–	–
	7	5	11	7	13	8	1*	1*

In the regular courses the first half-year are alike for all students; Professor Howard gives lectures with experiments and laboratory practice in the last half of freshman year, on general principles of chemistry and non-metals; in the next half-year, on the metals; and in the last half of sophomore year, on dry mineral analysis.

Professor Wellington gives lectures with experiments and laboratory practice in the first junior half-year, on humid qualitative analysis; in the second half-year, on organic chemistry.

During the senior year Professor Goessmann gives lectures on the chemistry of fertilizers and of commercial industries, and on organic chemistry.

During the same year Professor Wellington gives lectures and a course of practice in advanced laboratory methods.

* Every winter.

The work of the graduate years varies according to the attainments and purpose in view of the individual student. It is conducted by Professor Wellington, with a course in physical chemistry by Professor Howard.

Fourteen rooms, well adapted to their special uses, are supplied with all kinds of apparatus and chemical materials. 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 reagents, 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. This leads to analysis of the simpler combinations of the elements and their artificial preparation, which is followed by 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, such 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 weighing room has six balances and improved apparatus for determining densities of solids, liquids and gases.

Apparatus and Collections.—The apparatus includes, beside 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.

ENGLISH.

George F. Mills. Herman Babson.

The aim of this department is to secure: (*a*) ability to give oral and written expression of thought in correct, effective English; (*b*) acquaintance with the masterpieces of American and English literature; (*c*) ability to present, logically and forcibly, oral and written arguments on propositions assigned for debate. The following subjects are studied: —

1. *Rhetoric.* — The course in rhetoric comprises a study of the choice of words, the theory of phraseology, special objects in style, the sentence, the paragraph, the whole composition in its plan, arrangement and development. This is followed by lectures on invention, in which the elements and underlying principles of literature are discussed. The students are expected to give practical illustration of the principles taught in written exercises, themes and compositions that are required throughout the course.

2. *Oratory.* — Individual drill in declamation, first in private and then before the class, is given during freshman and sophomore years. The choice of speakers for the Burnham prizes is based upon this work. In the junior year at least three orations, upon subjects assigned by the instructor or chosen by the student, are written and delivered before the class. Every oration is criticised by the instructor before it is committed to memory by the student. The choice of speakers for the Flint prizes in oratory is based upon this work.

3. *Literature.* — American literature is studied in the spring semester of sophomore year and English literature in the fall and spring semesters of junior year. Text-books are used and attention is given to the *history* of the literature. This, however, is made secondary to the literature itself. An attempt is made to interest the student in literature, and to secure familiarity with authors through their writings rather than through what others have written about their writings.

4. *Argumentation.* — The required English of senior year is a course in written and oral argumentation. The principles of the subject are studied in text-books and in the work of eminent debaters, and the practical illustration and use of these principles are secured by written briefs and forensics and by oral debate.

The elective course in English, offered in senior year, comprises a study of the English language in its origin and development and of a limited portion of English literature. Poets and prose writers of the eighteenth century and of the early part of the nineteenth century are studied, for the purpose of making acquaintance with their thought and style and as illustrations of the principles of literary criticism.

HORTICULTURE.

SAMUEL T. MAYNARD.

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.

JOHN E. OSTRANDER. PHILIP B. HASBROUCK.

(*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.

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: algebra and geometry in the freshman year; trigonometry, mechanical drawing, mechanics and plane surveying, — the latter embracing lectures and field work, 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.

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

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.

MILITARY.

JOHN ANDERSON, CAPTAIN, U. S. A.

This was established by act of Congress, and all students, unless physically disabled, are required to attend its exercises. Its object is three-fold: 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 and freshman classes, and a weekly inspection of the rooms in the dormitories.

POLITICAL SCIENCE.

CHARLES S. WALKER.

Economics. — 1. The elements of political economy are taught by means of text-book and lectures, the aim being to make the student familiar with the facts, definitions, principles and laws of the science which are generally accepted, while at the same time he is trained to criticise theories, scrutinize facts and weigh arguments. 2. The industrial history of England and the United States is studied. 3. The following elective courses are offered: (1) economics of agriculture; (2) banks and banking; (3) problems of the currency; (4) trusts, or monopolistic corporations; (5) transportation; (6) socialism. 4. Practical economics. Each member of the class selects a question for investigation, in which he is interested, and devotes two or three months to its solution. The results of his work are presented in a paper read before the class, explained, and defended from criticism.

The purpose of the whole course is to fit the student to understand the economic movements of his time, so that he can successfully solve the problems which may confront him.

Constitutional History. — 1. Political institutions. By use of text-book and lectures the student is led to understand what is the government, municipal, State and federal, now existing in the United States. This government is compared and contrasted with the governments of England, France and Germany. Care is taken to familiarize the student with the practical methods of legislation, of nominating conventions, of elections and of administration. 2. Constitutional history of England and of the United States, with discussions relating to the origin, nature, scope and purpose of government.

VETERINARY.

JAMES B. PAIGE.

To give a general idea of the principles of veterinary science in such simple and comprehensive manner as to enable one to give animals under his supervision such care and treatment as will tend to secure and maintain a healthful condition, thereby preventing the occurrence of disease among them, is the aim of the course of study in this department. (*a*) The hygiene of farm animals; (*b*) the anatomy and physiology of the bony, muscular, circulatory, respiratory, genital and digestive systems; (*c*) a study of the more common pathological processes and the general causes, symptoms and effects of disease; (*d*) the consideration of the diseases of the different organs, particularly as regards causes, effects and prevention ; (*e*) the nature, action and uses of different drugs. This study is elective.

PHYSIOLOGY AND ZOÖLOGY.

RICHARD S. LULL.

Physiology. — This course is offered to the sophomore class during the fall semester. 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.

Junior zoölogy includes a thorough laboratory study of the morphology of a series of typical animals, ranging from the most lowly microscopic forms to the mammal ; supplemented by a parallel course of lectures, whose aim is to show the relationship and development of the groups already studied, and to render orderly the knowledge gained through the medium of the microscope and scalpel. The students have access to a reference library belonging to the department, as well as to the very complete zoölogical museum. Collateral reading is encouraged, and occasional quizzes are given, as a test of the student's knowledge from all sources.

Graduate zoölogy courses in invertebrate and vertebrate morphology and in comparative embryology are offered, constituting the requirements for one minor subject for candidates for the degree of Doctor of Philosophy.

ENTOMOLOGY.

CHARLES H. FERNALD. HENRY T. FERNALD.

A course of six hours a week is offered in entomology, during the spring semester, 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.

Senior Entomology. — During the senior year such members of this class as elect advanced entomology take a course of lectures on the external and internal anatomy of insects, and on the various methods by which the injurious forms are destroyed or held in check. The laboratory work consists of a critical study of the external and internal anatomy of members of the different groups, followed by the determination of insects of each group. In connection with this work a careful study of the literature is made, and familiarity with the analytical keys and the more important articles on injurious species is obtained. During the spring semester much of the time is spent in the field, where the student is taught how to look for and find injuries caused by insects, to recognize the species by the nature of the injuries, and how best to deal with each case, either by the use of insecticides or other methods. 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 occupation he intends to follow after graduation, and is then advised to prepare his thesis on those insects with which he will have most 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.

Graduate Entomology. — 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 to do 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.

A three-years' course, leading to the degree of Doctor of Philosophy, is in active operation, three subjects — botany, chemistry and entomology, arranged as a major and two minors — being required. In those cases where entomology is chosen as the major subject, the course consists of lectures and laboratory work, some of the topics treated being the following: —

General morphology of insects: embryology, life histories and transformations, histology, phylogeny and relation to other arthropods; hermaphroditism, hybrids, parthenogenesis, pædogenesis and heterogamy; colors, — chemistry of color in insects; luminosity; deformities of insects; variation; duration of life.

Œcology of insects: dimorphisms; polymorphisms; mimicry, warning coloration; insect architecture; fertilization of plants through the agency of insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects; insects as disseminators of disease; enemies of insects, vegetable and animal, including parasitism.

Economic entomology: general principles; insecticides; apparatus; special cases (borers, etc.); photography of insects and their work; methods of drawing for illustrations; field work on insects; insect legislation.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and in existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

In connection with these topics, corresponding laboratory work is given as far as possible, and, in addition, investigations on subjects not previously studied are made, and the results published in the form of graduation theses.

EXPENSES.

Room rent, in advance, $12 to $24 per semester,	$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,	$151 15	$291 55

In addition to the above expenses, $80 tuition is charged to foreigners.

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, $15 per semester used; zoölogical, $4 per semester used; botanical, $1 per semester used by sophomore class, $3 per semester used by senior class; entomological, $3 per semester 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.

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 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.

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.

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 1901 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 botanical department offers in 1901 a prize of five dollars for the best collection of pathogenic fungi, and also a prize of five dollars for the best collection of lichens.

The prizes in 1900 were awarded as follows: —

Burnham Rhetorical Prizes: Maurice A. Blake (1902), first; John C Hall (1902), second; George E. O'Hearn (1903), first; William W. Peebles (1903), second.

Flint Oratorical Prizes: Edward S. Gamwell (1901), first; George R. Bridgeforth (1901), second.

Grinnell Agricultural Prizes: Mark H. Munson (1900), first; Morris B. Landers (1900), second.

Hills Botanical Prizes: Arthur A. Harmon (1900), first; Mark H. Munson (1900), second.

Dairy Prizes, given by the Massachusetts Society for Promoting Agriculture: Edwin H. Cande, first (fifty dollars in gold); Charles W. Trow, second (thirty dollars in gold); William A. French, third (twenty dollars in gold).

RELIGIOUS SERVICES.

Chapel exercises are held every week-day at 8 A.M. Public worship in the chapel every Sunday at 9.15 A.M. Further opportunities for moral and religious culture are afforded by a Bible class taught by one of the professors for an hour every Sabbath afternoon and by religious meetings held on Sunday afternoon and during the week, under the auspices of the College Young Men's Christian Association.

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 breds 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 stock of Southdown sheep. Swine are represented by the Middle Yorkshire, Chester White, Poland China, Berkshire, Tamworth and Belted breeds. Besides work horses, we have a number of pure bred Percherons, used for breeding as well as for work ; and a few fine 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 material 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.

The botanical department is located in the building known as the Botanical Museum, and contains the botanical laboratory, lecture room and botanical museum. Adjacent to the botanical laboratory are a collection of native and ornamental shrubs available for botanical study, and a conservatory containing a series of houses ranging from twelve to twenty-five feet high and twenty-five to forty feet wide, representing 7,190 square feet ground surface, which is devoted to the cultivation of a large variety of exotic plants.

The Botanical Museum contains the Knowlton herbarium, of over thirteen thousand species of phanerogamous and the higher cryptogamous plants. There are about twelve hundred specimens of lichens and fifteen hundred specimens of mosses and liverworts. These include many foreign species, as well as such valuable local collections as Tuckerman's and Frost's. The collection of flowering plants has been entirely rearranged according to the system of Engler and Prantl during the past year, and the specimens have been provided with new genus covers and labels. A special feature of the herbarium is a comparatively large collection of old Massachusetts plants, which formerly constituted the State collection located at Boston. It is the intention to make the collection of Massachusetts plants as complete as possible for the purpose of reference. The museum 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 or turgidity of its growing cells the enormous weight of five thousand pounds.

The Botanical Lecture Room, having a capacity for sixty students, 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 forty compound microscopes, representing Leitz', Reichert's, Bausch and Lomb's, Beck's, Queen's and Tolles' patterns, 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 arcauxanometer, 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. The commercial plantation, called the "Clark orchard," consisting of seven acres, contains five hundred and twenty-eight trees of a few leading varieties of apples, pears, plums and peaches, planted in the spring of 1898. This is now in condition to produce fruit with which the commercial side of fruit growing may be more fully illustrated than in the older orchards, which contain only one or two trees of each kind.

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.

Department of Zoölogy.

Zoölogical Laboratory. — This very necessary adjunct to zoölogical teaching is a large, well-lighted room, situated in the old chapel building, and fitted with the necessary tables, trays and general apparatus, besides fifteen Zentmeyer microscopes, two dissecting microscopes, hand lenses and the like. There have lately been added aquaria, in which the various types studied may be seen in as nearly as may be their natural environment.

A reference library is kept in the laboratory, or in the museum when the former is not in session, and the students are urged to become familiar with the best zoölogical literature by constant use of the books.

Zoölogical Lecture Room. — An ample lecture room is situated in South College, adjacent to the museum. It is supplied with a set of Leuckart charts and many special ones as well, and with a complete set of Auzoux models illustrative both of human and comparative anatomy. A special set of typical specimens are being set apart for class illustration, although the more extensive museum collection is drawn upon for the same purpose.

Museum of Zoölogy. — The museum, of course, is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as fully as possible the fauna of the Commonwealth and those types which show the evolution and relationship of the members of the animal kingdom. A department of ethnology has lately been established, and already one case is full to overflowing with articles of human interest, mainly from the Island of Yezzo, collected by the late Colonel Clark. The museum is open to the public during a portion of each afternoon, and at present is in charge of Mr. D. Nelson West of the class of 1902 and Mr. Clarence E. Gordon of the class of 1901. The interest of the students in the museum is attested by the gifts which are continually being received from them.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glassware, and one portion is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of over forty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject, and this is supplemented by the library of Amherst College and by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room in the laboratory is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. The laboratory being directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room, fitted up for the analysis of insecticides and other chemico-entomological work; and the greenhouse, where plants infested by injurious insects are under continual observation, and the subject of experimental treatment, — are all available to the student, and in addition, several private laboratory rooms and a photographing room with an unusually good equipment of cameras are provided. The large hothouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for the study of the attacks of injurious insects under natural conditions.

Veterinary Department.

With a new and well-equipped laboratory and hospital stable, the department has unsurpassed facilities for the study of animal diseases. The department stands ready to investigate any outbreak of obscure disease among animals in the State, and it cordially invites any one to send specimens from diseased animals for examination, which will be made free of expense to the sender. It will not undertake, however, the treatment of animals suffering from common diseases.

The department can well carry out the course of instruction outlined, as it has been provided with a new laboratory and hospital stable for its special use. The former, fifty-nine feet wide and sixty-three feet ten inches deep, contains on the lower floor a large general laboratory, recitation room, office, animal room and store closets. Connected with the laboratory is a large incubator built into the building, an incubator room for portable incubators, fume chambers, balance cabinet, microscope cabinet, etc. The floor is asphalt, laid upon cement work. The walls are of enamelled brick.

The recitation room is sufficiently large to accommodate about forty students. On the second floor are two private laboratories, provided with store closets, fume chamber, water, gas and electric lights, a photographing room with dark room, janitor's rooms and a museum.

The hospital stable, located fifty feet in the rear of the laboratory, is of brick, consisting of three parts. A two-story upright portion, thirty-three by thirty feet in size, contains on the lower floor an office and pharmacy, an operating room with water-tight floor, a single stall and a large box stall, grain room and closets. The upper floor is used for storage purposes.

Extending to the south and west from the main part is an L, one hundred and four feet in length and twenty-nine feet in width.

This L is one story in height, and is divided by brick wall partitions into six sections, affording quarters for horses, cattle, sheep and swine. Each section is entirely independent of every other one, having separate ventilator, water, heat and light. The floors are of Portland cement, laid directly upon the ground. Everything has been arranged in this portion of the building to allow of the stabling of diseased animals, at the same time reducing to a minimum the liability of spreading infection. The floors, walls, ceilings and fixtures have all been so constructed as to allow of easy and complete disinfection.

In the rear of the main stable is an addition, thirty-four by twenty-two feet in size. This contains the kennels, a section for poultry and a dissecting room.

The hospital has sufficient capacity for the accommodation of about fifty animals.

The museum is well equipped with the apparatus necessary to illustrate the subject as taught in the class room, and in addition there is the clinical material to be observed in the hospital. The museum contains in part an improved Auzoux model of the horse, 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; five 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 cow; 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.

The laboratory is supplied with the usual apparatus required for work in histology, bacteriology and pathology, consisting of Zeiss, Leitz and Reichert microscopes, Lautenschlager's incubator and hot-air sterilizer, steam sterilizers, etc.

Library.

This now numbers 21,665 volumes, having been increased during the year, by gift and purchase, 1,625 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 from eight o'clock to half-past five in the afternoon, and an hour and a half in the evening.

ENTRANCE EXAMINATION PAPERS USED IN 1900.

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

Algebra.

1. Resolve into factors (*a*) $3x^2-19x-14$, and (*b*) $1-343x^3$.

2. Solve $\dfrac{5}{x}+\dfrac{16}{y}=79$

   $\dfrac{16}{x}-\dfrac{1}{y}=44$

3. Simplify and reduce to lowest terms $\dfrac{x+5+\dfrac{6}{x}}{1+\dfrac{6}{x}+\dfrac{8}{x^2}}$

4. Solve $x+\sqrt{1+x^2}=\dfrac{2}{\sqrt{1+x^2}}$

5. Solve $\dfrac{6\sqrt{x}-11}{3\sqrt{x}}=\dfrac{2\sqrt{x}+1}{\sqrt{x}+6}$

6. Solve $\begin{cases} x(x+y)=40 \\ y(x-y)=6 \end{cases}$

Geometry.

1. Prove that the sum of the angles of any triangle equals two right angles.

2. The angle at the vertex of an isosceles triangle *A B C* is equal

to five-thirds the sum of the equal angles *B* and *C*. How many degrees are there in each angle of the triangle?

3. Prove that the diagonals of a parallelogram bisect each other.

4. Prove that, in the same circle, or equal circles, two central angles are in the same ratio as their intercepted arcs.

5. Prove that the angle between two chords, intersecting within the circumference, is measured by one-half the sum of the intercepted arc.

Physical Geography.

1. Describe and locate the following: sirocco, trade winds, monsoon, tornado and typhoon.

2. Describe the action of water in shaping the contour of the earth's surface.

3. What are glaciers? What is the most probable theory of their formation? Define the terms lateral moraine and terminal moraine.

4. Name and locate the zones and the circles which separate them.

5. What are tidal waves? What phenomena do they accompany? What is their cause?

Civil Government.

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

1. Name *three* offices held by men connected with the government of the *town* or *city* in which you live. Are these men *elected* or *appointed?* By whom? How long may they hold the office? Do they receive pay for their services?

2. Name *three* offices held by men connected with the government of the *State* in which you live. Are these men *elected* or *appointed?* If elected, by whom? How long may these men hold the office to which they have been elected? State *two* qualifications of a voter in your State.

3. Name *three* offices held by men connected with the United States government, and who are *elected* to these offices. By whom are they elected? State clearly and fully the manner of electing the President of the United States. What is the electoral college?

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 elected? How long do they hold this office of law-maker?

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? Where and how often does the Congress meet?

6. What is a tax? a poll tax? a direct tax? an indirect tax? When is an *indirect* tax paid? How is the amount of every citizen's *direct* tax determined? Name *three* objects for which a town may levy a tax upon its citizens; three objects for which a county tax is levied. Name any institution in the town of Amherst for the support of which the citizens of your town are taxed.

Physiology.

1. Name and locate all of the bones of the skull, bounding each bone as you would bound the countries on a map.
2. What is cartilage? Tell of its structure, the different sorts that may be found in the body and their uses.
3. Name, describe, and give the functions of the different glands which pour their secretions into the alimentary canal.
4. Define the following terms as applied to the human body: co-ordination, reflex-action, sensation, secretion and assimilation.
5. How would you classify yourself with reference to the rest of the animal kingdom? Give your reasons.

English.

Note. — Penmanship, punctuation and spelling are considered in marking this paper. The time allowed is an hour and a half.

1. Mention three important periods in the lives of any three of the following writers: Addison, Goldsmith, Scott, Cooper and Whittier; and then give the dates, as nearly as you can, of the lives of *all* of them.
2. State briefly for what Goldsmith, Scott and Cooper were especially noted.
3. From the following topics, write clearly and interestingly upon any three. Do not, however, choose more than one topic from any particular group. Give your title in each case.

Group a, "Sir Roger de Coverley."

The seven members of the Spectator Club.

Sir Roger's country house.

Sir Roger at church.

Sir Roger, — the seventeenth century English country gentleman.

Group b, "The Vicar of Wakefield."

The Primrose household.

A comparison of Olivia Primrose and Sophia Primrose.

Mr. Burchell, — his relation to the Primrose family.

Squire Thornhill.

Mr. Primrose in prison.

In what way does Mr. Primrose echo traits of his author, Mr. Goldsmith?

Group c, "Ivanhoe."

The relation between the Normans and the Saxons, as shown in "Ivanhoe."

A description of Cedric the Saxon, and of his dining hall.

The Ashby tournament.

Friar Tuck's home in the forest.

The character of Isaac of York.

The character of Rebecca, Isaac's daughter.

The trial of Rebecca.

What we learn of Robin Hood and his band from "Ivanhoe."

Group d, "The Last of the Mohicans."

The plot of "The Last of the Mohicans."

The character Hawk-Eye.

The characters of Cora and Alice compared.

The treacherous Indian Scout.

The massacre after the surrender of Fort William Henry.

Group e, "Snow Bound."

"Snow Bound" as a revealer of Whittier's early home.

Parts of "Snow Bound" that especially appeal to me.

Interesting winter scenes described in "Snow Bound."

Old New England life as described in "Snow Bound."

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.

PINCHOT — "Primer of Forestry." Forestry Division, United States Department of Agriculture.

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

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

MAYNARD — "Landscape Gardening." John Wiley & Sons, 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.

GREEN — "Vegetable Gardening." Webb Publishing Company, St. Paul, Minn.

GREEN — "Forestry of Minnesota." Webb Publishing Company, St. Paul, Minn.

VOORHEES — "Fertilizers." Macmillan & Co., New York.

ROBERTS — "The Fertility of the Land." Macmillan & Co., New York.

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

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.

ARMSBY — "Manual of Cattle Feeding." John Wiley & Sons, New York.

WING — "Milk and its Products." Macmillan & Co., New York.

NEWTH — "Text-book of Inorganic Chemistry." Longmans, Green & Co., New York.

REYCHLER and McCRAE — "Outlines of Physical Chemistry." Whitaker & Co., New York.

NOYES — "Qualitative Analysis." Macmillan & Co., New York.

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

TALBOT — "Quantitative Chemical Analysis." Macmillan & Co., New York.

FRESENIUS — "Quantitative Chemical Analysis." John Wiley & Sons, New York.

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

REMSEN — "The Compounds of Carbon." D. C. Heath & Co., Boston.

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

VULTÉ and NEUSTADT — "Inorganic Preparations." G. G. Peck, New York.

COHEN — "Practical Organic Chemistry." Macmillan & Co., New York.

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

BRUSH — "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.

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

WELLS — "College Algebra." D. C. Heath & Co., Boston.

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

PHILLIPS and STRONG — "Elements of Trigonometry." Harper & Brothers, New York.

NICHOLS — "Analytic Geometry." D. C. Heath & Co., Boston.

MERRIMAN — "A Text-book on the Mechanics of Materials." John Wiley & Sons, New York.

CARHART — "University Physics." Allyn & Bacon, Boston.

OSBORNE — "An Elementary Treatise on the Differential and Integral Calculus." D. C. Heath & Co., Boston.

MERRIMAN — "A Text-book on Roofs and Bridges." John Wiley & Sons, New York.

YOUNG — "A Text-book of General Astronomy." Ginn & Co., Boston.

PHILLIPS 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.

BRADFORD — "The Lesson of Popular Government." Macmillan & Co., New York.

BULLOCK — "Introduction to the Study of Economics." Silver, Burdett & Co., Boston.

HADLEY — "Economics." J. P. Putnam's Sons, New York.

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

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

HALLECK — " History of English Literature." American Book Company, Boston.

JOHNSON — " English Words." American Book Company, Boston.

CORSON — " Selections from Chaucer's Canterbury Tales." Macmillan & Co., New York.

WEBSTER — " English: Composition and Literature." Houghton, Mifflin & Co., Boston.

BAKER — " The Principles of Argumentation." Ginn & Co., Boston.

EDGREN — " Complete French Grammar." D. C. Heath & Co., Boston.

LABOULAYE — " Contes Bleus." D. C. Heath & Co., Boston.

LAMARTINE — " Jeanne d'Arc." D. C. Heath & Co., Boston.

CORNEILLE — " Le Cid." D. C. Heath & Co., Boston.

MOLIÈRE — " Le Bourgeois Gentilhomme." D. C. Heath & Co., Boston.

RACINE — " Esther." D. C. Heath & Co., Boston.

HUGO — " Ruy Blas." D. C. Heath & Co., Boston.

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

JOYNES-MEISSNER — " German Grammar." D. C. Heath & Co., Boston.

GUERBER — " Märchen und Erzählungen." D. C. Heath & Co., Boston.

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

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

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 four hundred 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, Jan. 1, 1900, to Jan. 1, 1901.*

	Received.	Paid.
Cash on hand Jan. 1, 1900, ...	$7,700 99	–
State Treasurer, Morrill fund, . . .	16,666 66	–
State Treasurer, endowment fund, . .	9,749 45	–
State Treasurer, maintenance appropriation,	5,000 00	–
State Treasurer, maintenance appropriation, special, ...	2,500 00	–
State Treasurer, maintenance appropriation, special, ...	6,000 00	–
State Treasurer, scholarship appropriation,	10,000 00	–
State Treasurer, labor appropriation, . .	5,000 00	$4,710 98
Gassett scholarship fund, income, . .	60 40	20 00
Mary Robinson scholarship fund, income, .	35 84	–
Whiting Street scholarship fund, income, .	76 10	63 90
Grinnell prize fund, income, . . .	50 00	40 00
Hills fund, income, ...	356 16	388 82
Library fund, income, ...	421 84	421 84
Burnham emergency fund, income, . .	122 08	101 22
Salary, ...	–	29,160 90
Extra instruction, ...	–	451 50
Botanical laboratory, ...	98 40	97 18
Chemical laboratory, ...	817 61	743 99
Entomological laboratory, ...	20 00	54 51
Zoölogical laboratory, ...	130 57	219 73
Veterinary laboratory, ...	1,000 00	1,196 14
Term bill, ...	2,662 26	1,033 28
Advertising, ...	–	269 33
Electric equipment, ...	699 33	2,895 49
Agricultural department, ...	986 73	2,006 96
Farm, ...	6,639 44	9,376 79
Horticultural department, ...	4,168 49	6,781 15
Expense, ...	1,543 50	13,482 58
Insurance, ...	–	554 00
Investment, ...	5 00	–
Cash on hand Jan. 1, 1901, ...	–	8,440 56
	$82,510 85	$82,510 85

This is to certify that I have this day examined the accounts from Jan. 1, 1900, to Jan. 1, 1901, 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 eight thousand, four hundred forty dollars and fifty-six cents ($8,440.56), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Dec. 26, 1900.

Cash on hand, as shown by the Treasurer's Statement, belongs to the following Accounts:

Gassett scholarship fund,	$66 42
Mary Robinson scholarship fund,	12 28
Whiting Street scholarship fund,	24 11
Grinnell prize fund,	40 00
Hills fund,	117 90
Labor appropriation,	950 85
Burnham emergency fund,	115 56
Veterinary laboratory,	104 89
College,	7,008 55
	$8,440 56

Bills receivable Jan. 1, 1901.

Botanical laboratory,	$39 00
Chemical laboratory,	373 26
Entomological laboratory,	14 00
Zoölogical laboratory,	119 70
Term bill,	798 71
Electric equipment,	216 71
Horticultural department,	897 36
Expense,	91 65
	$2,550 39

Bills payable Jan. 1, 1901.

Electric equipment,	$105 75
Horticultural department,	262 88
Expense,	181 70
Labor appropriation,	40 06
	$590 39

Inventory — real estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 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	
Chemical laboratory,	8,000 00	
Amounts carried forward,	$104,575 00	$44,350 00

Amounts brought forward,	$104,575 00	$44,350 00
Entomological laboratory,	3,000 00	
Veterinary laboratory and stable,	22,500 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	
		213,775 00
		$258,125 00

EQUIPMENT.

Botanical department,	$3,710 00
Horticultural department,	12,578 69
Farm,	18,265 47
Chemical laboratory,	1,804 00
Botanical laboratory,	2,606 53
Entomological laboratory (estimated),	15,000 00
Zoölogical laboratory,	1,970 97
Zoölogical museum,	5,912 56
Veterinary laboratory,	5,351 75
Physics and mathematics,	5,338 00
Agricultural department,	3,424 80
Library,	21,473 00
Fire apparatus,	625 00
Furniture,	850 00
Text-books,	275 00
Tools and lumber,	265 45
Electric equipment and supplies,	6,422 70
	$105,873 92

SUMMARY.

Assets.

Total value of real estate, per inventory,	$258,125 00
Total value of equipment, per inventory,	105,873 92
Bills receivable,	2,550 39
Notes and interest,	123 28
Investment, New York Central & Hudson River Railroad stock,	100 00
Cash on hand,	7,008 55
	$373,781 14

Liabilities.

Bills payable,	$590 39	
Burnham emergency fund,	3,495 57	
		$4,085 96
		$369,695 18

MAINTENANCE FUNDS.

	Fund.	Income in 1900.
Technical educational fund, United States grant,*	$219,000 00	$7,300 00
Technical educational fund, State grant,*	141,575 35	2,449 45
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890,	–	16,666 66
Hills fund,	8,542 00	356 16

MAINTENANCE APPROPRIATIONS.

State appropriation made by Legislature of 1896 for four years,	–	5,000 00
Labor appropriation made by Legislature of 1896 for four years,	–	5,000 00
State appropriation made by Legislature of 1899 for one year not paid in 1899,	–	2,500 00
State appropriation made by Legislature of 1900 for four years ($8,000),	–	6,000 00

SCHOLARSHIP FUNDS.

Whiting Street fund,	$1,260 00	50 40
Gassett fund,	1,000 00	40 40
Mary Robinson fund,	858 00	35 84

SCHOLARSHIP APPROPRIATION.

State appropriation by the Legislature of 1886,	–	10,000 00

PRIZE FUND.

Grinnell prize fund,	$1,000 00	50 00

MISCELLANEOUS FUNDS.

Library fund,	$10,546 12	421 84
Burnham emergency fund,	5,000 00	122 08
		$55,992 83

* Two-thirds of the income of these funds comes to the college.

GIFTS.

From N. I. Bowditch, Framingham, Keystone corn husker and shredder.

N. I. Bowditch, Framingham, Berkshire boar.

Massachusetts Society for Promoting Agriculture, Boston, one hundred dollars in prizes for Dairy School.

Massachusetts Society for Promoting Agriculture, Boston, fifty dollars for special lectures for Dairy School.

Massachusetts Society for Promoting Agriculture, Boston, two hundred dollars for the purchase of equipment in the veterinary department.

Edmund Boltwood, Ottawa, Kan., plough and ancient cannon from Philippine Islands.

Nitrate of Soda Syndicate, New York, five tons nitrate of soda.

German Kali Works, New York, three and one-half tons muriate of potash, two and one-half tons high-grade sulfate of potash, one-half ton kainite, one-fourth ton low-grade sulfate of potash, one hundred pounds silicate of potash.

Genesee Salt Company, New York, one barrel salt.

Heller & Merz Company, New York, one gallon Alderney butter color.

Bullock Manufacturing Company, Flint, Mich., perfection calf dehorner.

James J. H. Gregory & Son, Marblehead, eight varieties seed corn on the ear; thoroughbred seeds of corn, onion, carrot and cabbage.

Peter Henderson & Co., New York, thoroughbred seeds of onion, carrot, celery and cabbage.

A. E. Blount, Wellesley, frames containing samples of grasses.

Bowker Fertilizer Company, Boston, insecticides and fungicides.

W. H. Owen, Catawba Island, O., insecticides and fungicides.

Division of Botany, Department of Agriculture, Washington, D. C., seeds.

F. Barteldes & Co., Lawrence, Kan., seeds.

W. A. Burpee & Co., Philadelphia, Pa., seeds.

From Elmer Stearns, Los Angeles, Cal., seeds.

J. H. Leheman & Co., Enon, O., plants.

A. B. Howard, Belchertown, plants.

J. B. Stearns, Danbury, Conn., plants.

Luther Burbank, Santa Rosa, Cal., scions.

C. S. Dickinson, North Amherst, several specimens for the veterinary museum.

R. T. Booth Company, Ithaca, N. Y., inhaler outfit for the treatment of diseases of the respiratory tract of animals.

Newton Wallace, Amherst, ancient post axe, common eel.

George F. Parmenter (M. A. C., 1900), Dover, nematode worm.

James B. Henry (M. A. C., '01), Scitico, Conn., osprey.

Percy F. Felch (M. A. C., 1900), Worcester, two pine grosbeaks, three cedar birds.

Wallace R. Pierson (M. A. C., '01), Cromwell, Conn., one regal moth, one catocala moth.

Alexander C. Wilson (M. A. C., '01), Boston, great blue heron.

Ernest L. Macomber (M. A. C., '01), Taunton, great blue heron.

Julio M. Ovalle (M. A. C., '01), Santiago, Cuba, redstart.

John C. Barry (M. A. C., '01), Amherst, striped snake.

Maurice A. Blake (M. A. C., '02), Millis, Dekay's brown snake (alive).

Charles M. Kinney (M. A. C., '02), Northampton, Dekay's brown snake (alive).

Robert H. Vaughan (M. A. C., '97), Worcester, saw whet owl.

W. E. Burnham, Greenfield, two spread adders (one alive).

Clifford L. Stacy (M. A. C., '99), Gloucester, young bald eagle.

Loans to the College and Experiment Station.

From Vermont Farm Machine Company, Bellows Falls, Vt., four separators, one separator bowl, one cream pan, one swing churn.

D. H. Burrell & Co., Little Falls, N. Y., one churn, one tester.

DeLaval Separator Company, New York, four separators.

P. M. Sharpless, West Chester, Pa., one separator.

National Dairy Machine Company, Newark, N. J., one separator with stand.

United States Butter Extractor Company, Newark, N. J., two separators.

FARM REPORT.

The operations of the college farm for the past year call for no extended notice. In pursuance of the policy of close retrenchment followed for the past few years, the work undertaken has been for the most part restricted to the ordinary necessary routine. The chief improvement is that in live stock, in which we have a larger number of well-bred animals in almost all classes. The increase in our inventory is to be ascribed almost wholly to this change. Values assigned to the numerous items included in our equipment have been generally largely reduced, to cover the inevitable depreciation, and still the aggregate inventory for this year is $18,255.47, against $16,339.95 for last year. This difference represents real and not fictitious values, and must be kept in mind in estimating the economic results of the year's operations.

The nature of the farm operations and the financial results with the several crops are shown in the following table : —

College Farm Crops, 1900.

CROPS.	Acres.	Total Product.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.*	Labor and Seed.			
Hay, ...	65	-	129.25	$117 56	-	$2,326 50	-	-
Rowen, ...	-	-	29.13	-	-	524 34	-	-
Corn, ...	36	615 shelled.	376 silage. 36 fodder.	425 00	$675 45	1,873 50	$773 05	-
Potatoes, ...	7	958 large. 169 small.	-	99 33	276 95	576 90	200 62	-
Celery, ...	2	420 doz. bunches.	-	85 48	251 85	483 00	145 67	-
Japanese millet, ...	4	180 seed.	10 straw.	40 00	93 60	470 00	336 40	-
Soy beans, ...	2	60 seed.	2 straw.	16 00	51 05	126 00	58 95	-
Turnips, ...	⅓	96	-	6 32	8 00	19 20	4 88	-
Carrots, ...	½	-	5½	11 05	28 32	33 00	-	$6 37
Mangels, ...	½	-	15	13 76	18 88	52 50	19 86	-

* One-half the value of manure and three-fourths the value of the fertilizers.

System of Manuring.

The large quantity of manure made upon our farm is taken from stables to pits adjoining, which are water-tight, and covered by shed roofs. These have capacity only to hold the accumulations of a few weeks, and none of our manure, therefore, lies in these pits for any considerable length of time. As a rule, it is hauled directly from the pits to the fields, and is spread at once. It is generally put on after the fields have been ploughed, and wheel-harrowed in, or it may be that it is turned under by shallow ploughing. If the season is winter, it lies upon the surface until spring. In connection with manure we use a moderate quantity of fertilizers, supplying chiefly potash for most of our hoed crops and nitrate of soda for our old mowings, in which there is but little clover. We have within the last two or three years given much of the low, heavy soil of the farm a dressing of lime, using for this purpose either freshly slaked "forked lime" * or air-slaked lime in quantities of about one ton per acre. Such lime costs about $4.50 to $5 per ton laid down here. We prefer to apply after ploughing and to wheel-harrow in. Fall or early spring is the best time. The manures used for the several crops the past season are shown in the following table: —

* Forked lime is fine quicklime.

Manure and Fertilizers for the Several Crops, per Acre, 1900.

FERTILIZERS.	Old Mowings, Thirty Acres.	Field Corn, Sixteen Acres.	Field Corn, Twenty Acres.	Turnips, One-third Acre.	Japanese Millet, Four Acres.	Mangels, One-half Acre.	Soy Beans, Two Acres.	Celery, Two Acres.	Carrots, One-half Acre.	Potatoes, Seven Acres.
Manure (cords), per acre,	-	4½	4½	5	5	8	4	10	7	-
Nitrate of soda (pounds), per acre,	150	-	-	100	-	100	-	200	100	150
Plain superphosphate (pounds), per acre,	-	40	-	150	-	200	-	-	200	400
Dried blood (pounds), per acre,	-	35	-	-	-	-	-	500	-	200
Tankage (pounds), per acre,	-	50	-	-	-	-	-	500	-	-
Muriate of potash (pounds), per acre,	100	200	-	140	-	200	-	-	-	-
High-grade sulfate of potash (pounds), per acre.	-	-	-	100	-	-	-	350	150	300
Dry-ground fish (pounds), per acre,	-	50	-	-	-	-	-	-	-	200
Lime (pounds), per acre,	-	2,000	-	2,000	-	2,000	-	2,000	2,000	-

Live Stock.

The general average health of all classes of live stock has been good. There have been a few losses among swine from causes of no general interest. It is matter for congratulation that our large herd of cattle remains entirely free from tuberculosis. We have received during the year the gift of several valuable animals (reported in list of gifts).

Particular attention is called to the fact that our sheep are perhaps our most profitable class of live stock. With a flock of 27 breeding ewes and an average for the year, including yearling ewes and bucks, of 43 animals, we have returns for the year amounting to $195.22, — an average of $4.54 for each animal kept; while we now have a total of 63 animals, against 43 one year ago. The increased value of our flock is $158, making a total for income and increased value of $353.22, or rather over $8 per head.

The kinds and numbers of the several classes of live stock are as follows: —

Horses. — French Coach, 1 stallion, 1 mare, 1 yearling stallion and 1 colt; Percheron, 1 stallion; French Coach, half-blood, 3 colts; work horses, 6; total, 14.

Neat Cattle. — Jersey, 1 bull, 3 cows; Shorthorn, 1 bull, 2 heifers; Holstein-Friesian, 1 bull, 3 cows, 1 heifer; Guernsey, 1 bull; Ayrshire, 1 bull, 1 cow, 1 heifer; Dakota Rangers, 20 cows; grade, 22 cows, 19 heifers, 7 calves; total, 84.

Sheep. — Southdowns, males, 1; breeding ewes, 39; ewe lambs, 23; total, 63.

Swine. — Poland-China, 1 boar, 1 sow; Middle Yorkshire, 1 boar, 5 breeding sows, 18 shoats, 33 pigs; Berkshire, 1 boar, 1 sow; Belted, 1 boar, 1 sow; Tamworth, 1 boar, 1 sow; total, 65.

Improvements.

The chief improvements of the year are as follows: —

The road leading west from the barn has been straightened, and for a considerable distance relocated and improved. The total length thus treated is 1,500 feet. Minor improvements have also been made in some of the other farm roads.

A counter-shaft and pulleys have been put up in the main barn, for the operation of threshing machine, corn husker and shredder, etc., by means of the electric motor. The new machines purchased are a Stevens' fertilizer distributer, a De Laval steam turbine separator and a Syracuse sulky plough. All of these do their work in a thoroughly satisfactory manner. The gift from Mr. N. I. Bowditch of a corn husker and shredder — not yet fully tested — supplies a long-felt want.

Financial Outcome.

The cash receipts for the year amount to $6,628.77, and there is due for produce and work rather more than $1,200. The total expenses have amounted to $9,205.84. The increase in inventory is $1,915.52. The farm has therefore given returns exceeding expenses by the sum of $538.45. Interest on investment has not of course entered into the above calculation.

In estimating the merits of this result, the following points should be kept in mind: —

1. We keep a considerable number of breeds in all classes of live stock except sheep; this necessitates maintaining numerous unproductive individuals. The policy is believed to be advisable, since we must keep the educational element prominent.

2. Our herd of cows is being bred up in dairy lines from grade Shorthorns procured in the west, and includes an unusually large proportion of heifers.

3. We dispose of most of our products at a disadvantage, because it is our policy not to compete in the local retail markets. Could we, for instance, make a market among consumers for our milk and cream, the returns from our dairy might be very largely increased.

4. A larger share of time and labor is employed in keeping our premises "cleared up," barns and stables swept, roads and lawns trimmed, etc., than a strict regard to the financial outcome would allow.

5. Our operations are in part carried out with an experimental object in view. We weigh and measure more than would a private business manager.

The cash received during the year has come from the following sources: milk and cream, $3,413.96; cattle, $526.62; horses, $189.50; swine, $435.53; sheep, $110.22; hay, $286.79; potatoes, $446.49; celery, $192.69; team labor, $574.81; manual labor, $13.20; millet seed, $318.60; sundries, $100.36.

The total amount of milk produced during the year is 282,639 pounds; the average number of cows kept is 50; the average yield per cow, is therefore, 5,652.8 pounds, bringing in an average money return of $68.28 per head. For a herd containing rather more than one-quarter heifers with first or second calf, such a yield must be looked upon as fairly satisfactory. It should be materially increased, however, within the near future, as the quality of cows is improving, and the proportion of animals not yet in their prime will decrease.

In conclusion, I desire to express my thanks to all connected with the farm management for hearty co-operation and the devotion shown to its interests. The members of the farm committee of the board of trustees have been most helpful. Their suggestions and no less their friendly criticisms are of value, and are invited both by superintendent and director.

WM. P. BROOKS,
Director College Farm.

AMHERST, Dec. 20, 1900.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The work of this department during the past year has been carried along on similar lines to that of previous years. Variety testing of fruits, vegetables, flowering plants under glass, hardy ornamental trees, shrubs and plants has received considerable attention.

Fruits.— The past season has been one of the best in the history of the college for the perfecting of nearly all fruits, the crops being large and of fine quality. Of the varieties of apples fruiting, a large number bore for the first time sufficient for study and comparison. Several of these varieties were remarkable in size and other qualities that make a variety valuable. Of the pears, only two or three new varieties fruiting showed sufficient merit to place them among the best of the standard market sorts. With the peach a very large number of varieties fruited, and the conditions were such that they reached the greatest perfection, permitting a close comparison of the newer sorts with the standard varieties. The plum crop, including most of the old and new varieties of domestica, Japanese and American types, was especially fine, giving a good opportunity for the study and comparison of these three important groups, as to their market value, their freedom from disease and insects, as well as their susceptibility to treatment when attacked by either. Many varieties of cherries fruited to a limited extent, but all were more or less injured by the late frost that came while they were in full bloom. The grapes ripened late, but, owing to the long season, nearly all varieties matured fully. Numerous seedling grapes originated on the grounds fruited for the second or third time. Some of these show remarkable qualities as to earliness, vigor, productiveness, high flavor and keeping qualities. The crop of currants and gooseberries was rather under the average quantity and size of berries, owing to the drought in June, but many new varieties show decided merits. The blackberry crop was remarkable as to yield, size and quality of fruit. Only one or two new varieties show decided merits above the older sorts. The red raspberry crop was not quite up to the average. Many new varieties fruited abundantly for the first time, among them many of the Shaffer seedlings originating here some four years ago. These are being planted in other localities for more extended trial. Owing to the dry weather in early June, the strawberry crop was light, but of good quality. The number of new varieties fruiting was larger than in 1899.

In connection with the variety tests of fruits and vegetables, spraying of crops is carried on to protect the crops in a commercial way. Numerous insecticides and fungicides found in the markets or sent in for trial are tested and careful records made, the results of which will be reported in bulletin form, as well as the behavior of varieties of all the fruits, vegetables, etc. Numerous pumps, nozzles and other spraying appliances are also tested as they are offered.

A few varieties of all the leading market vegetables and any varieties that may be sent in for trial are grown, but no attempt is made to grow all the leading sorts except of perhaps one or two kinds each year. The past season collections of the best varieties of beets and turnips were grown, the results of which have been carefully recorded.

Experiments in thinning all the large fruits have been carried on to a considerable extent, with remarkable results as to improvement in quality and profit.

Grafting plum trees has been practised in many ways, at different dates and with different kinds of wax and cover materials.

Various cover crops for orchards and vineyards upon hilly land are being used upon the Clark orchard and in the college vineyard: first, to prevent washing of the soil during the winter; second, to prevent the loss of nitrogen; third, to increase the amount of nitrogen.

Pruning peach trees at different times of the year, to determine the effect on the hardiness of the fruit buds and the growth of the trees, has been begun in the Clark orchard, as well as the spraying of peach trees with limewash to prevent the starting of the buds in bright warm weather during the fall and early winter.

A large number of different kinds of packages for the storing and shipping of apples and other large fruits are being tested, as well as several kinds of wrapping papers.

All varieties of fruits are put into a storage room, where their keeping qualities can be compared under exactly the same condition.

Seeds are tested to determine purity and germinating qualities whenever sent for this purpose, as well as all seeds purchased for variety tests or field growth.

The answering by mail of questions upon all kinds of horticultural subjects and the visiting and advising of horticulturists on their own grounds has largely increased, this part of the work requiring a large share of the time of the head of the department.

MILITARY DEPARTMENT.

Amherst, Mass., Dec. 31, 1900.

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

Sir: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 31, 1900.

I was assigned to duty at the college as professor of military science and tactics under the provisions of an act of Congress, approved Nov. 3, 1893, and Special Orders No. 6, War Department, A. G. O., dated Jan. 8, 1900, and commenced my duties Jan. 12, 1900. Previous to this time all military instruction and drills had been suspended for nearly two years, owing to the absence of any military officer at the college, in consequence of which very much of the interest heretofore shown in the military department had been lost. There were many difficulties to overcome, the students were unknown to me, a new organization had to be effected, officers and non-commissioned officers appointed who had previously received little if any military instruction, and a new interest awakened. The class of 1900 having been excused by the faculty from all military exercises, the other three classes were organized into a battalion of two companies of infantry, which, upon occasions of battalion drill, were subdivided into four companies, and the two improvised companies commanded by lieutenants taken from the other two. Drills commenced January 22, and have continued on Mondays, Tuesdays and Thursdays of each week, one hour for each drill, which were held out of doors when the weather permitted.

The drill exercises have been individual instruction, "setting up" exercise, school of the soldier, squad, company, battalion, extended order, target and gallery practice and bayonet exercise.

During the fall term two detachments have been instructed by a well-drilled non-commissioned officer in artillery, with the new model 3.2 breech-loading steel guns. These guns were called in by the War Department during the recent war with Spain, and returned, with implements complete, but not in time for use during the last college year. It is proposed to give most of the students instruction in artillery drill, by detachments, during the present college year. It is evident that in all drill exercises considerable proficiency has been gained, and greater interest is now manifested.

Two hours in each week have been given to theoretical instruction,— the seniors one hour in "Elements of Military Science," the freshmen one hour in "Infantry Drill Regulations." A portion of the time assigned for recitations has been devoted to informal lectures. During the coming winter and spring terms it is proposed to add "Elements of Military Law" for the seniors; United States army regulations, sabre exercise and castrametation for both seniors and freshmen.

The limited time allowed for theoretical instruction necessarily restricts it to elementary branches, such as would find application in actual practice pertaining to the duties of subaltern officers. This covers all the ground required by the regulations of the War Department governing military instruction in colleges.

About the middle of October last a military band of sixteen pieces was organized, most of the members purchasing their own instruments and paying by quarterly instalment. The college employs an instructor to give a limited number of lessons. The instructor is now giving one lesson of two hours per week, and in addition to this the band receives three hours' instruction per week under one of the members, who is also the band leader. In order to encourage more practice, members of the band are excused from all other military exercises. Considering the short time the band has been practising, and its evident improvement, I am encouraged to believe that before next commencement it will become one of the bright and attractive features of the college. The value of a good band to the military department — in fact, to the whole college — cannot be overestimated. I earnestly recommend that the college give it every encouragement within its means, especially a small appropriation for distinctive trimmings for the present uniforms.

Much-needed improvements have been made in the drill hall building during the past summer. A toilet room has been put in, also water pipes for heating placed in the lecture room and commandant's office. The whole exterior of the building needs painting, which I recommend during the coming year, and shower baths near the drill hall, which is also used as a gymnasium.

I wish to invite special attention to the building used for students' mess hall and kitchen. The whole building is very much in need of paint, and some of the rooms require papering.

I recommend that provision be made for an annual encampment of one week, during which time special facilities would be offered for field exercises, such as extended order drill, duties of sentinels, target practice and castrametation. I believe tentage and the necessary camp equipage can be borrowed from the Adjutant-General of the Commonwealth. The most favorable time for the encampment would be about the middle or last of May. This matter of annual encampment has heretofore been recommended in reports of the Inspector-General to the Honorable Secretary of War.

I have noticed, in my weekly inspections, a great improvement in the rooms occupied by students in the dormitories. They are kept neater and more orderly. Many little repairs, such as painting and papering, are needed, estimates for which will be submitted later.

The battalion has carried only the national colors. The old silk college flag is entirely worn out. That the battalion may be more closely identified with the college, I recommend the purchase of a new silk flag for the M. A. C. battalion, that the two may be carried together on occasions of ceremony. The cost will be about twenty-eight dollars. The national colors have been raised upon the flag-staff each morning and lowered at night, when the weather has been favorable. The old flag which has been used for this purpose is considerably worn and will soon need to be replaced. The Legislature, recognizing the lessons of patriotism that the flag teaches, has enacted a law making it obligatory for the national flag to be raised over every public school and college, when in session, throughout the State. It has been found impracticable to comply strictly with this law at this college, on account of the high winds prevailing during the storms of winter.

During my service at this college it has been my constant aim to fulfil the purpose for which I was detailed, and to work for the best interest of the college. I realize that, to some, discipline carries the idea of inferiority or the deprival of certain rights and privileges. But such is not the case. Discipline is not only the bone and sinew of every military organization, but the strength of every public institution whatever. It is all that distinguishes an organization from a mob. Those only who cheerfully submit to it are qualified to exercise it. I have endeavored to make the military department attractive as well as instructive to the student, whether he is to embrace the military profession or not. If I have accomplished any good purpose, if the lessons I have labored to teach have presented more clearly the relations between the citizens and the national government, if they have been the inspiration of a higher patriotism and a greater love of country, I shall feel that, in some measure at least, I have performed the duty assigned me.

It is to the young men of to-day that our country must look for its strength in times of danger.

The following-named members of the last graduating class were reported to the Adjutant-General of the Army and the Adjutant-General of the State of Massachusetts as having shown proficiency in the art and science of war: —

Frank H. Brown,	Newton Centre.
Morris B. Landers,	Bondsville.

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

2 3.2-inch breech-loading steel guns, with implements complete.
2 8-inch mortars with implements.
2 gun carriages.
2 caissons, with spare wheels.
2 mortar beds and platforms.
147 cadet rifles.
147 sets of infantry accoutrements.
51 headless shell extractors.
1 set reloading tools
6 non-commissioned officer's swords, steel scabbards.
14 non-commissioned officer's waist belts and plates.
14 sliding frogs for waist belts.
58 blank cartridges for field guns.
500 metallic blank cartridges.
4,600 metallic ball cartridges.
104 friction primers for field guns.
28,450 cartridge primers.
18,750 round balls.
2,650 pasters, black, for targets.
1,000 pasters, buff, for targets.
99 paper targets.
60 pounds of powder for small arms.

There is no signal property on hand.

The battalion organization is as follows: —

Commandant.

Capt. JOHN ANDERSON,	U. S. Army.

Field and Staff.

Cadet Major,	WILLIAM C. DICKERMAN.
Cadet Adjutant,	CLARENCE E. GORDON.
Cadet Quartermaster,	JOHN C. BARRY.
Cadet Sergeant-Major,	CHARLES L. RICE.

Company A.

Cadet Captain,	N. D. Whitman.
Cadet First Lieutenant,	E. S. Gamwell.
Cadet Second Lieutenant,	Thaddeus Graves, Jr.
Cadet First Sergeant,	J. H. Chickering.
Cadet Sergeant,	H. A. Paul.
Cadet Sergeant,	W. A. Dawson.
Cadet Sergeant,	P. C. Brooks.
Cadet Sergeant,	R. W. Morse.
Cadet Corporal,	W. Z. Chase.
Cadet Corporal,	G. R. Bridgeforth.
Cadet Corporal,	C. A. Tinker.
Cadet Corporal,	W. R. Pierson.

Thirty-five privates.

Company B.

Cadet Captain,	A. C. Wilson.
Cadet First Lieutenant,	E. L. Macomber.
Cadet Second Lieutenant,	Thomas Casey.
Cadet First Sergeant,	C. T. Leslie.
Cadet Sergeant,	R. I. Smith.
Cadet Sergeant,	J. H. Todd.
Cadet Sergeant,	J. B. Henry.
Cadet Sergeant,	A. L. Dacy.
Cadet Corporal,	C. E. Dwyer.
Cadet Corporal,	J. C. Hall.
Cadet Corporal,	E. F. McCobb.
Cadet Corporal,	T. F. Cooke.

Thirty-five privates.

Band.

Cadet First Sergeant Myron H. West, chief musician, and fifteen privates.

Respectfully submitted,

JOHN ANDERSON,
Captain, U. S. Army, Commandant.

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, 1900.

1. The only changes in the course have been making French, German and geology required studies in freshman, sophomore and junior years respectively, and electives in senior year. The course in chemistry has been greatly extended.

2. The veterinary laboratory and hospital stable, for the erection of which the Legislature of 1898 appropriated the sum of $25,000 and a yearly maintenance fund of $1,000, has been satisfactorily completed, and equipped with the latest and most approved apparatus. The increased facilities have resulted in a larger number of students selecting the veterinary course. An annual increase to the income of the college of $8,500 was granted by the Legislature of 1900 for the term of four years.

II. Receipts for and during the Year ended June 30, 1900.

1. Balance on hand July 1, 1899,	–
2. State aid: —	
(*a*) Income from endowment,	$2,458 97
(*b*) Appropriation for current expenses,	25,000 00
3. Federal aid: —	
(*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) Additional endowment act of Aug. 30, 1890,	16,666 66
(*c*) For experiment stations, act of March 2, 1887,	15,000 00
4. Fees and all other sources,	2,195 23
Total,	$68,620 86

III. Expenditures for and during the Year ended June 30, 1900.

1. Instruction in the subjects specified in section 1, act of Aug. 30, 1900,	$23,133 32
2. Instruction in all other subjects, if any, not mentioned in question 1 of this series,	951 50
3. Administrative expenses (president's, secretary's, treasurer's, librarian's salary, clerical service, fuel, light, etc.),	8,939 93
4. Experiment station,	15,000 00
Total,	$48,024 75

IV. Property, Year ended June 30, 1900.

Value of buildings,	$213,775 00
Value of other equipment,	85,336 60
Total number of acres,	425
Acres under cultivation,	300
Acres used for experiments,	75
Value of farm lands,	$37,000 00
Amount of all endowment funds,	360,575 35
Number of bound volumes June 30, 1900,	21,075

V. Faculty during the Year ended June 30, 1900.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	21
2. Number of staff of experiment station,	20

VI. Students during the Year ended June 30, 1900.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	165
2. Graduate courses,	12
Total, counting none twice,	177

THIRTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1901.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

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.*
Henry T. Fernald, Ph.D.,	*Associate 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).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
James E. Halligan, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant Chemist* (foods and feeding).
James W. Kellogg, B.Sc.,	*Assistant Chemist* (foods and feeding).
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Henry L. Crane, B.Sc.,	*Assistant Horticulturist.*
Charles L. Rice,	*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. 41. On the use of tuberculin (translated from Dr. Bang).
No. 43. Effects of electricity on germination of seeds.
No. 47. Field experiments with tobacco.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 66. Variety tests of fruits; fertilizers for fruits; thinning fruits, pruning; spraying calendar.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

Of the numerous problems presented for solution, a few only of the more important have been selected. From a series of experiments on the effect of food on the composition of milk and butter fat and on the consistency or body of butter, it was found: (*a*) that different amounts of protein do not seem to have any influence on the composition of milk; (*b*) that, in general, feeds containing much oil have a tendency to slightly increase the fat content of milk when first fed, but after a few weeks the fat percentage gradually returns to normal; (*c*) that it is not practicable to feed large amounts of oil to cows, as it has a tendency to derange the digestive and milk-secreting organs; (*d*) that linseed oil effected a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and iodine coefficient; (*e*) and that cotton-seed meal produced butter fat quite similar in composition to that produced by the standard ration.

In experiments to show the feeding value of barnyard millet, it is shown: (*a*) that the millet has less nutritive value than corn, for the reason that it must be cut when in early blossom to secure it in the most desirable condition for feeding, while the corn can partially mature its grain and still be readily eaten by animals; (*b*) that it is not suitable for hay and is inferior to maize as a silage crop; (*c*) that it furnishes quite a desirable green feed, especially during the month of August, and for this purpose can be most satisfactorily utilized.

A study of the effects of different chemical solutions on germination brought out some interesting facts. The solutions formed from those substances known to exist in seeds and seedlings were of two kinds: ferments, as diastase and pepsin; and amides, as asparagin and leucin. In each experiment one hundred seeds were used, the solution varying in strength from one-tenth per cent. to two per cent. The seeds were soaked in the solution for twelve hours, then rinsed in water and placed in Zurich germinators. With asparagin as the solution on such seeds as vetch, rape, alfalfa, the average percentage of germination for normals was seventy-four and five-tenths per cent.; for the treated was eighty-eight and eight-tenths per cent. and an acceleration of germination in several seeds. With leucin on buckwheat and alfalfa the average of three experiments gave eighty-three per cent. for normal and ninety-two per cent. for treated. With pepsin and diastase there was in like manner a gain of about ten per cent.

Great complaint having been made of the difficulty of growing asters, fifteen thousand were grown under different conditions of fertilizers, varieties, localities, time of planting and methods of handling. A peculiar and obscure disease was made out, not resulting from organisms of any kind, but very destructive in its effects. There was an abnormal development, due to disturbance of the assimilative functions of the plant.

Remedies for the various diseases of lettuce grown under glass have occupied the attention of the division of plant pathology for several years. The "drop," which is characterized by rotting of the stem and sudden and complete collapse of the whole plant, is the most destructive of these diseases. The amount of loss is very commonly twenty-five per cent. of the entire crop. It has been found that by sterilizing the soil, either wholly or in part, the drop and its kindred disease can be wholly eradicated or suppressed. Experiment shows that five-eighths inch or three-fourths inch surface covering of sterilized sand or earth gave an average reduction of forty-seven per cent. in the amount of drop; one inch of sterilized sand or earth gave an average reduction of eighty-seven per cent.; one inch and a half of sterilized soil, an average of ninety-three per cent.; and two, three and four inches secured entire immunity from the disease.

In the entomological division the structure and life history of various insect pests have been worked out and published, and the remedies to be employed. Among those thus treated are the grass thrips; the thrips of the greenhouse, attacking cucumbers; the fall canker worm; the marguerite fly; and greenhouse aleurodes, doing great damage to tomatoes and cucumbers grown under glass. The San José scale continues its ravages in the State. It has already been found in thirty-seven different towns, and it probably exists in as many more. It attacks the fruit as well as the bark, and specimens of currants, pears and apples have been sent in so completely covered with them as to render their sale impossible.

In the agricultural division the results of experiments continued since 1890 with oats, rye, soy beans, clover and potatoes seem to indicate that the various manures supplying nitrogen rank in the following order: (*a*) nitrate of soda, barnyard manure, sulfate of ammonia and dried blood; (*b*) that in crops of the clover family as nitrogen gathers, the crops not being turned under, but improvement sought from roots and stubble, there was no appreciable improvement from soy beans, but marked from clover; (*c*) that potatoes, clovers, cabbages and soy beans did much the best on sulfate of potash, while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate; (*d*) that, if the muriate is used continuously, sooner or later lime must be applied; (*e*) that, with garden crops, both early and late, the sulfate rather than the muriate should be used; (*f*) that none of the natural phosphates appear to be suited to crops belonging to the turnip and cabbage family; (*g*) that, while it is possible to procure profitable crops of most kinds by a liberal use of natural phosphates, the best practice will probably be found to consist in using one of those in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

A detailed account of the operations of the year is herewith submitted.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1900.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,614 58	
for labor,	4,278 90	
for publications,	409 40	
for postage and stationery,	228 53	
for freight and express,	127 48	
for heat, light and water,	254 96	
for chemical supplies,	108 53	
for seeds, plants and sundry supplies,	602 04	
for fertilizers,	1,168 55	
for feeding stuffs,	136 62	
for library,	157 31	
for tools, implements and machinery,	673 63	
for furniture and fixtures,	51 90	
for scientific apparatus,	384 95	
for live stock,	60 30	
for travelling expenses,	22 02	
for contingent expenses,	125 25	
for buildings and repairs,	595 05	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,600 00	
from farm products,	1,720 86	
from miscellaneous sources,	1,979 82	
		$18,500 68
Cash paid for salaries,	$8,158 11	
for labor,	4,696 81	
for publications,	556 56	
for postage and stationery,	313 85	
for freight and express,	123 64	
Amount carried forward,	$13,848 97	

Amount brought forward,	$13,848 97	
Cash paid for heat, light and water,	582 04	
for chemical supplies,	525 14	
for seeds, plants and sundry supplies,	611 53	
for fertilizers,	162 47	
for feeding stuffs,	995 78	
for library,	96 95	
for tools, implements and machinery,	107 81	
for furniture and fixtures,	50 73	
for scientific apparatus,	546 38	
for live stock,	125 66	
for travelling expenses,	216 62	
for contingent expenses,	94 00	
for buildings and repairs,	536 60	
		$18,500 68

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, 1900; 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 $33,500.68 and the corresponding disbursements $33,500.68. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1900.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 9, 1900.

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., J. W. KELLOGG.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

A. Effect of feed on the composition of milk, butter fat, and on the consistency or body of butter.

B. The feeding value of barnyard millet.

C. Dried distillery grains.

D. Digestion experiments with sheep.

E. The composition of purslane.

F. Parsons' "six-dollar" feed.

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* Resigned Nov. 1, 1900.

† Resigned Nov. 1, 1900, to accept position in the Utah Experiment Station.

PART I.

LABORATORY WORK.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has materially increased over all previous years. There have been sent in for examination 287 samples of water, 123 of milk, 888 of cream, 20 of pure and process butter, 29 of oleomargarine, 123 of feed stuffs and 10 of vinegar. In connection with experiments by this and other divisions of the station, there have been analyzed 45 samples of milk and cream, 60 of butter and 695 of fodders and feed stuffs.

In addition to the above, 707 samples of commercial concentrated feed stuffs have been collected under the provision of the feed law, and tested, either individually or in composite; and 40 tonics, condimental feeds, etc., have been examined. This makes a total of 3,036 substances analyzed during the year, as against 2,045 last year and 1,875 in the previous year.

CHARACTER OF CHEMICAL WORK.

Water, Milk, Cream, Feed Stuffs, etc., sent for Examination. — More than the usual number of samples have been received during the year. Sanitary examinations of water have been carried on as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for live stock. In milk analysis, the percentages of total solids and fat are the usual ones determined. The percentage of fat only is determined in cream, unless the quantity of other ingredients is requested. An estimation of the percentage of protein is usually all that is necessary to determine the genuineness of a feed stuff. In some cases it is wise to determine the percentage of fat; in others, the percentage of ash and fibre.

Full information concerning water, milk and cream, how to take samples, etc., will be found in our report for 1899. Special information will be furnished upon application.

Cattle Feed Inspection. — We have continued the inspection of concentrated feeds during the year, collecting and analyzing over 700 samples. A bulletin is about to be issued, giving the results of the work accomplished. The better class of feeds is practically free from adulteration. Some manufacturers and jobbers are still disposed to put cotton-seed meal mixed with ground hulls upon the market, marked simply cotton-seed meal. Mixed feed, so called, consisting principally of wheat bran together with several hundred pounds of fine or flour middlings to the ton, is beginning to be adulterated with wheat hulls, ground corn cobs, etc. This material ought to be accompanied by a guaranty to assure the purchaser of its purity. Many very inferior oat feeds, containing 50 to 60 per cent. of oat hulls, are still on sale. They are very expensive at the price asked for them. These inferior oat feeds are often used by millers to mix with cracked corn, the resulting product being sold as provender. It is quite inferior to a mixture of genuine ground oats and corn. New feeds are constantly coming into the market, most of them by-products from different industries. The writer is convinced that the time is nearly at hand for a change in the present feed law, making it conform to the laws in the other New England States.

Methods of Analysis. — This department has co-operated with the Association of Official Agricultural Chemists in investigating different methods of analysis, with a view to their improvement. During the present year investigations have been made relative to the best methods of determining starch, pentosans and galactan in feed materials, and of casein and albumin in milk. Work of this character cannot be expressed in figures. It consumes much time, but is very necessary, and likely to be productive of valuable results.

Chemical and Physiological Investigations. — So far as time and resources permit, the chemical staff is engaged in investigating some of the many pressing dairy and feeding problems. The time at present is largely devoted to the examination of butter fat, the manufacture of butter and to the digestibility of feeding stuffs. It is to be regretted that the analysis of the various materials sent to the station — waters, milk, cream, butter and feed stuffs — consumes each year an increasing amount of time, and necessarily limits the extent of experimental work.

Part II.

FEEDING EXPERIMENTS AND DAIRY STUDIES.

A.—EFFECT OF FEED ON THE COMPOSITION OF MILK, BUTTER FAT, AND ON THE CONSISTENCY OR BODY OF BUTTER.

J. B. LINDSEY.*

Conclusions.

As a result of the experiments which follow, concerning the influence of feeds and feed constituents on the composition of milk, butter fat, and on the character of the butter, the following deductions are made : —

1. Different amounts of protein do not seem to have any influence on the composition of the milk.

2. Linseed oil in flax-seed meal, when fed in considerable quantities (1.40 pounds digestible oil daily), increased the fat percentage and decreased the nitrogenous matter of the milk. This fat increase was only temporary, the milk gradually returning (in four or five weeks) to its normal fat content. The nitrogenous matter also gradually returned to normal, but more slowly than the fat.

3. In general, feeds containing much oil have a tendency to slightly increase the fat content of milk when first fed. The fat percentage gradually returns to normal.

4. It is not practicable to feed large amounts of oil to cows, as it has a tendency to derange the digestive and milk-secreting organs.

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* Ably assisted by E. B. Holland, F. W. Mossman, B. K. Jones and P. H. Smith, Jr.

5. Linseed oil effected a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and iodine coefficient.

6. All oils do not produce the same effects on butter fat.

7. The melting point of butter fat is not always indicative of the firmness or body of butter.

8. An excess of linseed oil produced a soft, salvy butter, with an inferior flavor.

9. Linseed and corn gluten meals, with a minimum percentage of oil (3 per cent.), produced a normal butter fat. The corn gluten meal produced butter with a desirable flavor and of good body.

10. King gluten meal (corn gluten meal with 13 per cent. oil) increased the iodine coefficient of the butter fat several degrees above standard ration butter fat, and slightly depressed the melting point of the fat. This effect was probably due to the corn oil. The same meal produced butter of a very desirable flavor and body.*

11. Cotton-seed meal produced butter fat quite similar in composition to that produced by the standard ration. The butter produced by this meal was rather crumbly when hard, and slightly salvy to the taste.

Further experiments concerning the effects of food and food constituents on butter fat and butter are now in progress.

(*a*) Preliminary Statement.

During the last six years a number of experiments have been made at this station relative to the effect of food, first on the composition of milk and later on the composition of butter fat. It is not the writer's intention at this time to attempt any historical or critical review of the work of others along these lines, nor to present the full data of his own work, but rather to call attention to the progress thus far made in the effort to secure positive knowledge on the subject under investigation. The detailed experiments will be published at a proper time. The writer believes that experimenters have hitherto neglected to note the effect of the several food

* The body of this butter was very satisfactory to Mr. W. A. Gude, the scorer, but might have been considered by some as lacking in firmness.

constituents — protein, fat and carbohydrates — on the milk and butter fat, but have rather attempted to observe the influence of the combinations of these groups as they exist in the different foods. It is believed that the former method would yield more definite information on this perplexing subject.

(b) The Effect of Protein on the Composition of Milk.

In an early experiment * different amounts of protein were fed, and the effect on the composition of the milk was noted. The experiment showed that the fat content of the milk appeared to be increased. Unfortunately, the ration contained, in addition to the protein, an excess of corn and cotton-seed oil, derived from gluten feed and cotton-seed meal, and it was not at all clear whether the protein or the oil was responsible for the fat increase. Again, the periods were of too short duration to make clear whether the increase was temporary or permanent. In the next two experiments† the oil factor was eliminated as far as possible, the protein being derived from corn and gluten meals. The length of the periods were increased so as to cover from four to six weeks, and, because of increased facilities for carrying out the experiments, many outside influences bearing upon the results were eliminated. The results of these two investigations showed no particular influence of the protein upon the several ingredients of the milk, except a very slight increase in the nitrogenous matter of the milk when the largest amount of protein was fed. It therefore seemed probable that the oil in the rations fed in the first experiment above referred to was responsible for the fat increase.

(c) The Effect of Fat on the Composition of Milk.

About this time (1898), Soxhlet, a German investigator, made the statement that, contrary to general teachings, the fat of the food — as found in the different oil cakes fed on the continent — did produce a very noticeable increase in the

* Report of Massachusetts State Experiment Station, 1894.
† Ninth and eleventh reports of Hatch Experiment Station.

relative amount of fat in the milk. The full data proving this statement has not been published. The conclusion of several American experimenters who had previously fed different fats to dairy animals was that no positive increase was to be observed. Soxhlet suggested that the reason the effect of "food fat" had not been more pronounced was because the fat or oil fed had not been digested and assimilated by the animals. Following out the suggestion made by our first experiment, and endeavoring to prove or disprove Soxhlet's statements, several experiments were instituted.

The first two were made with three animals, — the only ones in condition at the time, — in the summer of 1898, and have been designated Experiments I. and II. It was merely a preliminary test. These animals were in rather an advanced stage of lactation, but producing 15 to 20 pounds of milk each per day. The coarse feeds during the several periods consisted of first and second cut hay, or second cut hay and green feed. The grain feed during the "normal oil" periods was wheat bran, or bran and Chicago gluten meal; and in the so-called "excess oil" periods flaxseed meal* was added to the wheat bran, or was substituted for the Chicago gluten meal. In the normal oil periods the amount of oil calculated to be digested was from .4 to .5 pounds, and during the excess oil periods from 1.4 to 1.8 pounds. The normal oil periods lasted seven days, then followed excess oil period of ten days, subsequently normal oil periods of four days. Each period proper was preceded by a preliminary period of seven days. When the excess oil was fed, the fat of the milk increased one-half per cent. in almost every case (that is, from 5 to 5.50, for example), and in some cases even more, and dropped back again when the excess oil was removed to even below what it was in the first or normal oil period. Part of the increase might be attributed to change of feed. The periods were short and the weather warm, and the experiment could be considered of only sufficient importance to warrant still further investigations under more favorable conditions.

* This meal contained about 37 per cent. of linseed oil.

Experiment III.

[New-process linseed meal (Cleveland flax meal) *v.* flaxseed meal.]

The next experiment was begun in October, 1898, and continued until February, 1899. The cows, ten in number, were divided as evenly as possible into Herds I. and II. Both herds received rowen (second cut hay) as the coarse fodder during the entire experiment. The grain ration for each herd consisted of bran, new-process linseed meal* (Cleveland flax meal, so called) and corn meal during the first period of three weeks, one week of which was preliminary. This was designated the "normal oil" ration. In the second period of twelve weeks Herd II. received flaxseed meal in place of the Cleveland flax meal, and corn meal; and the entire ration of Herd I. was continued unchanged. The ration consumed by Herd II. in the second period was designated the "excess oil" ration. The third period proper lasted two weeks, and both herds were fed the same ration as in the first period. Herd I. then received the same (normal oil) ration throughout the entire experiment and Herd II. the excess oil ration in the second period. The normal oil ration consisted of about .5 pounds of digestible oil and the excess oil ration of 1.75 pounds. The amount of protein and carbohydrates were essentially the same, the oil being the varying factor.

Daily Ration (Pounds).

First period: both herds normal oil ration.

HERDS.	Wheat Bran.	Cleveland Flax Meal.	Flaxseed Meal.	Corn Meal.	Rowen.
Herd I., ...	2	2	-	2 to 3	20 to 24
Herd II., ...	2	2	-	2 to 3	20 to 24

Second period: Herd I., normal oil ration; Herd II., excess oil ration.

HERDS.	Wheat Bran.	Cleveland Flax Meal.	Flaxseed Meal.	Corn Meal.	Rowen.
Herd I., ...	2	2	-	2 to 3	20 to 24
Herd II., ...	2	-	4	0 to 1	20 to 24

Third period: both herds normal oil ration.

HERDS.	Wheat Bran.	Cleveland Flax Meal.	Flaxseed Meal.	Corn Meal.	Rowen.
Herd I., ...	2	2	-	2 to 3	20 to 24
Herd II., ...	2	2	-	2 to 3	20 to 24

* This meal contained less than 3 per cent. of oil.

The animals completed the experiment with only slight disturbances. Composite samples of each cow's milk and of the mixed milk of each herd were made for five days of each week, and the milk was tested for total solids, fat, nitrogen and ash. The analyses of the mixed milk only are presented at this time: —

Milk Analyses.

First period: both herds normal oil ration.

SAMPLES.	TOTAL SOLIDS.		FAT.		SOLIDS NOT FAT.		NITROGEN.		ASH.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Weekly sample,	13.27	13.25	4.23	4.05	9.04	9.20	0.519	0.531	0.69	0.72
Weekly sample,	13.55	13.43	4.62	4.40	8.93	9.03	0.539	0.543	0.70	0.71
Weekly sample,	13.79	13.62	4.59	4.52	9.20	9.10	0.547	0.544	0.72	0.72
Averages, .	13.54	13.43	4.48	4.32	9.06	9.11	0.535	0.539	0.70	0.72

Second period: Herd I., normal oil ration; Herd II., excess oil ration.

Weekly sample,	14.00	14.36	5.07	5.56	8.93	8.80	0.550	0.511	0.71	0.72
Weekly sample,	14.12	–	5.05	–	9.07	–	0.581	–	0.71	–
Weekly sample,	14.16	14.25	4.96	5.24	9.20	9.01	0.572	0.529	0.72	0.71
Weekly sample,	14.21	14.19	5.16	5.27	9.05	8.92	0.574	0.532	0.73	0.71
Weekly sample,	14.26	14.02	5.08	5.14	9.18	8.88	–	–	–	–
Weekly sample,	14.21	14.03	5.13	5.19	9.08	8.84	0.575	0.519	0.72	0.71
Weekly sample,	14.07	13.85	4.85	4.96	9.22	8.89	0.575	0.517	0.72	0.70
Weekly sample,	14.07	13.92	4.85	5.00	9.22	8.92	0.572	0.531	0.72	–
Weekly sample,	–	13.96	–	5.05	–	8.91	–	–	–	–
Weekly sample,	14.30	14.06	4.85	4.93	9.45	9.13	0.587	0.536	0.72	0.71
Averages, .	14.16	14.07	5.00	5.15	9.16	8.92	0.573	0.525	0.72	0.71

Third period: both herds normal oil ration.

Weekly sample,	14.14	13.54	4.87	4.38	9.27	9.16	–	0.561	–	0.70
Weekly sample,	14.06	13.70	4.68	4.28	9.38	9.42	–	0.566	–	0.71
Averages, .	14.10	13.62	4.77	4.33	9.33	9.29	–	0.563	–	0.71

In studying the *average results*, one notes that in the first period both herds produced milk of approximately the same quality. The second period of twelve weeks showed an increase in the fat of Herd I. from 4.48 to 5, or .52 per cent.,

— a natural increase, due to the advance in the period of lactation; and in Herd II. from 4.32 to 5.15, or .83 per cent. The percentage increase in Herd I. was 11.6 per cent. and in Herd II. 19.2, showing that Herd II. made the greater average increase. The total solids increased about the same in each herd. The average nitrogen percentage increased for Herd I. from .535 to .573, in about the same proportion as the total solids; while Herd II., instead of showing an increase, had a slight decrease. The ash remained practically unchanged. In the third period there was a slight decrease in the total solids and fat of Herd I., and a very noticeable decrease in the fat of Herd II. The nitrogen percentage of Herd II. in this period increases to about the average produced by Herd I. in the second period. To note, however, the full effect of the excess oil ration, one must observe the weekly analyses of the milk of both herds in the excess oil period. For example, the last fat test in the normal oil period was 4.59 per cent. for Herd I. and 4.52 per cent. for Herd II. The first fat test in the second period was 5.07 for Herd I. (receiving the normal oil ration) and 5.56 for Herd II. (receiving the excess oil ration). During this entire period Herd I. showed little variation in fat, and averaged 5 per cent. Herd II. increased from 4.48 to 5.56 at the beginning of the excess oil period, and then gradually decreased, until at the close of the period it tested 4.93 and averaged 5.15 per cent. of fat. When it is remembered that the figures given represent the mixed milk of five cows, it seems safe to conclude that the excess of oil did increase the percentage of fat in the milk, but the increase was only temporary, the fat percentage gradually dropping back to an amount parallel with Herd I. The nitrogen percentage of Herd II. in the second period did not increase so rapidly as did the fat. At the beginning of the period it was less than at the close of Period I., and did not begin to increase until near the close of the period. In the third period it was apparently normal again.

One might suppose that the fat increase in the case of Herd II. could be accounted for by the shrinkage in milk production. The shrinkage, however, was no more than with Herd I. Again, should this be the case, why should not the nitrogen increase in the same proportion, instead of actually decreasing, etc.?

To summarize briefly, the marked effect of the oil was to produce a quite noticeable increase in the percentage of milk fat when first fed; this increase gradually diminished, until at the end of the fifth week it reached the normal.* When the excess oil ration was removed, the milk fat percentage dropped noticeably below the normal. A second effect of the oil ration was to cause a depression in the percentage of nitrogen in the milk, which began to increase only towards the close of the period, and increased to the normal percentage when the excess oil ceased to be fed. As a result of this experiment, one is led to inquire in what way the oil in the feed caused the temporary increase of fat in the milk. Does the *feed oil* to any extent enter directly into the milk fat, or does it by substitution cause the body fat to be utilized by the animal in the production of milk fat, as Soxhlet suggests; or does the feed oil produce a disturbance in the milk glands, causing an increased fat secretion, by utilizing a portion of the material that would otherwise become nitrogenous matter and milk sugar? These are questions worthy of further investigation.

This experiment is rather more decisive in its teachings than many earlier investigations. The question for further investigation is, whether other oils, derived from cotton-seed, corn, etc., act in a similar way to linseed oil. Investigations touching this and other points are now in progress.†

(*d*) The Effect of Linseed Oil on Butter Fat.

Two samples of butter fat were taken weekly from each herd, in the experiment above described, and upon analyses yielded the following *average* results: —

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* By normal is meant the percentage produced by Herd I.

† This experiment was completed during the winter of 1898–99, but has remained unpublished, owing to the prolonged illness of the writer. Since that time Hills (twelfth report, Vermont Experiment Station), Rhodin (Milch Zeitung 27, pp. 306–323, 1898), Bartlett (fourteenth report, Maine Experiment Station) and others have published results of a similar nature, to which more extended reference will be made at another time.

Butter Fat Analyses.

First period: both herds normal oil ration.

HERDS.	Length of Period (Weeks).	Specific Gravity $\left(\frac{100}{100}\right)$.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Melting Point (Degrees C.).	Iodine Number.
Herd I., . . .	2	.905	29.79	5.24	31.99	28.93
Herd II., . . .	2	.906	28.62	5.04	32.24	30.02
Second period: Herd II., excess oil ration.						
Herd I., . . .	12	.904	30.28	5.33	32.89	28.16
Herd II., . . .	12	.903	25.17	4.43	36.93	43 19
Third period: both herds normal oil ration.						
Herd I., . . .	2	-	-	-	-	-
Herd II., . . .	2	-	27.96	4.92	33.03	32.15

The averages show that the effect of the oil was to depress the volatile acids and to increase the melting point and iodine number. The change was noted in the case of Herd II. at the beginning of the excess oil period, and continued uninterrupted until its close.

In the third period of two weeks (one week preliminary and two weeks proper), in which both herds received the normal oil ration, the butter fat in case of Herd II. changed in composition nearly to that of Herd I. at the close of the second period. The effect of the change of feed was observed at the close of the first week, but it seemed to require several weeks for the animals to thoroughly readjust themselves. It is evident that the linseed oil caused a butter fat to be produced having lower volatile acids than that produced in the normal oil period. One would also assume that it caused a change in the relative proportions of stearin, palmitin and olein. The question arose as to whether linolic and linolinic acids — the characteristic acids of linseed oil — had been actually transmitted to the butter fat, and an effort was made to detect them, but without positive results. We hope to still further investigate this matter.

(e) The Effect of Linseed Oil on Butter.

When this experiment was begun it was not the intention to convert the cream into butter, but to note particularly the effect of the oil on the composition of the milk and butter fat. The oil, however, effected such a change in the chemical character of the butter fat that it seemed wise to note its effect on the resulting butter product. Accordingly six lots of butter were made from each herd, towards the close of the second or excess oil period. It was not possible at the time to make a first-class article, owing to poor facilities. We were obliged to ripen the cream in cans, to churn with a small hand churn and to work the butter with a small paddle.* Two lots of butter from each herd were submitted to chemical analysis, and found to be of normal character. They contained from about 10 to 12 per cent. of water, 85 to 87 per cent. of butter fat, less than 1 per cent. of curd and a normal amount of salt. The several samples were scored by Mr. W. A. Gude, of the firm of Gude Bros., New York, who stated that both lots were of poor flavor, having a burnt taste, as of rendered butter; and the body from Herd I. was short grained, brittle and crumbly; from Herd II., salvy or very salvy.

Mr. C. H. Eckles, butter maker at the college dairy school, reported as follows concerning the body and flavor of the several butters: "The butter from the normal ration is considerably firmer than that from the excess oil ration, and the grain is shorter. As compared with the product of the best creamery butter, neither is exactly normal in consistency, the normal ration butter being more crumbly and the butter from the excess oil ration more salvy or greasy than normal. From a commercial stand-point, the body of excess oil butter is possibly the more objectionable. The flavor and aroma of normal ration butter is inferior to that of excess oil butter. In case of the former, something of an old flavor, impossible to describe, is noticed. The flavor of excess oil butter, while not very good, is more the flavor

* Since then a small dairy building for experimental purposes has been erected and fully equipped for this department.

of fresh butter." Referring to another lot, Mr. Eckles says: "The same difference in consistency was observed, and in about the same degree, and the difference in flavor was the same, but more marked."

The writer lays no claim to being an expert judge of butter, but his observations, made at the time, were as follows: Butters from normal ration were hard and firm at 15° C., and those from excess oil ration of a softer, lardy nature. It required some effort to force a glass rod into normal ration butter, but the same rod slipped much easier into excess oil butter. One could distinguish the two butters almost with the eye, and easily with the touch. Samples of the two butters were placed in crystallization dishes upon a hot-water radiator. Normal ration butter remained firmer for a time than excess oil butter, but resolved itself into oil more quickly. When normal ration butter was nearly all oil, excess oil butter was soft enough to spread out over the bottom of the dish, but had melted but little. This latter observation is very interesting, and shows, at least in case of this experiment, *that the melting point of the butter fat did not govern the firmness or body of the butter.* Does this hold true in all cases? The average melting point of normal oil butter fat was 32.89 and of excess oil butter fat 36.93. While the excess oil butter fat showed a melting point 4° higher than the normal oil fat, yet the normal oil butter was firmer at ordinary temperature, and kept its body better when a gentle heat was applied. When, however, the heat was increased, the firmer normal oil butter actually resolved itself into oil more quickly than did the salvy excess oil butter. The reason for this cannot be discussed at this time.

It is clear, from the foregoing observations, that the butters from both herds were of quite inferior flavor. It was unfortunate that our facilities for butter making at the time were not better. Just why the flavor of both lots was so poor is not quite clear, as they were made by an experienced butter maker, the stable was clean and the milk carefully handled. How much of this is to be attributed to poor facilities, how much to inferior bacteria and how much to influence of food, cannot be ascertained. The butters were probably rather overworked. One point, however, stands out *very distinctly; namely, the influence of food on the body of the butter.* The linseed oil surely produced a butter of high melting point, yet soft and salvy, and unable to stand up under a gradually rising temperature, as did the butter when the oil was not fed.

The above experiment naturally suggests two questions: First, do the oils in the various feed stuffs tend to produce a salvy butter, lacking in firmness? Second, what is the effect of different forms of protein, as found in linseed, cotton-seed and gluten meals on the body of butter?

(*f*) The Effect of Different Concentrated Feeds on Butter Fat and Butter.

At the close of the above experiment it seemed advisable to note the effect of several concentrated feeds, as they are found in the markets, upon the character of butter fat and butter. Accordingly a "standard" grain ration was adopted, and other rations compared with it. It is not to be inferred that the so-called "standard" ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce a normal butter.

Two experiments, known as Experiments IV. and V.,* were completed in the spring of 1898, with twelve cows, divided into two herds of six cows each. Rations containing 4 pounds of Cleveland flax meal and 4 pounds of Chicago gluten meal, respectively, were compared with the standard ration. Herd II. received the standard ration, and Herd I. the Cleveland flax meal and Chicago gluten meal rations. All these rations contained only a normal amount (.5 to .6 pounds) of digestible oil, while the Cleveland flax or the Chicago gluten meal themselves contained less than 3 per cent. of oil, so that one could note particularly the effect of the protein in the linseed and gluten meals on the butter fat and butter.

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* These two experiments were made in connection with the Department of Agriculture.

Daily Ration (Pounds).

RATIONS.	Wheat Bran.	Ground Oats.	Cotton-seed Meal.	Chicago Gluten Meal.	Cleveland Flax Meal.	First Cut Hay.	Corn Silage.
Standard ration, . .	3	5	.5	.5	-	12-15	20
Cleveland flax meal ration.	2	2	-	-	4	12 15	20
Chicago gluten meal ration.	2	2	-	4	-	12-15	20

The experiments proper lasted five weeks, preceded by a preliminary period of ten to fourteen days.

Experiment IV.

[Standard ration *v.* Cleveland flax meal ration.]

Five samples of butter fat were analyzed, with the following average results: —

Butter Fat Analyses.

RATIONS.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Insoluble Acids.	Melting Point.	Iodine Number.
Standard ration,.	30.92	5.44	88.48	33.80	28.96
Cleveland flax meal ration, . .	29.50	5.19	88.69	33.23	26.77

The averages show comparatively slight variations, the fats resulting from both rations being normal in character. The Cleveland flax meal ration produced a fat with less volatile acids and a trifle lower melting point and iodine number than did the standard ration. Whether this difference is due to the individuality of the two herds, or to the influence of the linseed meal, cannot be stated.

Ten lots of butter were made from each herd. The ripening, churning, etc., were made in the same way as in the previously described linseed oil experiment (Experiment III.). Five lots of butter made from each ration were analyzed and found to be of normal character. The ten lots were scored by Mr. W. A. Gude of New York, with the following average results: —

Average Butter Score.

	Flavor.	Body.	Color.	Salt.	Style.	Total.
Standard ration, ...	35.9	24.2	15	10	5	90.1
Cleveland flax meal ration, . . .	31.4	22.0	15	10	5	82.4
Standard score, ...	45.0	25.0	15	10	5	100.0

Mr. Gude reported the flavor of the butter from the flax meal ration as "stale, rancid or oily," "strong, oily, seems rancid," "oily," etc. Concerning the flavor of standard ration butter he reported "fair to fine" and in four instances he referred to "oily flavor." With regard to body of flax meal butter he used the terms "brittle, dry, salvy, short," and for standard ration butter "good, but trifle short," and "perfect." In a letter Mr. Gude said: "While trying to pay particular attention to body, I notice that the most objectionable feature is that peculiar oily taste," etc. "This I notice you have apparently overcome in No. 1282" (standard ration butter). Again: "I notice a particular improvement in the quality, particularly of samples 1272 and 1274" (standard ration butter).

The butters were rather dry, having about 12 per cent. of water. It is clear that, while the butter made from both rations did not score high, that made from the flax meal ration was noticeably inferior in flavor and in body to the standard ration butter. This seems to agree with the linseed oil experiment (Experiment III.). In that experiment, even when only two pounds of flax meal were fed, the flavor was inferior; and when flax-seed meal was fed the body and flavor were both bad. It is not desired, however, to be too positive about the flax meal (linseed meal, with a minimum amount of oil) producing an inferior-flavored butter, but we prefer to call attention to the results thus far secured, and to repeat the experiment.

Experiment V.

[Standard ration *v.* Chicago gluten meal ration.]

This experiment was identical with Experiment IV., excepting that 4 pounds of the Chicago gluten meal (corn gluten) were substituted for 4 pounds of flax meal. The average results of the analyses of five samples of butter fat follow: —

Butter Fat Analyses.

RATIONS.	Reichert-Meissl Number.	Butyric Acids Equivalent.	Insoluble Acids.	Melting Point.	Iodine Number.
Standard ration, ...	30.07	5.29	88.84	34.76	29.00
Chicago gluten meal ration, . .	32.07	5.64	88.26	33.04	27.67

No wide variations are noted. The Chicago gluten ration produced rather more volatile acids, a trifle less insoluble acids, a lower melting point and a lower iodine number. The differences are too slight to draw any positive conclusions. In both these experiments (Experiments IV. and V.) one notes that the standard ration produced butter with a little higher melting point and a lower iodine number. All the butter fats, however, were of normal character.

Ten lots of butter were made from each ration, under similar conditions, as previously described. Five samples were analyzed chemically and found to be normal. The butter was quite dry, showing but 11 per cent. of water. Mr. Gude scored the ten samples made from each ration with the following average results: —

Average Butter Score.

	Flavor.	Body.	Color.	Salt.	Style.	Total.
Standard ration, ...	35.6	23.8	15	10	5	89.4
Chicago gluten ration, ...	35.2	24.0	15	10	5	89.2
Standard score, ...	45.0	25.0	15	10	5	100.0

These butters appear to be practically identical, no particular feed influence being noted. The first four or five lots from each ration were reported as having a "tainted off flavor," and were marked down. The last five lots were reported as being "good," "clean flavor," etc., and scored 38 and 39 out of a possible 45. The body of each of the two lots was reported a "trifle short," "brittle," "breaks easily," etc., and were marked down one point. The score is not very high, due to rather poor flavor. This is attributed, partly at least, to rather poor facilities in ripening and handling and not to feed. The corn gluten in this case does not appear to have had any bad influence on the body of the butter. It is held by many that gluten products produce a soft, salvy butter. This we are inclined to attribute to the influence of the corn oil, which is now largely removed before the gluten products are put upon the market. Bartlett's recent experiments support this view.*

Both lots of butter were tested for firmness of body by the usual method of allowing a plunge of given weight to drop from a certain height, noting the degree of penetration in millimeters. The average figures were 6.9 millimeters for the standard ration, and 6.7 millimeters for the Chicago gluten meal ration, showing practically no difference.

Experiment VI. 1899–1900.

[Period I., standard ration, both herds; Period II., standard ration *v.* King gluten meal ration; Period III., standard ration *v.* cotton-seed meal ration.]

During the winter of 1899–1900 another experiment was instituted, to note the effect of King gluten meal, with 14 per cent. corn oil, and normal cotton-seed meal, with 12.6 per cent. oil, on the butter fat and butter. Ten cows were divided as evenly as possible into herds of five each. In the first period, lasting two weeks,† both herds were fed the standard ration. In the second period of five weeks † Herd I. received the standard ration and Herd II. the King gluten meal ration. In the third period of five weeks † Herd I. received the standard ration and Herd II. the cotton-seed meal ration. It will thus be seen that both Herds received the same ration in the first period, then Herd II. was changed

* Maine Experiment Station report, 1898, pp. 97–113.

† Preliminary period of two weeks not included.

to the other two rations and Herd I. was used as a check for comparison. The several rations were as follows: —

Daily Rations (Pounds).

RATIONS.	Wheat Bran.	Ground Oats.	Cotton-seed Meal.	Chicago Gluten Meal.	King Gluten Meal.	Corn Silage.	Hay.
Standard ration,	3	5	.5	.5	-	20	10–15
King gluten meal,	2	2	-	-	4	20	10–15
Cotton-seed meal,	2	2	4	-	-	20	10–15

The average results follow: —

Analyses of Butter Fat.

First period: both herds standard ration.

HERDS.	Number Samples.	Saponification Equivalent.	Insoluble Acids.	Reichert-Meissl Number.	Butyric Acid Equivalent.	Melting Point (Degrees C.).	Iodine Number.
Herd I.,	4	233.3	88.35	32.18	5.67	34.08	25.84
Herd II.,	4	232.9	87.98	32.64	5.74	33.94	26.78
Second period: Herd I., standard ration; Herd II., King gluten meal ration.							
Herd I.,	10	232.4	88.27	31.48	5.54	34.00	26.44
Herd II.,	10	231.0	88.24	32.62	5.76	32.80	32.75
Third period: Herd I., standard ration; Herd II., cotton-seed meal ration.							
Herd I.,	10	229.6	88.62	30.56	5.38	34.12	26.35
Herd II.,	10	227.9	88.70	31.03	5.46	35.60	29.35

The experiment began December 7 and ended April 15, or 130 days. It is interesting to note the evenness in the composition of the butter fat during this time produced by Herd I. receiving the standard ration. There was a slight decrease in the saponification equivalent and the Reichert-Meissl number, but practically no change in the melting point or iodine number.

In the first period both herds produced butter fat of similar composition. In the second period the fat produced by Herd II., receiving the King gluten meal ration, showed no change in Reichert-Meissl number, a slight depression in melting point and a noticeable increase in the iodine number. The effect would probably have been more marked had more corn oil been fed. In the case of the linseed oil experiment both the melting point and iodine number were increased.

In the third period the fat produced by the cotton-seed meal ration showed but little change in composition from that produced by the standard ration.

It seems evident that different oils — linseed, corn and cotton-seed oils — exert a different influence on butter fat, these oils themselves being of different composition.

In making the butter, the creams, raised by the gravity process, were treated as nearly alike as possible. Our dairy building was completed, and afforded excellent facilities for doing the work. The cream was ripened to approximately .7 acidity in forty-eight hours. A skim-milk starter was used without the aid of any specially prepared ferment. Every sample of butter was analyzed and found to be normal, showing about 12 per cent. of water, 80 to 82 per cent. of butter fat and 1 per cent. casein. The butters were scored by Mr. W. A. Gude, with the following average results : —

Average Butter Score.

First period : both herds standard ration.

HERDS.	Number Samples.	Flavor.	Body.	Color.	Salt.	Style.	Total.
Herd I.,	4	36.2	23.4	15	10	5	89.6
Herd II.,	4	36.2	23.4	15	10	5	89.6
Second period : Herd I., standard ration ; Herd II., King gluten meal ration.							
Herd I.,	10	37.8	24.0	15	10	5	91.8
Herd II.,	10	39.7	24.9	15	10	5	94.6
Third period : Herd I., standard ration ; Herd II., cotton-seed meal ration.							
Herd I.,	10	36.0	24.1	15	10	5	90.1
Herd II.,	10	35.9	24.4	15	10	5	90.3
Standard score,	–	45.0	25.0	15	10	5	100.0

Mr. Gude's notes concerning the different samples are as follows: First period: flavor, "fair aroma," "fairly clean," "oily taste;" body, "short and breaks easily, seems brittle," "slightly short and brittle." Second period: flavor, Herd I., "fairly clean, lacks aroma," "defective;" Herd II., "clean and fine;" body, Herd I., "brittle, short, seems light and spongy, trifle salvy;" Herd II., "all right." Third period: flavor, Herd I., "fairly clean, but lacks aroma," "slight taints;" body, Herd I., "spongy when soft, short and crumbles when hard;" Herd II., "perfect," "short when soft, crumbles when hard," "salvy to taste."

Average Degree of Penetration (Millimeters).

HERDS.	First Period.	Second Period.	Third Period.
Herd I., ...	4.8	4.9	5.4
Herd II., ...	4.9	6.7	5.8

Our own deductions, based on the score and remarks of Mr. Gude and the degree of penetration concerning this experiment, are as follows: The tendency of the standard ration was to make butter with a firm body and likely to crumble. It seemed also to produce at times a slight oily or defective flavor. The hardness is probably due to the oats, and possibly the oily flavor to the oil of the oats. The King gluten meal seemed to produce a butter very satisfactory to Mr. Gude. He gave it an average score of 94.6, spoke of its flavor as clean and fine and of its body as perfect. The degree of penetration shows it to be a softer, more yielding butter than that produced by the standard ration. This condition is probably brought about by the corn oil. Butters of this consistency are objected to by some. It is our intention soon to feed corn gluten without oil, and the same with different quantities of oil.

The cotton-seed ration produced butter of about the same quality and condition as the standard ration. Mr. Gude spoke of it as lacking aroma and having a slight taint, and of being rather spongy when soft and crumbling when hard. This butter is firmer than the King gluten butter. It would be of interest to note the influence of the cotton-seed protein and the cotton-seed oil separately on the butter, and we hope to carry out such experiments.

It is clear, from our several experiments, that food does influence to a noticeable degree the composition of the butter fat and the body of the butter. It seems also to influence the flavor; to what extent, as compared with the influence produced by bacteria, is not quite clear. This matter is being given further study.

B. — THE COMPOSITION, DIGESTIBILITY AND FEEDING VALUE OF BARNYARD MILLET (*Panicum crus-galli*).

J. B. LINDSEY.

Conclusions.

1. Barnyard millet is a warm-weather plant, similar in this respect to Indian corn.

2. As harvested in early blossom, the fodder contains less nitrogen-free extract matter, more fibre or woody matter, and rather more ash than corn fodder. The seed resembles the cereals (especially oats) in composition. It contains considerable more fibre, rather more ash and 5 to 6 per cent. less extract matter than maize.

3. Barnyard millet, grown on naturally moist and fertile land, will probably yield as much dry matter per acre as corn.

4. It has less nutritive value than the corn, the principal reason for this being that the corn can partially mature its grain and still be readily eaten by animals, while the millet must be cut when in blossom to secure it in the most desirable condition for feeding.

5. It is not suitable for hay, and, while it makes a fairly satisfactory silage, it is inferior to maize as a silage crop.

6. It furnishes a desirable green feed, especially during the month of August, and *it is for this purpose that it can be most satisfactorily utilized*.

7. The millet can be used for silage in place of corn whenever it is not convenient or possible to grow the latter.

Preliminary Statement.

During the last ten years the attention of farmers has been frequently called to the value of several varieties of Japanese millets.* Experiments have demonstrated the *Panicum crus-galli* — now termed barnyard millet — to be the most useful Japanese variety for fodder purposes; and this department has endeavored to ascertain, by experiment and observation, its relative value, as compared with other materials of similar character, as a food for dairy animals. The term barnyard millet has been adopted as its common name, for the reason that it appears to be a cultivated and improved variety of the common barnyard grass. The information given below is not meant to be an exhaustive treatise on the subject, but rather a bringing together of data already at hand concerning the nutritive value and practical utility of the plant.

(*a*) Character of the Millet.

This variety of millet is a coarse-growing form, with a comparatively heavy leafage and compact beardless heads. When headed out it stands from four to six feet in height, and rarely lodges. It is a warm-weather plant, similar to corn, and makes a very rapid growth when the temperature is high. Sown the middle of May, it begins to head about August 1, the time varying a little, depending on weather conditions. After the heads appear it becomes woody, and proportionately less valuable for fodder purposes. It will not endure dry weather as well as corn, and succeeds best upon moist land in a good state of fertility. If cut when it begins to bloom, a second crop may be frequently secured, but it is apt to be small in quantity and coarse in quality.

(*b*) Composition of Green Millet.

Numerous analyses of this material have been made, the more recent ones by this department being tabulated as follows: —

* See, in the different reports of the Massachusetts Agricultural College and Hatch Experiment Station, the articles by Prof. W. P. Brooks, to whom we are indebted for the introduction of these fodder plants. See also Farmers' Bulletin, 101, published by the United States Department of Agriculture, on millets.

I. Water-free Material (Per Cent.).

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
(*a*) First week of blossom,*	–	7.84	8.44	32.06	49.92	1.74
(*b*) Second week of blossom,*	–	8.59	11.00	35.03	43.65	1.73
(*c*) Well headed,†	–	10.18	10.73	34.48	43.05	1.56
(*d*) Beginning to head,†	–	8.36	6.77	36.69	46.78	1.40
Average,	–	8.74	9.23	34.56	45.85	1.62
Corn fodder for comparison,‡	–	5.20	9.70	21.30	60.60	3.20

* (*a*) and (*b*) grown in same year on same plot.
† (*c*) and (*d*) grown in different years.
‡ Flint varieties, average forty analyses, Jenkins' and Winton's tables.

II. Average Results, Natural Moisture (Per Cent.).

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Millet,	80.00	1.75	1.85	6.91	9.17	.32
Corn,	79.80	1.10	2.00	4.30	12.10	.70

As is to be expected, the different samples of millet vary somewhat in composition, depending upon the stage of growth, weather conditions, fertility of land and possible errors in sampling. The natural tendency is for the fibre to increase as the plant approaches maturity.

Of the total crude protein in sample (d) (6.77 per cent.), 6.02 per cent. was found to exist as true albuminoids and .75 per cent. in the form of amids. The amids thus represented 12.46 per cent. and the albuminoids 87.54 per cent. of the matter calculated as crude protein. This is what might be expected in immature material of this character. The same sample showed 22.46 per cent. of pentosans, representing about one-half of the non-nitrogenous extract matter. It is quite probable, however, that a small quantity of the total pentosans still remained in the crude fibre and could not be counted as extract.

When the analysis of the millet is compared with that of corn fodder, on the basis of dry matter, one striking difference is noted, namely, that the fibre is much in excess in the millet, and the nitrogen-free extract matter correspondingly less. The millet naturally develops relatively more woody matter than the corn, and for this reason it is necessary to cut the millet for feeding purposes while in blossom. If allowed to grow until the seed is developed, the straw is hard and woody, and quite unsatisfactory for feeding. Corn fodder, the analysis of which is given above, is supposed to be rather thickly seeded corn, with ears more or less developed, and probably cut late in August. It is an advantage to allow the corn fodder when fed green to grow until it has reached the above stage, for the reason that its digestibility and palatability are not appreciably decreased, while the nutritive value is considerably enhanced because of the ear development. The character also of the extract matter in the two fodders is not the same, the corn having a considerable amount of the valuable starch, which is practically lacking in the millet. The principal difference, then, from a chemical stand-point, between these two plants, consists, in case of the corn, in the extra percentage of nitrogen-free extract matter containing considerable quantities of starch, and the smaller percentage of the less valuable woody fibre.

The protein percentage is about the same. The millet shows relatively rather more ash than the corn. This may be due to the fact that it is cut at an earlier stage in its growth. From the comparative chemical analysis of the two plants, as given above, one would naturally expect a greater nutritive effect from the corn than from the millet.

Composition of the Ash (Dry Matter).

Only two analyses of the ash of the millet are on record. One of them was made a number of years ago, and is very incomplete; the other represents a recent analysis of sample (d) : —

SAMPLES.	Crude Ash.	Soluble Ash.	Insoluble Ash.	Calcium Oxide.	Potassium Oxide.	Phosphoric Acid.	Undetermined.
Sample (d), .	8.36	6.33	2.03	.96	3.70	.52	1.15
Earlier sample, .	–	–	–	–	1.96	.44	–
Green corn,* .	6.12	5.00	1.12	.82	2.18	.60	–

* From Wolff tables, given for comparison; exact stage of growth unknown.

The amount of the several ash constituents will of course vary, depending upon the state of growth, soil moisture and fertility. The above figures are not sufficient to enable one to form any very correct idea of the mineral constituents of the plant; they indicate, however, that the millet takes considerable quantities of mineral constituents from the soil, especially potash, and fully as much as Indian corn at a corresponding stage of growth.

Composition of the Seed.

SAMPLES.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Millet seed (1898),	11.47	2.81	9.44	7.69	65.20	3.39
Millet seed (earlier),	10.30	3.10	12.30	7.70	60.90	5.70
Average of both samples,	10.88	2.96	10.87	7.69	63.05	4.55
Oats for comparison,*	11.00	3.00	11.80	9.50	59.70	5.00

* Jenkins's and Winton's tables, average 30 samples.

The millet seed resembles oats very closely in composition. The protein and fibre are a trifle higher in the oats, and the nitrogen-free extract correspondingly lower.

Composition of Millet Silage (Natural Moisture).

	Number Analyses.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free-Extract.	Fat.
Millet,	3	74.0	2.40	1.70	7.50	13.60	.80
Millet and soy beans,*	9	79.0	2.80	2.80	7.20	7.20	1.00
Millet and soy beans,†	2	81.0	2.21	2.04	6.66	7.44	.65
Corn and soy beans,*	4	76.0	2.40	2.50	7.20	11.10	.80
Corn and soy beans,†	1	75.0	1.80	2.35	7.06	13.19	.60
Corn silage for comparison,‡	99	79.1	1.40	1.70	6.00	11.00	.80
Dry Matter.							
Millet,	3	–	9.24	6.50	28.80	52.36	3.10
Millet and soy beans,	11	–	13.06	12.91	34.40	35.07	4.56
Corn and soy beans,	5	–	9.42	10.20	29.63	47.59	3.14
Corn silage for comparison,	99	–	6.60	8.00	28.70	53.00	3.70

* Previous to 1897; approximately two-thirds millet or corn and one-third bean.
† During 1897. ‡ Jenkins's and Winton's tables.

The millet silage and the corn silage, so far as the above figures are concerned, show no great analytical differences. It must not be forgotten, however, that the non-nitrogenous extract matter of the corn contains a considerable amount of starch, which fails in the millet. The mixtures made from millet and corn, with soy beans, were not perfect. The object was to add one-third beans and two-thirds corn in putting the materials into the silo, but this was done only by loads of material and not by actual weight. The analytical results on the basis of dry matter are about what might be expected; namely, an increase in the protein percentage and a decrease in the extract matter in each case, when compared with millet or corn silage. One notes, however, more extract matter in the corn and bean than in the millet and bean silage. The protein and ash are higher in the millet and bean than in the corn and bean silage. This condition is satisfactorily explained on the ground that the millet and bean, being cut at an earlier stage than the corn and bean, would naturally contain relatively more ash and protein and less extract matter.

The Digestibility of Millet.

The following figures represent the digestibility of the different ingredients of millet, and were obtained by the use of sheep at this station. The numbers mean that, of the total amount of ash, protein, etc., contained in the millet, such and such amounts or percentages were digested. Thus, if green millet contains 6.91 per cent. of fibre, 73 per cent. of it is digestible, or $6.91 \times 73 = 5.04$ per cent.

CHARACTER OF MATERIAL.	Number Different Samples.	Number Single Trials.	Dry Matter.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Green millet, early to late blossom, . . .	1	3	71	64	69	73	72	63
Dent corn fodder (in milk) for comparison, .	3	9	70	-	61	64	76	78
Millet hay, full blossom,*	1	3	57	63	64	61	52	46
Millet hay, full blossom,†	1	2	56	24	31	63	55	50
Timothy hay for comparison, ...	12	26	57	-	48	52	63	60
Millet silage for comparison,‡	-	-	-	-	-	-	-	-
Millet and soy bean silage, ...	1	4	59	-	57	69	59	72
Corn and soy bean silage,§	1	3	69	-	65	65	75	82
Corn silage for comparison,‖	-	10	71	30	56	70	76	82

* Same plot as green material previously given.

† *Panicum italicum*, — a different species of Japanese millet.

‡ No digestion tests have been made.

§ Pride of North corn (dent) and medium green soy beans, two-thirds former and one-third latter, in excellent condition.

‖ Average dent and flint.

The green millet appears, from the figures at our disposal, to be as digestible as the fodder corn.

The millet hay shows a very much less degree of digestibility than the same material green. Generally speaking, the mere withdrawal of the water is not supposed to affect digestibility, and this is likely to be the case with young and tender plants and with grains that can be ground fine. In the case of coarse, woody plants the reverse is likely to be true. The hardening of the woody stalks in the curing process, and the less perfect mastication resulting, in all probability are the most important factors in bringing about this apparent result. We hope to make other experiments to still further prove this point. Unfortunately, no figures are on hand for the millet silage. The corn and bean silage shows about 10 per cent. more total digestible matter than the millet and bean silage. The extract matter of the former is noticeably more digestible. The high degree of digestibility of the extract matter of the corn and bean silage is explained when one remembers the considerable amount of corn grains present. Corn and soy bean silage, as shown by this experiment, appears to be nearly as digestible as average corn silage, and the protein even more so.

Multiplying the percentage composition of the millet, as given in a previous page, by the digestion percentages or coefficients as stated above, one obtains the following percentages digestible in one hundred : —

[Figures equal percentages, or pounds in 100 digestible.]

CHARACTER OF MATERIAL.	Fresh or Air-dry Material.					Dry Matter.			
	Dry Matter.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Green millet, ...	14.20	1.28	5.04	6.60	.20	6.37	25.23	33.01	1.02
Green corn, fodder, . .	14.14	1.22	2.75	9.19	.55	5.91	13.63	46.06	2.50
Millet hay, ...	48.45	5.02	17.91	20.25	.63	5.90	21.08	23.84	.73
Timothy hay for comparison,	49.00	4.10	14.70	27.20	1.10	4.80	17.10	31.60	1.30
Millet and soy bean silage, .	12.15	1.51	4.90	4.27	.68	7.36	23.74	20.69	3.28
Corn and soy bean silage, .	16.70	1.60	4.66	8.64	.62	6.63	19.26	35.69	2.57
Corn silage for comparison, .	14.84	.95	4.20	8.44	.66	4.48	20.09	40.28	3.12

Millet hay is assumed to contain 15 per cent. of water and timothy hay 14 per cent. It is doubtful if the water content of the millet could be brought as low as 15 per cent.

The above figures tell the same story as those representing the *composition* of the several materials, namely, the excess of fibre and the lack of extract matter in the millet, as compared with the corn. While the green millet appears to be as digestible as the green corn, *there is more digestible fibre in the millet and correspondingly less digestible extract matter.* The corn silage shows rather less digestible protein than the millet and bean silage, and nearly twice as much digestible extract matter. There is not a great deal of difference between the corn and bean silage and the corn silage, excepting the increased amount of protein in the former.

Utility of Barnyard Millet.

Yield per Acre. — The millet is a heavy yielder of green fodder; from 12 to 18 tons per acre have been grown upon the college farm, on naturally moist land in good condition, while as high as 35 tons per acre have been reported by outside parties. Our own experience has shown it to yield from 12 to 14 tons per acre upon medium loam in good state of fertility, but not naturally very retentive of moisture. Such quantities, however, were produced without the millet appearing to suffer from lack of water; and it is believed that this amount is a conservative estimate of its productiveness, unless the land is especially moist, warm and fertile. If the millet is planted in drills 15 inches apart and allowed to mature, it will yield about 60 bushels of seed per acre, of an average weight of 35 pounds per bushel. When sown broadcast, 90 bushels per acre have been reported.

Millet as a Soiling Crop. — For use as a soiling crop, the seed should be sown broadcast and harrowed in May 10 to 15, at the rate of 12 quarts per acre. The fodder will be ready to cut August 1 or a few days earlier. It is wise to begin cutting before the heads appear, and to continue for twelve days. It cannot be cut to advantage for a much longer period, for the reason that after it is well headed it becomes tough and woody, and the animals refuse a portion of it. In order to secure green millet feed during the entire month of August, a second seeding can be made June 1, and a third about June 20. If green feed of this character is desired in September, later seedings are necessary. We have found it advantageous to sow peas with the first seeding of millet, at the rate of one and one-half bushels of Canada peas together with six quarts of millet per acre. The peas are first deeply harrowed in, and the millet covered with a tooth harrow. If the weather should prove cool during May and June, the peas are likely to get ahead of the millet, but the latter catches up as the warm weather comes on. This pea and millet mixture makes a desirable green feed. No experiments have been made to measure the feeding value of green millet for milk production, for the reason that the time in its growth when it is available is too short to secure any very reliable data. We have fed the green millet to the station herd during the first three weeks of August for a number of years. During the first week of the cutting the animals eat it well, but the second week a considerable portion of the stems remain unconsumed. Millet acts as a laxative as well as a diuretic, and it is not advisable to feed it as the entire source of coarse fodder. Fed in this way, we have observed that the bowels become very loose, the animals soon refuse to eat above 60 pounds per day, and they lose in flesh and milk production. When they are fed entirely in the barn or yard, 10 pounds of hay per day, together with what green millet they will eat, is a desirable quantity. This usually amounts to about 50 or 60 pounds of millet daily. When animals run in pastures, a supplementary feeding of green millet at night is quite helpful.

From our observations we prefer corn fodder to millet as a green feed, because more milk is secured and the animals tend to keep in better condition. The corn fodder can be fed for a longer period than the millet, and, being more or less eared, its nutritive value is thereby enhanced. Millet, on the other hand, has the advantage of requiring less labor to grow than corn, as after it is once sown it requires no further attention until ready to cut.

Millet as a Hay Crop. — Brooks,* a number of years since, called attention to the fact that, although the yield of hay was from 3 to 6 tons per acre, the difficulty of properly curing it was such that the millet could not be very satisfactorily utilized as a hay crop. We can simply confirm this. The coarseness of the fodder renders it very difficult to eliminate sufficient of the water to enable the hay to keep well unless several extra hay days follow one another; the hay therefore is likely to become musty and consequently unsatisfactory for feeding, and the farmer cannot depend upon it as a rule to furnish him with any considerable amount of dry fodder.

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* *Loco citato.*

Millet as a Grain Crop. — According to Brooks,* the birds have a great liking for the seed and it is therefore difficult to harvest without loss. The yield of one ton to the acre is small, as compared with an average crop of corn. Brooks and Smith fed millet meal to four dairy cows, comparing it to an equal quantity of ground oats, and noted no difference in the results (experiment not published). The cost of threshing the grain is to be considered, and the straw would be quite inferior to corn stover for fodder purposes. It does not seem probable that the grain could be made an economic feed for farm animals.

Millet for Silage. — Millet makes a very fair silage, but, as a result of the writer's experience, it is not considered equal to maize. So far as known, there are no exact feeding experiments on record comparing these two plants for silage purposes. It lacks the large quantity of digestible starchy matter which the corn contains in the form of the grain. It could not be put into the silo after it had ripened its seed, as is the case with corn, for the straw would then be dry and tough, and the seed is covered with a hard seed-coating. Our observations have convinced us that millet silage has less nutritive effect than corn silage. The digestion experiments with millet and bean silage, as compared with corn and bean silage, confirm this opinion. We have also noticed that animals are inclined to consume a larger quantity of corn than of millet silage, especially when fed for a considerable length of time. While the labor involved in growing a crop of millet is certainly less than in growing a crop of corn, the extra work in harvesting the former for the silo makes up for it, at least to a considerable degree. If for any reason, however, the corn crop should fail, and millet could be advantageously grown, it would certainly make a very desirable substitute for the former. Millet and soy bean silage is preferable to millet silage, from a nutritive stand-point; but the cost of growing and harvesting the same prevents its general use.

The following estimate of the value of millets on the farm is made in Farmer's Bulletin, 101, already referred to, and

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* *Loco citato.*

it so fully expresses the writer's estimate of the utility of barnyard millet that it is quoted in full: —

On the whole, it is doubtful if there are many sections in this country where millets should be made a primary crop. Their place is rather that of a supplementary one, — a "catch-crop," when the corn has been destroyed by hail or otherwise; a substitute for corn, where that crop is not easily grown; a crop to be grown on a piece of land that might otherwise lie idle; a readily available crop for use in short rotations; an excellent thing to grow on foul land, to get rid of weeds, giving practically the same results as fallowing or summer cultivation, and in addition a crop of forage; a supplement to the regular and permanent pastures and meadows. It is in such ways that the millets are most valuable on the average farm, and such is the place they should be given in American agriculture.

C. — DRIED DISTILLERY GRAINS.

What They are. — Dried distillery grains consist of the residue remaining in the process of manufacturing alcohol, spirits and whiskey from the several cereals. Briefly stated, the process consists in grinding the various grains employed and heating them with a solution of malt, thus converting the starch into sugar. The addition of yeast converts the sugar into alcohol, which is then distilled, and the residue or distillery slop is filtered, dried in especially constructed driers and put upon the market as a cattle food. It consists chiefly of the hulls, germ and protein of the grains. It has a more or less sour taste and smell, because of the fermentation. If the slop remains undried too long, this sour condition is increased. Well-informed parties state that the quality of the dried grains depends, in the first place, upon the composition of the distillers' mashes (*e.g.*, the kinds and proportions of the grains employed); secondly, upon the distillers' mode of mashing and fermenting; and, thirdly, somewhat upon the process of drying.

How They may be classified. — The dried grains may be classified as follows, depending upon the source from which they are derived: —

A. Alcohol and spirits grains.
B. Bourbon whiskey grains.
C. Rye whiskey grains.

The grains produced from *alcohol and spirits distilleries* are the highest in quality, and of the most uniform grade. Corn is practically the only grain used.

The grains produced by *whiskey distilleries* vary according to the proportion of corn, rye and malt contained in their mashes. The larger the proportion of corn and the smaller that of rye and malt (small grain, so called), the higher the grade of dry grains produced. Some bourbon whiskey distillers use very little "small grains," and their product stands near that of Class A. Many make bourbon, half rye and pure rye whiskey alternately in one season, and their product of dried grains varies in quality accordingly. Others, especially in Pennsylvania and Maryland, produce rye grains only.

Their Average Composition. — A large number of analyses of Class A grains are said to show an average of 35.33 per cent. of protein and 11.25 per cent. of fat.

Class B, or bourbon whiskey grains, run from 23.9 to 38.06 per cent. of protein and from 6.3 to 15 per cent. of fat.

Class C, or rye grains, show from 17.85 to 24.28 per cent. of protein and from 5.04 to 7.5 per cent. of fat, averaging 20.87 per cent. protein and 6.32 per cent. fat.

Where manufactured. — The grains derived from spirits and alcohol are manufactured chiefly in Illinois and Indiana, those from bourbon whiskey in Kentucky, and those from rye whiskey in Pennsylvania and Maryland. All grades are produced in Ohio and Wisconsin.

The Yearly Product. — According to the last annual report of the commissioner of internal revenue (page 104), there were used in the distilleries of the United States during the fiscal year ending June 30, 1900: —

Bushels corn,	16,277,034
Bushels rye,	4,070,861
Bushels malt,	2,721,124
Bushels wheat,	27,225
Bushels oats,	15,414
Bushels barley,	1,328
Bushels mill feed and other materials,	1,276
Bushels grain of 60 pounds,	23,114,262

At present the annual output of distillers' dried grains in this country is less than 40,000 tons; but, if all the distillery slop were dried by perfect machinery, the country would produce about 170,000 tons yearly. The output of single distilleries varies from 1½ to 40 tons per day. Alcohol and spirits grains are produced in the largest establishments, which are generally operated throughout the year. Bourbon and rye whiskey grains are produced in smaller distilleries, rarely turning out more than 5 tons per day, and they are in operation only between November and July.

Where Distillers' Grains are consumed. — Very few grains have been thus far used in the United States, they being mostly exported and consumed in Germany. Statistics of the quantity exported have been lacking until recently, because of the classification employed. The export of distillers' dried grains, brewers' dried grains and malt sprouts, from July 1 to Oct. 31, 1900, was 22,347 tons, or about 5,600 tons per month. How much of this is distillers' dried grains is a trifle uncertain. It is estimated that the exports from July to October consisted of about 50 per cent. brewers' dried grains, 35 per cent. distillers' dried grains and 15 per cent. malt sprouts; that from January 1 to June 30 distillers' grains will predominate, and that the total export of the latter will amount to about 28,000 tons during the present fiscal year.*

* For the larger part of the above information we are indebted to the J. W. Biles Company, Cincinnati, O.

We understand it is the intention to introduce this material in our eastern markets. Our inspectors have already noticed it occasionally. For convenience in distinguishing the different qualities, the sellers have divided the various products into five grades, namely, "R," "X," "XX," "XXX" and "XXXX." Those marked "R" are lowest in protein and fat, and those marked "XXXX" highest. Some two years since, this department secured several tons of these grains. They were analyzed, tested for digestibility and fed to milch cows.

Composition of Distillers' Grains.

CONSTITUENTS.	Brand "R."	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."
Water,	7.00	7.00	7.00	7.00	7.00
Protein,	16.67	29.76	26.20	30.01	35.46
Fat,	5.68	10.88	9.77	11.90	10.04
Extract matter,	55.87	40.89	43.00	38.69	34.14
Fibre,	12.74	9.77	11.53	10.33	11.63
Ash,	2.04	1.70	2.50	2.07	1.73
Total,	100.00	100.00	100.00	100.00	100.00

The several grades showed between 7 and 8 per cent. of water; for the sake of uniformity, they were all calculated to a 7 per cent. basis.

The sellers state that the markings on "X" and "XX" must have been reversed, as the "XX" grains should show a higher percentage of protein than those marked "X." The "R" grains, as the sellers claim, are the poorest in composition, showing in this particular lot 16.67 per cent. of protein and 5.68 per cent. of fat, — about equal to the amounts found in wheat bran. The others gradually increase in these two ingredients, the "XXXX" showing 35.46 per cent. of protein and 10.04 per cent. of fat. The fibre is not excessive, being from 2 to 4 per cent. more than in bran. The analyses show these materials to be valuable feeding stuffs and worthy of the attention of feeders, providing they are sold on a guaranty. The sellers state that a guaranty will always accompany the different grades.

Digestibility of Distillers' Grains.

Digestion tests were made with sheep, and the following co-efficients obtained: —

CONSTITUENTS.	Brand "R."	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."	Average, excepting Brand "R."
Total dry matter, .	58	87	84	76	77	81
Protein, ...	59	73	77	74	71	74
Fat, ...	84	93	95	93	96	94
Extract matter, . .	67	89	84	75	79	82

Excepting the "R" brand, these materials show relatively high digestibilities, with comparatively small variations. In the last column is given an average of the four "X" brands, which may represent the average digestibility of distillery grains made largely from corn.

Multiplying the composition by the percentages digestible, one obtains the *percentage or pounds in 100 digestible:* —

CONSTITUENTS.	Brand "R."	Wheat Bran for Comparison.
Dry matter, ...	53.94	54.29
Dry matter contains: —		
Protein, ...	9.84	12.60
Fat, ...	4.77	3.20
Extract matter, ...	37.43	35.40
Organic nutrients (excluding fibre) digestible, ...	52.04	51.20

The "R" brand appears to contain about the same quantity of digestible nutrients as does wheat bran. The latter contains rather more protein, and a trifle less fat and extract matter digestible than the former.

CONSTITUENTS.	Brand "X."	Brand "XX."	Brand "XXX."	Brand "XXXX."	Gluten Feed for Comparison.*
Dry matter,	80.91	78.12	70.68	71.61	77.28
Dry matter contains: —					
Protein,	21.72	20.17	22.21	27.30	22.50
Fat,	10.12	9.28	11.07	9.64	3.30
Extract matter,	36.39	36.12	29.02	26.96	43.80
Organic nutrients, excluding fibre digestible.	68.23	65.57	62.30	63.90	69.60

* We refer to such well-known brands as Buffalo, Davenport, Rockford, being the residue from the glucose factories.

These several brands are quite similar in digestible ingredients to gluten feed, and for the present they can be considered as having approximately an equal value. They have noticeably more digestible fat and less digestible extract matter than the latter. They are likely to vary more in composition from time to time than the regular gluten feeds. The highest grade would probably contain rather more protein.

Tests with Milch Cows.

We were not in a position at the time to carry on any exact experiments with dairy animals. The several lots of grain were, however, fed to a number of cows, and the results were as good as one would naturally expect. The animals ate them well, receiving 3 or 4 pounds daily, mixed with wheat bran; the milk yield was satisfactory. We see no reason why the quality of the milk and butter should not be equal to that derived from animals fed upon corn silage, dried brewers' grains, etc. It would probably be wise not to feed such materials to animals when the milk was intended for infant feeding. Should these grains be generally introduced, it would be advisable to note particularly their influence, if any, on the flavor of milk and butter.

Several years since, a considerable quantity of so-called Atlas gluten meal was sold in Massachusetts and Vermont. This was dry distillery grains, sold by a distilling company in Peoria, Ill. It was not accompanied by a guaranty, and varied from 22 to 36 per cent. of protein. It has not been in the market of late. Hills* fed this material (testing 35 per cent. of protein) to milch cows, and secured very satisfactory results. Its effect on the flavor of milk and butter was not mentioned, and we can assume it was satisfactory. He considered it the cheapest source of protein in Vermont markets at the time.

D.—DIGESTION EXPERIMENTS WITH SHEEP.

These experiments were made during the winter of 1898–99. The method employed was the usual one, as described in the eleventh report of the Massachusetts State Experiment Station for 1893. The full data will be published at another time. By digestion coefficients is meant the percentages of protein, fat, etc., that the animal is capable of digesting. Thus, if wheat bran contains 16 per cent. of protein, or 16 pounds in 100, and the percentage digestible or digestion coefficient is 78, it means that the animal can digest 78 per cent. of the 16 pounds, or 12.46 pounds.

Description of Feed Stuffs.

Hay. — This hay was used in connection with the several concentrated feeds. It was largely Kentucky blue grass, with a small admixture of red clover. It was cut in bloom.

Meadow Fescue. — This was grown on an experimental plot, on land in an average state of fertility. It was free from weeds or other grasses.

Kentucky Blue Grass. — Same conditions as for meadow fescue.

Tall Oat Grass. — Same conditions as for meadow fescue.

Distillery Grains. — Fully described on pages 132–138. The digestibility of the fibre varied to such an extent with the different sheep that no digestion coefficient is presented. It seems to be very digestible in the various "X" brands, possibly 75 or more per cent.

Oat Feed. — This food consisted of the refuse from the oatmeal mills. It was quite an inferior sample of its kind,

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* Vermont Experiment Station report, 1895, p. 222.

containing a large quantity of hulls. The sheep digested only one-third of it.

Rye Feed. — This material is a mixture of rye bran, with a considerable quantity of fine middlings.

Chop Feed. — This consists of the hull, bran and broken germs of Indian corn, and is one of the residues remaining in the manufacture of starch and glucose. The sheep digested this material very unevenly, and the digestion coefficients given represent the average results from six sheep. They are not as satisfactory as could be desired.

Cleveland Flax Meal. — Linseed meal, with the oil quite thoroughly extracted by the naphtha process.

Parsons' "Six Dollar" Feed. — Fully described on pages 141–142.

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 June grass in bloom (*poa pratensis*).	1	6	59	61	47	62	57	48
Meadow fescue, full bloom (*Festuca elatior pratensis*).	1	2	61	52	54	59	67	46
Kentucky blue grass, full bloom (*poa pratensis*).	1	1	56	57	42	53	63	42
Tall oat grass, late bloom (*Arrhenatherum elatius*).	1	2	55	51	56	58	55	41
Distillery grains, Brand "R,"	1	2	58	59	84	67	?	-
Distillery grains, Brand "X,"	1	2	87	73	93	89	?	-
Distillery grains, Brand "XX,"	1	2	84	77	94	84	?	-
Distillery grains, Brand "XXX,"	1	2	76	74	93	75	?	-
Distillery grains, Brand "XXXX,"	1	2	77	71	96	79	?	-
Oat feed (large amount hulls),	1	3	34	62	92	33	27	13
Rye feed,	1	3	82	80	90	88	?	35
Chop feed,	2	6	80	67	82	84	82	-
Cleveland flax meal,	1	2	87	83	76	94	?	21
Parsons' "six dollar" feed,	1	2	56	57	81	64	47	12

E. — THE COMPOSITION OF PURSLANE (*Portulaca oleracea*).

During the present summer this department received a letter from a Massachusetts farmer inquiring concerning the feeding value of purslane. He stated that he had been feeding it to his cows, and had noticed a decided increase in the quantity of milk; and that, while the animals at first refused to eat it, they soon became accustomed to it, and consumed considerable quantities daily. At the time we had no analysis of the material on hand, consequently a sample was procured and examined. Since making the analysis, we have found a similar analysis made by the Indiana station.* The results are presented below: —

	Green Material.						Water-free Material.				
	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Massachusetts station,	90.90	1.55	2.28	1.61	3.42	.24	17.08	25.11	17.71	37.44	2.66
Indiana station,	86.56	2.23	1.81	2.12	6.49	.50	-	-	-	-	-
Corn fodder for comparison,	79.80	1.10	2.00	4.30	12.10	.70	5.20	9.70	21.30	60.60	3.20

The analyses show that the plant contains a very large percentage of water, mineral constituents and nitrogenous matter (protein).

The Missouri station* found .29 per cent. of nitrogen, .85 per cent. of potash and .045 per cent. of phosphoric acid in the green matter, equivalent to approximately 2 per cent. of nitrogen, 6 per cent. of potash and .3 per cent. of phosphoric acid in dry matter. We have found .37 per cent. of nitrogen, equivalent to 4.1 per cent. of nitrogen in dry matter. The percentage of potash present in the Missouri sample is exceptionally large. The plants selected by us must have been in an earlier stage of growth than those of the Indiana and Missouri stations, for both the water and the protein content are very high.

* Farmers' Bulletin, 119, Department of Agriculture.

The above results show that purslane takes large quantities of water, nitrogen and potash from the land, and must be considered a great soil exhauster.

Plumb* has fed purslane to pigs with quite satisfactory results. If dairy animals can be induced to eat it, it would quite naturally increase the flow of milk, because of its high protein content. Whether it would produce any undesirable flavor in the milk, has not been observed.

It being a most objectionable weed where clean cultivation is desired, growing and spreading with wonderful rapidity, and being at the same time a large consumer of plant food, it would hardly be considered a desirable fodder crop on most farms. Whether it has any special ability to dissolve and utilize ordinarily insoluble plant food, has never been determined.

Purslane has been frequently used in many sections as a pot herb, being cooked in a similar way to spinach, etc. It is thus highly esteemed by many.

F. — PARSONS' "SIX DOLLAR" FEED.

The station frequently receives letters requesting information relative to the value of this material. We think Mr. Parsons himself quite fairly states in his circular what this feed is. He says: "It is composed principally of the hulls of different kinds of grains and other low-grade stuff from grain mills and elevators." A sample lot was procured for us by an outside party. In appearance it seemed to consist of the chaff of different grains. It analyzed as follows: —

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Parsons' feed, ...	11.00	7.90	9.99	17.89	51.10	2.12
Oat hulls for comparison, . .	14.30	10.00	4.00	34.00	36.20	1.50

It is quite evident from the above analysis that this sample of the feed contained a considerable quantity of hulls, chaff,

* Bulletin, 82, Indiana Experiment Station.

etc., because of the presence of so large an amount of fibre. It contained, however, in addition, other grain refuse and sweepings, for there is considerable more protein and extract matter than would be found in clear hulls.

The material was fed to sheep, to ascertain its digestibility. These animals were induced to eat it after a little effort. The figures following represent the *percentages digestible* of the total amounts of the several ingredients contained in the feed, and are termed digestion coefficients: —

	Dry Matter.	Ash.	Protein.	Fibre	Nitrogen-free Extract.	Fat.
Parsons' "six dollar" feed, .	56	12	57	47	64	81
Oat hulls for comparison, .	-	-	35	57	45	35

This lot showed a degree of digestibility approaching average late-cut English hay, and superior to oat hulls. How much different lots are likely to vary in quality, we cannot state. Considerable difference in quality would naturally be expected.

We endeavored to feed this material to cows, as a partial hay substitute, but the animals could not be induced to eat it. This was in the spring of the year. It is possible that in the winter some of it might have been consumed with satisfactory results. It is dry, possesses considerable fertilizing value, having 1.60 per cent. of nitrogen, and is chiefly useful as an absorbent. We have not determined its content of phosphoric acid and potash. Oat hulls show .45 per cent. of potash and .13 per cent. of phosphoric acid. A conservative estimate of its fertilizing value would be $3 per ton.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, SAMUEL W. WILEY, JAMES E. HALLIGAN.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1900.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 55; of these, 33 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 6 in Connecticut, 2 in Vermont, 2 in Rhode Island, 1 in Canada, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and forty-four distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

Four hundred and forty-three samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and seventy-two samples were analyzed at the close of November, 1900, representing 251 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 65, March; No. 68, July; and No. 70, November, 1900.

The samples not already analyzed, together with others that may be collected before the first of May, 1901, will be examined with a view of being published in our spring bulletin. It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

For the readers' benefit the following abstract of the results of our analyses is here inserted: —

	1899.	1900.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	16	15
Number with two elements above the highest guarantee,	27	24
Number with one element above the highest guarantee,	73	85
Number with three elements between the lowest and highest guarantee,	88	118
Number with two elements between the lowest and highest guarantee,	84	92
Number with one element between the lowest and highest guarantee,	58	43
Number with three elements below the lowest guarantee,	–	1
Number with two elements below the lowest guarantee,	19	11
Number with one element below the lowest guarantee,	68	50
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	7	5
Number with one element above the highest guarantee,	32	20
Number with two elements between the lowest and highest guarantee,	20	19
Number with one element between the lowest and highest guarantee,	27	6
Number with two elements below the lowest guarantee,	2	–
Number with one element below the lowest guarantee,	18	20
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	15
Number between the lowest and highest guarantee,	16	9
Number below lowest guarantee,	10	10

A comparison of the above-stated results of our inspection with the results of 1899 shows, with the exception of those fertilizers which are classed under (*b*) (where two essential elements of plant food are guaranteed), a marked superiority in favor of the samples analyzed in 1900.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1899 and 1900 (Cents per Pound).

	1899.	1900.
Nitrogen in ammonia salts,	15.0	17.0
Nitrogen in nitrates,	12.5	13.5
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade fertilizers.	14.0	15.5
Organic nitrogen in fine bone and tankage,	14.0	15.5
Organic nitrogen in medium bone and tankage,	10.0	11.0
Phosphoric acid soluble in water,	4.5	4.5
Phosphoric acid soluble in ammonium citrate,	4.0	4.0
Phosphoric acid in fine-ground fish, bone and tankage,	4.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.0	4.0
Phosphoric acid in coarse fish, bone and tankage,	2.0	3.0
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.0	2.0
Potash as sulfate (free from chlorides),	5.0	5.0
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows a marked increase, as compared with the preceding year, 1899.

The above trade values are based on the market cost, during the six months preceding March, 1900, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

Sulfate of ammonia.
Azotine.
Cotton-seed meal.
Linseed meal.
Bone and tankage.
Nitrate of soda.
Dried blood.
Castor pomace.
Dry ground fish.
Dry ground meat.
Dissolved bones.
Acid phosphate.
Refuse bone-black.
Ground phosphate rock.
High-grade sulfate of potash.
Sulfate of potash and magnesia.
Muriate of potash.
Kainit.
Sylvinite.
Crude saltpetre.

How to use the table of trade values in calculating the approximate value of a fertilizer: Calculate the value of each of the three essential articles of plant food (nitrogen, phosphoric acid and potassium oxide, including the different forms of each wherever different forms are recognized in the table) in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made: —

Analysis of Fertilizer (Per Cent., or Pounds in One Hundred Pounds of Fertilizer).

Nitrogen,	4
Soluble phosphoric acid,	8
Reverted phosphoric acid,	4
Insoluble phosphoric acid,	2
Potassium oxide (as sulfate),	10

	Value per Hundred Pounds.	Value per Ton (Two Thousand Pounds).
Four pounds nitrogen, at 15.5 cents,	$0 62×20	=$12 40
Eight pounds soluble phosphoric acid, at 4.5 cents,	36×20	= 7 20
Four pounds reverted phosphoric acid, at 4 cents,	16×20	= 3 20
Two pounds insoluble phosphoric acid, at 2 cents,	04×20	= 80
Ten pounds potassium oxide, at 5 cents,	50×20	= 10 00
Value per ton,	. . . .	$33 60

The following table gives the average analysis of officially collected fertilizers for 1900: —

Average Analysis of Officially Collected Fertilizers for 1900.

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.29	2.95	2.53	4.53	3.79	2.81	10.52	9.02	7.96	7.31	5.40	5.02
Ground bones,	5.06	3.30	2.79	.58	8.29	15.73	24.11	11.31	8.46	6.46	-	-
Tankage,	6.57	4.18	4.02	-	9.68	10.65	19.76	17.67	9.68	-	-	-
Dissolved bone black,	11.33	-	-	14.75	3.00	.53	18.25	16.00	16.32	15.54	-	-
Wood ashes,	4.59	-	-	-	-	-	1.84	1.00	-	-	6.59	4.75
Kainit,	1.35	-	-	-	-	-	-	-	-	-	12.90	12.00
Nitrate of soda,	1.17	15.75	15.22	-	-	-	-	-	-	-	-	-
Muriate of potash,	1.77	-	-	-	-	-	-	-	-	-	49.55	50.27
High-grade sulfate of potash,	.44	-	-	-	-	-	-	-	-	-	50.78	48.00
Sulfate of ammonia,	.47	21.15	19.00	-	-	-	-	-	-	-	-	-
Acid phosphate,	16.22	-	-	13.82	2.06	.12	16.00	15.00	15.88	13.15	-	-
Cotton-seed meal,	5.70	7.64	7.00	-	-	-	-	-	-	-	-	-
Cotton-hull ashes,	8.05	-	-	-	-	-	10.38	10.00	-	-	24.48	20.00
Sulfate of potash and magnesia,	2.25	-	-	-	-	-	-	-	-	-	24.04	25.93

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1900, to May 1, 1901), and the Brands licensed by Each.

Armour Fertilizer Works, Chicago, Ill.: —
- All Soluble.
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- High-grade Potato.
- Cape Cod Asparagus Mixture.
- Armour's Grain Grower.
- Bone Meal.
- White Bone Flour.
- Armour's Flower Food.

Wm. H. Abbott, Holyoke, Mass: —
- Animal Fertilizer.
- Eagle Brand for Grass and Grain.
- Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Castor Pomace.
- A. A. Ammoniated Superphosphate.
- Complete Potato Manure.
- Strawberry Manure.
- Complete Tobacco Manure.

C. A. Bartlett, Worcester, Mass.: —
- Pure Ground Bone.

Berkshire Mills Co., Bridgeport, Conn.: —
- Complete Fertilizer.
- Potato Phosphate.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Farm and Garden Phosphate.
- Bowker's Hill and Drill Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.
- Ground Bone.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's X. L. Phosphate.
- Potato Manure.
- Potato Fertilizer.
- Complete Manure for Potatoes and Vegetables.
- Corn Phosphate.
- Breck's Lawn and Garden Dressing.
- Eclipse Phoshate.
- Niagara Phosphate.
- Fine-ground Bone.
- Muriate of Potash.
- Kainit.
- Double Manure Salts.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Brightman's Fish and Potash.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer, G. G.
- Potato Manure.
- Potato Fertilizer.
- Great Planet Manure.
- King Philip Guano.

Cleveland Dryer Co., Boston, Mass.: —
- Cleveland Superphosphate.
- Cleveland Potato Phosphate.
- Cleveland High-grade Complete Manure.

E. Frank Coe Co., New York, N. Y.: —
- High-grade Ammoniated Bone Superphosphate.
- Special Potato Fertilizer.
- Fish and Potash, F. P.
- Gold Brand Excelsior Guano.
- Tobacco and Onion Fertilizer.
- Vegetable and Vine.
- Bay State Phosphate.
- Market-garden Special Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
- Crocker's Ammoniated Corn Phosphate.
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's New Rival Ammoniated Superphosphate.
- Crocker's General Crop Phosphate.
- Crocker's Superior Fertilizer.
- Crocker's Grass and Oats Fertilizer.

Cumberland Bone Phosphate Co., Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
- Potato and Root Crop.
- Blood, Bone and Potash.
- Fine Bone.
- Potato Manure.
- Animal Fertilizer.
- Complete Ten Per Cent. Manure.
- Nitrate of Soda.
- Muriate of Potash.

John C. Dow & Co., Boston, Mass.: —
- Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Wood Ashes.

Farmers' Union Fertilizer Co., Peabody, Mass.: —
- Corn King.
- Market-garden Special.
- Complete Potato Fertilizer.
- Ammoniated Bone Fertilizer.

Great Eastern Fertilizer Co., Rutland, Vt.: —
- Northern Corn Special.
- Vegetable, Vine and Tobacco.
- General Fertilizer.
- Grass and Oats Fertilizer.
- Garden Special.

Thomas Hersom & Co., New Bedford, Mass.: —
- Meat and Bone.
- Ground Bone.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Canada Hardwood Ashes.

Charles W. Hastings, Jamaica Plain, Mass.: —
- Ferti Flora.

Thomas Kirley, South Hadley Falls, Mass.: —
- Pride of the Valley.
- Tankage.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Animal Brand.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Market Garden.
- Swift's Lowell Fruit and Vine.
- Swift's Lowell Tobacco Manure.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Potato Manure.
- Swift's Lowell Ground Bone.
- Swift's Lowell Nitrate of Soda.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Celebrated Onion Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's High-grade Special for Spring Crops.
- Lister's Special Tobacco Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass.: —
- Tankage.

The Mapes Formula & Peruvian Guano Co., New York, N. Y.: —
- The Mapes Bone Manures.
- The Mapes Superphosphates.
- The Mapes Special Crop Manures.
- Sulfate of Potash.
- Nitrate of Soda.
- Tobacco Ash Constituents.

Geo. L. Monroe, Oswego, N. Y.: —
- Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
- Pure Ground Bone.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Market Garden.
- Chittenden's Complete Fertilizer.
- Chittenden's Ammoniated Bone.
- Chittenden's Fish and Potash.

Pacific Guano Co., Boston, Mass.: —
- High-grade General.
- Soluble Pacific Guano.
- Potato Special.
- Nobsque Guano.

Packer's Union Fertilizer Co., New York, N. Y.: —
- Gardener's Complete Manure.
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato Fertilizer.
- Special Strawberry Manure.
- A. A. Brand.
- Star Brand Superphosphate.
- Pure Ground Bone.
- P. & P. Potato Fertilizer.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Corn Manure.
- Market-garden Manure.
- Grass Fertilizer.
- Pequot Fish and Potash.
- Havana Tobacco Fertilizer.
- Climax Phosphate.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Fertilizer for Oats and Top Dressing.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's Fairchild's Formula for Corn.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Potato Manure.
- Hubbard's All Soils and All Crops.
- Hubbard's Corn Phosphate.
- Hubbard's Raw Knuckle-bone Flour.
- Hubbard's Strictly Pure Fine Bone.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex XXX Fish and Potash.
- Essex Potato Fertilizer.
- Essex Corn Fertilizer.
- Essex Complete Manure for Potatoes and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Fertilizer.
- Essex Tobacco Starter.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Around Fertilizer.
- Complete Potato and Vegetable Fertilizer.
- Complete Corn Fertilizer.
- Fish and Potash.
- High-grade Soluble Tobacco and Potato.
- High-grade Oats and Top Dressing.
- High-grade Grass and Grain.
- High-grade Tobacco Fertilizer.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent): —
- Read's Standard.
- High-grade Farmer's Friend.
- Practical Potato Special.
- Bone, Fish and Potash.
- Samson.
- Potato Manure.
- Vegetable and Vine.

Lucien Sanderson, New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Formula A.
- Sanderson's Blood, Bone and Meat.
- Sanderson's Nitrate of Soda.
- Sanderson's Dissolved Bone-black.

Standard Fertilizer Co., Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.
- Standard A Brand.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

Henry F. Tucker Co., Boston, Mass.: —
- Original Bay State Bone Superphosphate.
- Special Potato Fertilizer.

Darius Whithed, Lowell, Mass.: —
- Ground Bone.
- Champion Animal Fertilizer.

The Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass.: —
- High-grade Special.
- Ammoniated Bone Superphosphate.
- Potato Phosphate.
- Corn Phosphate.
- Potato Manure.
- Special with ten per cent. Potash.
- Royal Bone Phosphate.
- Prolific Crop Producer.
- Fine Wrapper Tobacco Grower.
- Bone Meal.

M. E. Wheeler & Co., Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Havana Tobacco Grower.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.
- Electrical Dissolved Bone.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
- Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.
3. Notes on sludge, its agricultural value.
4. Notes on phosphatic slag, as a source of phosphoric acid for manurial purposes.

1. Analyses of Materials sent on for Examination.

During the past season 237 materials have been received and the results of our examination have been published in detail in bulletins 65, 68 and 70 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality from which they come. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of our industries are becoming from year to year more numerous and important. As the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value, frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements are made to attend to the examination of these materials to the full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below is given a list of materials received during the past season, which shows the general nature of the work: —

Wood ashes,	73	Acid phosphate,	1
Cotton-hull ashes,	8	Dissolved bone-black,	2
Brickyard ashes,	1	Dissolved bone,	2
Leather-scrap ashes,	1	Cotton-seed meal,	4
Lime-kiln ashes,	2	Castor pomace,	1
Lime refuse,	1	Cotton waste,	7
Muriate of potash,	3	Tobacco stems,	3
High-grade sulfate of potash,	2	Tobacco dust,	1
Sulfate of potash and magnesia,	3	Muck,	2
Kainit,	1	Peat,	1
Silicate of potash,	1	Soot,	1
Sulfate of ammonia,	1	Bat guano,	1
Nitrate of soda,	3	Cork dust,	1
Ground bone,	7	Kiln dust,	1
Raw bone flour,	1	Complete fertilizers,	13
Steamed bone meal,	1	Refuse from garbage plant,	1
Tankage,	5	Stable manures,	14
Dry fish meat,	2	Stable refuse material,	1
Florida rock phosphate,	1	Sludge,	7
Phosphatic slag,	1	Soils,	29
South Carolina rock phosphate,	2	Bug death,	1
Apatite,	1	Miscellaneous materials,	22

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to the farmers of the State. As our resources are limited, we have to request all farmers sending material for examination to prepay express charges.

2. Notes on Wood Ashes.

During the past year (1900) 30.8 per cent. of the materials sent on for analysis consisted of wood ashes, as against 24.4 per cent. the previous year (1899). The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article.

The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to furnish a guarantee of the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of these two elements is present.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and general character of the foreign matters are apt to seriously affect the weight of a given volume. The following table shows the general character of the wood ashes, so far as their chemical composition is concerned, that have appeared in the general markets during the season of 1900 : —

Analysis of Wood Ashes.

CONSTITUENTS.	Number of Samples.	
	1899.	1900.
Moisture below 1 per cent.,	2	1
Moisture from 1 to 10 per cent.,	21	25
Moisture from 10 to 20 per cent.,	35	32
Moisture from 20 to 30 per cent.,	1	13
Moisture above 30 per cent.,	1	1
Potassium oxide above 8 per cent.,	4	1
Potassium oxide from 7 to 8 per cent.,	9	6
Potassium oxide from 6 to 7 per cent.,	13	12
Potassium oxide from 5 to 6 per cent.,	7	25
Potassium oxide from 4 to 5 per cent ,	19	14
Potassium oxide from 3 to 4 per cent.,	2	7
Potassium oxide below 3 per cent.,	2	7
Phosphoric acid above 2 per cent.,	4	6
Phosphoric acid from 1 to 2 per cent.,	43	62
Phosphoric acid below 1 per cent.,	10	4
Average per cent. of calcium oxide (lime),	34.10	32.51
Per cent. of mineral matter insoluble in diluted hydrochloric acid: —		
Below 10 per cent.,	16	15
Between 10 and 15 per cent.,	26	35
Between 15 and 20 per cent.,	7	12
Above 20 per cent.,	7	11

To assist our farmers in selecting the best quality of wood ashes in our market, it is desirable that those sending samples for analysis will state the name of the party of whom the goods were purchased and price per ton paid.

3. Notes on Sludge, its Agricultural Value.

The interest in the character of this class of materials and their value for manurial purposes is deservedly steadily increasing, judging from inquiries received at this office. As the source of the article as well as the mode of collecting the same may differ widely, it is but natural that no definite advice can be furnished without a special examination into the existing circumstances. The subsequent compilation of analyses of sludge, made at the request of farmers of the State, are published to increase a more general interest in the matter: —

Analyses of Samples of Sludge (Per Cent.).

[The five samples were received from Worcester, Mass. I., taken from bottom of basin, unpressed; II., taken from top of basin, unpressed; III., pressed sample, yellowish in color; IV., pressed sample, black color; V., pressed sample, reddish color.]

CONSTITUENTS.	I.	II.	III.	IV.	V.
Moisture at 100° C.,	65.99	63.59	54.98	68.15	53.11
Nitrogen,	.44	.38	.49	.36	.62

Analyses of Samples of Sludge (Per Cent.).

[I., Average complete analysis of the above five samples; II., sludge received from Worcester, Mass.; III., sludge received from Brockton filter beds (1899); IV., sludge received from Brockton filter beds (1900).]

CONSTITUENTS.	I.	II.	III.	IV.
Moisture at 100° C.,	61.16	65.61	21.44	2.77
Phosphoric acid,	.39	.47	.86	.72
Potassium oxide,	.13	.07	.16	.66
Nitrogen,	.46	.58	1.31	1.27
Calcium oxide,	5.08	–	1.13	trace.
Ferric oxide,	6.50	–	–	–
Aluminum oxide,	2.05	–	–	–
Magnesium oxide,	2.19	–	–	–
Sulfuric acid (SO_3),	.44	–	–	–
Carbonic acid,	4.86	–	–	–
Chlorine,	trace.	–	–	–
Insoluble matter,	10.57	5.63	–	–

It will be seen from the above analyses that there is a great difference in the percentage of the fertilizing constituents present in the different samples. There remains, however, no doubt that these materials when properly studied furnish a valuable source of plant food, when they can be conveniently obtained, and supplemented by such ingredients as potash and phosphoric acid compounds, to render them more suitable for manurial purposes in case of different crops.

4. Notes on Phosphatic Slag as a Source of Phosphoric Acid for Manurial Purposes.

The phosphatic slag, sometimes called Thomas basic phosphatic slag, or odorless phosphate, in advertisements of dealers of commercial fertilizers, is obtained as a by-product in the conversion of phosphorus containing iron ores into phosphorus free metallic iron. Investigations regarding its fitness as an economical source of phosphoric acid for manurial purposes have received, from the date of its first production, the special attention of agricultural chemists and agriculturists of Germany and other European countries. Field observations in the United States date back, as far as the writer is informed, to the year 1888. Summing up the results of the past, it will be admitted that a genuine phosphatic slag, judiciously applied, has proved a valuable addition to our phosphoric-acid-containing manurial resources, and that its use is only limited by its supply at a reasonable cost.

The subsequent tabular statement may convey some more definite idea regarding the general character of the phosphatic slag tested at Amherst, Mass. : —

Analyses of Phosphatic Slag (Per Cent.).

[I., German phosphatic slag (sent on), 1887; II., English phosphatic slag (sent on), 1887; III., German phosphatic slag (imported for station use), 1888; IV., phosphatic slag received from England, 1888.]

CONSTITUENTS.	I.	II.	III.	IV.
Moisture at 100° C.,	.10	.37	5.08	.37
Ferric and aluminum oxides,	4.26	–	15.98	8.55
Total phosphoric acid,	31.51	18.91	21.05	18.91
Available phosphoric acid,	.19	5.93	–	–
Insoluble phosphoric acid,	30.32	12.98	–	–
Calcium oxide,	41.87	49.82	53.97	49.22
Magnesium oxide,	–	–	3.83	–
Insoluble matter,	13.74	5.06	–	5.06

Analyses of Phosphatic Slag (Per Cent.).

[I., bought for field experiments, 1894; II., sent on from Hatfield, Mass., 1893; III., sent on from Marshfield, Mass., 1893; IV., sent on from Amherst, Mass., 1893; V., sent on from Mansfield, Mass., 1900.]

CONSTITUENTS.	I.	II.	III.	IV.	V.
Moisture at 100° C.,	.47	1.12	.60	.63	.25
Ferric and aluminum oxides,	14.35	-	-	-	-
Total phosphoric acid,	19.04	18.40	19.45	18.42	19.80
Available phosphoric acid,	-	-	-	-	6.04
Insoluble phosphoric acid,	-	-	-	-	13.76
Calcium oxide,	46.47	49.00	61.30	48.27	52.93
Magnesium oxide,	5.05	-	-	-	-
Carbonic acid,	-	2.67	2.25	-	-
Potassium oxide,	-	.32	.52	-	.50
Insoluble matter,	4.39	7.20	5.12	5.53	-

The analyses of phosphatic slag in earlier years, as a rule, show lower percentages of ammonium citrate soluble phosphoric acid when subjected to the same current mode of treatment as other phosphatic fertilizers, — a circumstance due to the presence of a varying quantity of caustic lime, which caused a decomposition of the citrate of ammonia, and thus affected more or less seriously its power to dissolve the available phosphoric acid present. The recognition of this fact on the part of chemists has caused the adoption of a modification in the character and the concentration of the citrate of ammonia solution proposed by Dr. P. Wagner, which aims at a neutralization of the free lime. The determination of available phosphoric acid in phosphatic slag, by Wagner's method, for trade purposes is to-day generally adopted. As our above-stated analyses of phosphatic slag extend over a period of more than twelve years, the main interest in our results consists in the statement of the amount of total phosphoric acid found present.

Aside from these recent changes in the current modes of analyzing these phosphates, there has been introduced an important change in the manufacture of phosphatic slag for manurial purposes. As in the fertilizer trade, the valuation of the phosphoric acid is based, as a rule, on the amount of available phosphoric acid present. Manufacturers of phosphatic slag have aimed at the production of a material which, by chemical analysis, will show the largest amount of available phosphoric acid; this result is obtained by fusing the slag at about 900° C. with sufficient quartz sand to change the free lime present into silicate of lime. The inventor of this process (G. Hoyermann) has published as an illustration the following results: —

Analyses of Thomas Phosphatic Slag (Per Cent.).

[I., analysis of Thomas phosphatic slag before smelting with quartz sand; II., analysis of the same material after fusing with quartz sand.]

CONSTITUENTS.	I.	II.
Calcium oxide (free lime),	11.00	.70
Silicic acid,	2 to 3	12.00
Available phosphoric acid (percentage of whole),	58.00	84.00

The general introduction of Hoyermann's process has changed the character of the phosphatic slag of earlier years materially. The phosphatic slag of to-day contains, in exceptional cases only, some free lime, not sufficient to charge any beneficial effect of the phosphatic slag on the crop raised to free lime present.

An imitation of phosphatic slag is reported as having been introduced in Sweden. It is obtained by fusing apatite with soda ash at from 700° to 800° C. No representative sample of this material has yet come to the writer's notice.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The work of this division during the past year has consisted as usual in the investigation of various forms of plant disease, together with a large amount of correspondence, the preparation of results for publication, and miscellaneous botanical work. Bulletin No. 69, on "The rotting of greenhouse lettuce," was issued during the year, giving an account of the work on this subject, to which reference has been made in several recent annual reports of this station. The extent of the lettuce-forcing industry in this State makes the subject of this bulletin one of great importance, as the financial loss from this source has been a large and increasing one. Notably in the case of the disease known as the "drop," the least understood and the most destructive of these troubles, results have been obtained which show hitherto entirely unknown characteristics in the development of the organism which causes the trouble, on the basis of which knowledge a practical and efficacious treatment can be applied. Another result of no small importance has been the demonstration of the worthlessness of many so-called remedies.

Our greenhouses used for purposes of experiment have as usual been devoted to the study of problems connected with the forcing of vegetables, principally cucumbers, in addition to lettuce.

Aster Diseases.

During the past summer, work on the diseases of the China aster has been continued, upon a much more extensive scale than heretofore. Altogether some 15,000 plants were grown, and a great variety of experiments were conducted upon fertilizers, varieties, localities, time of planting, methods of handling, etc. In one bed, 600 feet in length, were grown all the varieties of this plant obtainable from the leading seedsmen of the country, over 300 in all. This plant is very generally affected by a number of serious troubles, most prominent of which is a disease of a peculiarly obscure nature. No organism of any kind appears to be the cause of it, yet it has a very characteristic as well as destructive effect. Our most recent results indicate that the abnormal development is due to a disturbance of the assimilative (metabolic) functions of the plant. The conditions, however, which bring about this disturbance, seem, as shown by our results thus far, contradictory and obscure. At least three other diseases, all of a fungous nature, also attack the aster, with serious effects. These can be more readily understood, if not prevented. Complaint is made from all parts of the country of trouble in growing this popular flower.

Nematode Worms.

A peculiar disease on potted cuttings of perennial phlox was sent in during the past winter, which proved to be caused by a species of nematode, but quite different from that attacking the roots of many plants, to which this division has devoted considerable attention. This new form attacks the stem of the plant, causing there an abnormal enlargement, while the leaves are stunted or reduced to mere rudiments, and the plant generally dies. The worm causing the mischief is a slender creature of microscopic size, which embeds itself in the tissues of the stem, where it multiplies rapidly and produces the abnormal growth. The species is an undescribed one, though it appears to be the same as that mentioned by several writers as attacking the stems and leaves of plants. This is the only occurrence of the sort which we have known in this State, and from its nature it does not appear to be anything which will become generally prevalent or destructive.

Cucumber Mildew (*Plasmopara Cubensis*, B. and C.).

This mildew made its appearance in Massachusetts during the past autumn for the first time, so far as we are aware, since 1889, when it was reported by Dr. Humphrey * as found in two distinct localities in the State. This time it is again reported as occurring upon greenhouse cucumbers in two entirely distinct and remote localities, namely, Beverly and Leominster, but we are not aware of its presence during the summer on out-door cucumbers, squashes or melons. The fungus occurs more commonly in the south, and even no further remote than Ohio and Long Island it has proved exceedingly disastrous to out-door crops. It is surmised by Professor Selby of Ohio that it persists in the south and works its way northward as the season advances. The notable results in Long Island, obtained by Stewart,† in spraying with the Bordeaux mixture cucumbers affected with this mildew, show that the disease can be practically controlled.

The fungus appears largely upon the under side of the leaf, as a downy mass, greatly resembling the downy mildew of the grape. It must not, however, be confounded with the common powdery mildew found so frequently upon the upper surface of cucumber leaves. It is, moreover, more disastrous than the powdery mildew, and on this account should not be neglected when found.

Russian Thistle in Massachusetts.

The first report of the finding of the Russian thistle in Massachusetts which has come to our notice is made by Mr. Wm. P. Rich.‡ Two plants were first observed by him on a railroad bank at Dedham, Aug. 22, 1897, and since that time the plants have shown a tendency to increase slightly. Mr. Rich states that on Aug. 4, 1900, he found in the same locality twenty plants. A few of them had spread three hundred feet from where first observed in 1897. The Russian thistle has been previously reported in New York and Rhode Island.

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* Eighth annual report, Massachusetts Agricultural Experiment Station, p. 210.
† New York Agricultural Experiment Station Bulletin, No. 119, Geneva, N. Y.
‡ Rhodora, Vol. II., p. 204.

Influence of Chemical Solutions upon the Germination of Seeds.

It is well known that there are many chemical solutions which accelerate and retard the germination of seeds; it is also known that germinating seeds are very susceptible to changes in temperature and moisture, to variations in the degree and kinds of light, to the amount of oxygen they receive, to the influence of electricity, etc. It was our idea, in inaugurating these experiments, to determine to what degree seeds could be accelerated in their germination, and also to what extent their germinating capacity could be increased. Experiments in this direction have been carried on in this department since 1895, but they have been interrupted a number of times. These experiments have been directed along two lines, namely, a study of the influence of physical factors upon germination, and a study of the effects of different chemical solutions upon germination. The results of the former experiments have already been published, in a bulletin entitled "Electro germination;" while some of the results of the latter, which have been carried on by Mr. E. H. Sharpe, at one time a student in the college, constitute the subject of this article.

Any form of treatment capable of accelerating the germination of seeds possesses perhaps more scientific than practical value; but there are, nevertheless, some high-priced seeds which do not retain their germinating capacity very long, and, if the percentage of germination can be materially increased at a small expense, such a treatment would be worthy of practical consideration. It is not our purpose, however, to maintain, from the results shown in the following tables, that they warrant practical application.

The solutions selected for these experiments are those which are frequently found in seeds and seedlings; and it was thought that, by applying these solutions to the seeds for a certain number of hours, they might supply the deficiency in some essential constituent, and thus enable poorer and exhausted seeds to germinate. There are many seeds which do not retain the power of germinating very long; and it might be supposed that one cause of this had some connection with the normal condition of the enzymes or ferments, which are essential for the conversion of certain seed products into available forms for germination. It is with this idea in mind that our experiments with solutions have been conducted; and the solutions selected have been those which are known to exist in many seeds and seedlings as ferments or enzymes, termed diatase, pepsin, trypsin and others, and amides, such as asparagin, leucin, etc. With the exception of diatase, all of the chemicals used in making these solutions were obtained from Mercks, the diatase being made up from malt. These experiments are by no means as complete as desired, but circumstances did not permit of their continuation at the time they were made.

Experiments with Asparagin Solutions.

Asparagin is a typical amide, found in connection with many seedlings and storage organs. During germination the amides increase in some instances to a considerable extent. Asparagin is especially abundant in leguminous seedlings, and is believed to play an important part in metabolism. The following tables, I. to V., represent the effects of asparagin solution upon different seeds which display considerable variation in their germinating capacity. One hundred seeds were used in all instances for each strength of solution, and the strength of solution varied in each experiment from .1 to 2 per cent. The seeds were soaked in asparagin twelve hours, after which they were rinsed with water and placed in Zurich germinators excluded from the light in a room with fairly even temperature. The number of seed germinating each day were taken out and recorded, no observations being made previous to twenty-four hours after placing them in the germinator. In many instances the number of observations have been omitted in the tables, to save space, and the percentages in the last columns give the final results. The relative gain, however, during this period, is practically the same as that preceding it. The seeds were in every instance left a few days or a week longer, in order to see if any more would germinate. We endeavored to select seed which did not show a high percentage of germination, but in every case this was not accomplished.

TABLE I. — *Showing the Effects of Asparagin Solutions upon the Germination of Alfalfa Seeds (Medicago sativa L.).*

Experiment A.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).			
	1 (24 Hours).	2.	3.	4.
Normal,	65	85	87	88
2 per cent.,	81	92	97	97
1 per cent.,	85	96	98	99
.5 per cent.,	64	88	97	98
.25 per cent.,	73	93	98	99
.1 per cent.,	75	97	99	100

Normal average (per cent.), ... 88.0
Asparagin average (per cent.), ... 98.6

Experiment B.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).	
	1 (24 Hours).	2.
Normal,	53	90
2 per cent.,	93	100
1 per cent.,	88	99
.5 per cent.,	95	100
.25 per cent.,	89	98
.1 per cent.,	88	100

Normal average (per cent.), ... 90.0
Asparagin average (per cent.), ... 99.4

Experiments *A* and *B* in the table show an acceleration in germination as well as a gain in the germinating capacity. Experiment *B* is a repetition of *A*. Both experiments lasted three days longer than indicated by the table, but no further germination occurred in either.

TABLE II. — *Showing the Effects of Asparagin Solutions upon the Germination of Rape Seeds (Brassica napus L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION.									
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	19.
Normal,	–	–	–	–	–	2	8	16	25	68
2 per cent.,	1	1	2	2	4	11	23	39	47	97
1 per cent.,	5	5	5	6	10	10	14	17	28	85
.5 per cent.,	5	5	6	6	10	16	22	31	41	86
.25 per cent.,	6	7	10	12	17	28	40	51	58	90
.1 per cent.,	1	1	1	1	3	7	25	36	49	86

Normal average (per cent.), ... 68.0
Asparagin average (per cent.), ... 88.8

This experiment lasted three days longer than indicated in the table, and, as no further germination occurred, the experiment was discontinued.

TABLE III. — *Showing the Effects of Asparagin Solutions upon the Germination of Canadian Field Pea (Experiment A) and Vetch (Experiment B) Seeds.*

Experiment A.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).		
	1 (24 Hours).	2.	3.
Normal,	3	98	100
2 per cent.,	12	98	100
1 per cent,	18	100	100
.5 per cent.,	27	100	100
.25 per cent.,	12	100	100
.1 per cent.,	17	99	100

Normal average (per cent.), . . . 100
Asparagin average (per cent.), . . . 100

Experiment B.

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).		
	1 (24 Hours).	3.	3.
Normal,	35	97	99
2 per cent.,	78	100	100
1 per cent,	84	100	100
.5 per cent.,	71	100	100
.25 per cent.,	83	100	100
.1 per cent.,	89	100	100

Normal average (per cent.), . . . 99
Asparagin average (per cent.), . . . 100

On account of the especially good seed used in these experiments, the results merely show an acceleration, due to the asparagin.

TABLE IV. — *Showing the Effects of Asparagin Solutions upon the Germination of Buckwheat Seeds* (*Fagopyrum esculentum* Moench).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.
Normal,	1	36	60	65	71	71	71	71	71
2 per cent.,	1	42	71	76	77	77	77	77	77
1 per cent.,	–	30	67	71	77	80	80	80	80
.5 per cent.,	–	47	80	86	91	92	92	92	92
.25 per cent.,	–	32	64	68	72	75	75	75	75
.1 per cent.,	–	43	75	79	80	83	84	84	85

Normal average (per cent.), ... 71.0
Asparagin average (per cent.), ... 81.6

No change in the results were shown when experiment was allowed to remain two days longer.

TABLE V. — *Showing the Effects of Asparagin Solutions upon the Germination of Serradella Seeds* (*Ornithopus sativus*).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	17.
Normal,	–	2	7	10	16	28	34	40	42	55
2 per cent.,	–	2	7	16	25	28	34	41	46	76
1 per cent.,	–	3	16	24	34	39	44	47	53	74
.5 per cent,	–	4	13	23	26	32	39	48	52	68
.25 per cent.,	1	6	16	22	31	34	38	44	51	74
.1 per cent.,	1	4	10	21	29	35	41	47	52	82

Normal average (per cent.), ... 55.0
Asparagin average (per cent.), ... 74.8

The seeds in this experiment failed to germinate further than shown in the table. Another experiment showed a corresponding acceleration, and at the end of fifteen days, when no more seed would germinate, the normal gave 54 per cent. and the treated averaged 79 per cent. One experiment with asparagus seed showed an acceleration throughout, and gave for the normal 40 per cent., while the treated was 45 per cent., — a gain of little consequence.

In considering the results of asparagin experiments as a whole, we find that the average percentage of germination for the normals in five experiments was 74.5 per cent.; that for the treated, 88.6 per cent. When the average percentage of the normal is compared with the .5 per cent. asparagin solution, we obtain 88.8 per cent. for asparagin and 74.5 per cent. for the normal.

In experiments dealing with seeds showing a small germinating capacity, some allowance must be made for individual variation, and it is better to use a large number of seeds in such cases, or, what is better, to have the experiment repeated a number of times with each species. Four experiments, however, of one hundred seeds, possess more value than one where four hundred seeds are used. After due allowance has been made for individual variation, it will be observed that the asparagin exerts an acceleration upon the germination of certain seeds, and also increases their germinating capacity. The various solutions of asparagin used show no detrimental effect upon the seeds.

Experiments with Leucin Solutions.

Leucin, like asparagin, is an amide, and is found frequently in connection with the latter in germinating seeds and seedlings. The seeds were soaked twelve hours in different strengths of solutions, and then rinsed before placing them in Zurich germinators, as in the asparagin experiments. Tables VI. and VII. give the result of two experiments with leucin.

TABLE VI. — *Showing the Effects of Leucin Solutions upon the Germination of Buckwheat Seeds (Fagopyrum esculentum* Moench).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).								
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	11.
Normal,	–	20	56	68	72	72	72	72	72
1 per cent.,	–	20	61	68	70	72	73	73	74
.5 per cent.,	–	20	59	71	76	77	78	80	80
.25 per cent.,	–	11	51	64	71	74	74	75	80
.1 per cent.,	–	22	66	81	89	90	92	92	92
.05 per cent.,	–	21	61	74	76	78	78	79	80

Normal average (per cent.), ... 72 0
Leucin average (per cent.), ... 81 2

No further germination took place in the untreated seeds after the fifth day.

Table VII. — *Showing the Effects of Leucin Solutions upon the Germination of Alfalfa Seeds (Medicago sativa).*

Strength of Solution.	Percentage of Germination (in Days).				
	1 (24 Hours).	2.	3.	4.	5.
Normal,	43	87	90	90	90
1 per cent.,	43	90	93	95	96
.5 per cent.,	43	89	94	96	96
.25 per cent.,	46	95	98	98	98
.1 per cent.,	47	94	96	97	97
.05 per cent.,	51	95	98	98	98

Normal average (per cent.), ... 90.0
Leucin average (per cent.), ... 97.0

No further germination took place in the untreated seeds after the third day. Another experiment with alfalfa gave 89 per cent. for the normal and 98 per cent. for the treated seeds. The average of the three leucin experiments gave 83 per cent. for the normal and 92 per cent. for the treated. The various solutions of leucin had no injurious effect on the seeds.

Experiments with Pepsin Solutions.

Pepsin is a proteolytic ferment (enzyme), found in some seeds during germination, and is capable of converting non-diffusible proteids into diffusible ones. The seeds in the experiments shown in the two tables. VIII. and IX., were treated as in the preceding ones.

Table VIII. — *Showing the Effects of Pepsin Solutions upon the Germination of Crimson Clover Seeds (Trifolium incarnatum* L.).

Strength of Solution.	Percentage of Germination (in Days).						
	1 (24 Hours).	2.	3.	4.	5.	6.	7.
Normal,	9	21	25	27	27	28	28
5 per cent.,	9	22	29	31	33	36	36
2.5 per cent.,	10	19	26	30	35	39	43
1 per cent.,	17	26	31	37	39	40	42
.5 per cent.,	19	27	33	36	39	40	42
.25 per cent.,	16	23	31	36	39	41	43
.1 per cent.,	17	25	31	35	37	39	42

Normal average (per cent.), ... 28.00
Pepsin average (per cent.), ... 41 33

None of the seeds showed any further germination when left five days longer. Two other experiments with crimson clover were made: in one the normal seeds gave 22 per cent., the average of the treated seeds 38.6 per cent.; in the other, the normals were 22 per cent., while the average treated ones gave 33.8 per cent. The average of the three crimson clover experiments is: normal average, 24 per cent.; pepsin average, 34 per cent. The best results were obtained by the .25 per cent. solution in each experiment, and by comparing the results of this treatment we have for the normal averages 24 per cent. and pepsin averages 41 per cent.

TABLE IX. — *Showing the Effects of Pepsin Solutions upon the Germination of Cucumber Seeds (Cucumis sativus L.).*

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).											
	1 (24 Hours).	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Normal,	–	47	51	52	53	53	53	53	53	58	58	58
5 per cent.,	–	63	67	70	71	71	73	76	76	76	77	77
2.5 per cent.,	–	54	67	68	70	70	71	71	71	71	71	73
1 per cent.,	–	62	67	70	70	70	75	75	75	77	77	77
.5 per cent.,	–	53	56	58	58	58	63	63	66	70	70	70
.25 per cent.,	–	48	57	58	60	60	63	65	67	70	70	70
.1 per cent.,	–	53	56	58	60	63	69	71	72	75	75	75

Normal average (per cent.), ... 58.00
Pepsin average (per cent.), ... 73.66

None of the seeds showed any further germination. Another pepsin experiment with cucumber seeds gave for the normal 51 per cent. and an average of the treated was 68 per cent. Two pepsin experiments with vetch (*Vicia sativa*) gave precisely the same percentages of germination for both the normal and treated seeds, and all of the solutions except the .1 per cent. (which accelerated germination) resulted in a retardation. Yellow lupine seeds (*Lupinus luteus*) treated with the various pepsin solutions were also retarded, and alfalfa seeds responded to pepsin but slightly. It is known that pepsin does not exist, or at least has not been detected, in some germinating seeds. Among these is the lupine, and, from the results of the foregoing experiments, it would appear not to be present, or at any rate play a very unimportant role, in such seeds as vetch and alfalfa.

Waugh* obtained favorable results with pepsin on tomatoes and watermelon seeds, but not with radish seeds. In our experiments the seeds showed a slight tendency to mould by the use of pepsin.

Experiments with Diastase Solutions.

Diastase, the starch-converting ferment, is probably the most widely distributed enzyme in the vegetable kingdom, it being found in seeds and mature parts of plants, and usually increasing during the mobilization of reserved food materials. The official solution used by chemists was prepared for this experiment, and consisted of 10 grams of fresh, finely ground malt, mixed with 200 cubic centimeters of water. This we have roughly designated, for convenience, as a 5 per cent. solution, from which the other percentages were obtained. The methods of treatment follow those in the preceding experiments.

TABLE X. — *Showing the Effects of Diastase Solutions upon the Germination of Black Barley Seeds* (*Hordeum sativum* Jessen).

STRENGTH OF SOLUTION.	PERCENTAGE OF GERMINATION (IN DAYS).					
	1 (24 Hours).	2.	3.	4.	5.	6.
Normal,	75	84	88	88	88	88
5 per cent.,	14	39	63	74	85	89
2.5 per cent.,	71	92	95	96	97	97
1 per cent.,	80	91	94	94	94	98
.5 per cent.,	82	95	96	97	98	98
.25 per cent.,	82	93	94	96	98	98
.1 per cent.,	81	96	96	96	96	97
.05 per cent.,	85	93	94	94	94	94

Normal average (per cent.), ... 88
Diastase average (per cent.), ... 95

* Tenth annual report, Vermont Experiment Station, pp. 106-111; also eleventh annual report, Vermont Experiment Station, pp. 290-295.

Table XI. — *Showing the Effects of Diastase Solutions upon the Germination of Upland Rice Seeds* (*Oryza sativa* L.).

Strength of Solution.	Percentage of Germination (in Days).			
	1 (24 Hours).	2.	3.	4.
Normal,	-	-	-	28
5 per cent.,	-	-	1	32
2.5 per cent.,	-	-	2	32
1 per cent.,	-	-	5	43
.5 per cent.,	-	-	5	41
.25 per cent.,	-	-	6	39
.1 per cent.,	-	-	5	42
.05 per cent.,	-	-	2	48

Normal average (per cent.), ... 28.0
Diastase average (per cent.), ... 39.5

Two other experiments were made, with black barley and with wheat seeds; the results, however, are of no consequence, inasmuch as the treated seeds became mouldy. This troublesome feature constituted the worst drawback in all of the diastase experiments. Waugh experienced the same trouble in the use of many of his solutions. This difficulty does not lie in the sterilization of the germinating appliances, but in the use of the solutions, which constitute excellent media for mould development. We therefore made the practice of rinsing all of the treated seeds with water before placing them in the germinators, which process helps keep down the moulds, but in some cases the moulds would appear even after the seeds had been rinsed. The results obtained from the foregoing experiments have already been sufficiently explained, and no further comment upon them is necessary here. In conclusion, it may be stated, however, that the study of the effects of amides and ferments and other accelerated factors upon seeds still offers a field for investigation worthy of a much more serious consideration than that given here.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

During the year which has elapsed since the last report the entomological work of the station has been conducted as usual, and with satisfactory results. An increasing amount of correspondence shows that the people of Massachusetts appreciate the opportunities afforded them for assistance more than formerly, and are availing themselves freely of that assistance.

The addition of a very complete set of apparatus for the photography of insects and their work has already been of much advantage to the division, as photographs from life are now being made, for use in the entomological publications of the station. The equipment in this line includes an enlarging, reducing and copying camera, a Premo camera for field work and another for use in photomicrography, all of which, with the necessary accessories, are in constant use.

Last spring a bulletin on the grass thrips was issued from this division, being a presentation of the practical and economic portions of the paper on the same subject by Mr. W. E. Hinds, which was published as an appendix to the last annual report of the college; and other bulletins on various important subjects are now being prepared. A catalogue of the Coccidæ of the world is also in preparation, and will probably be ready for publication during the coming year. Several papers on injurious insects have been written by Dr. H. T. Fernald, and published by the secretary of the Board of Agriculture of Massachusetts.

Many of the entomological bulletins from different stations have been bound for preservation and more convenient reference, and a number of valuable recent publications have been added to the insectary library.

Insects of the Year.

The past year has witnessed few serious insect attacks in Massachusetts. Why this was the case is difficult to determine, though it is possible that weather conditions last spring were in a measure responsible. An early warm period, continuing long enough to produce some of the earlier changes in insects from their winter conditions toward those of spring was followed by a colder period, which, coming after the initial changes had been taken, caught the insects in a state where they were unprepared for it, and may have caused the death of so many as to reduce their numbers. How far this explanation holds, however, cannot be determined.

The San José Scale.

This most serious pest to fruit growers has been present in Massachusetts a number of years. When it first made its appearance in the State it was believed by many that it had reached about its northern limit of distribution, and that its injuries would not be likely to be serious on that account. Time has shown, however, that this is not the case, and that the scale can not only become a very serious pest here, but that it can survive a temperature of thirty degrees below zero. The past summer, perhaps because of its dryness, has been distinctly favorable to the rapid increase of the scale and to a correspondingly increased destructiveness. As early as July 19 currants were received at the station so thoroughly covered by the young scales as to make them unsalable, and during the fall apples and pears were received in a similar condition. Up to the present year it was not known that fruit in Massachusetts could be so injured by the scale as to prevent its sale, though fruit trees killed by it were met with frequently. Now, however, the scale has demonstrated its ability to attack the fruit itself in this latitude, and this must call the attention of fruit raisers to the necessity of giving the most careful attention to their trees, if they desire to sell their products.

The scale has now been received from thirty-seven different towns in the State, and in all probability it occurs in as many more. It is believed to have been exterminated in three places and in several others to be under control, but, as it is being sent in from other States on nursery stock each year, it is but a question of time when it will be present in almost every orchard, and destroy many of our ornamental trees and shrubs as well. That this is more than a mere fear is shown by the remark of a nurseryman in another State recently, when refused a certificate of inspection because of the presence of this scale: "Well, I can fill my Massachusetts orders with this stock, any way."

Much of the correspondence of the division of entomology has been about this and the other common scales, and, as little literature on the subject has recently been published in this State, a bulletin is being prepared upon these insects and the best methods of treatment for them.

Seventeen-year Locust.

This interesting insect appeared last June on Martha's Vineyard in considerable abundance. As this is the only place east of Pennsylvania where the brood due in 1900 has been found, it seemed desirable to make investigations as to the accuracy of previous observations, and to ascertain, if possible, whether this isolated colony was holding its own. Through the kindness of Mr. George Hunt Luce of West Tisbury, the necessary information and specimens were obtained, from which it appears that the brood is a well-known one on the island, and was as much in evidence as ever this year.

Birch Bucculatrix.

During September the birches were seriously attacked by the caterpillars of this insect, causing the leaves to become brown and noticeable, even at some distance. The injury was most apparent in the southern half of the State, except in the Connecticut valley, where it extended northward nearly to the State line. In 1887, 1890 and 1892 this insect was very abundant and destructive in Massachusetts, and has been present in smaller numbers every year. As it does not attract particular attention generally, it is not improbable that little will be seen of it in 1901, or, if abundant, that it will appear in the northern portions of the State, which escaped this year.

Marguerite Fly.

This little pest was sent to the station in February, 1900, with the statement that it was destroying the marguerites in the greenhouses of the sender. Careful studies upon its life history and methods for its destruction were at once commenced, and are now nearly completed. A successful, easy and inexpensive treatment for it has been discovered, and it is hoped that the results of the work will soon be in readiness for publication.

Greenhouse Aleurodes.

This insect has also caused much destruction in greenhouses in the State during the past year, a loss of four thousand dollars having been reported in one case, the damage being to early tomatoes and cucumbers, which were completely destroyed. Thorough investigations of the structure and life history of this insect are now being carried on at the insectary, together with a search for methods which will ensure its control.

Fall Canker Worm.

Little has been published upon the life history of the fall canker worm. During the year this insect has been raised from the egg, and its various stages fully described, much being added to our previous knowledge of the subject.

Pea-vine Louse.

Less has been heard about this insect than in 1899, though it has caused considerable loss in several places in the State. Whether it will increase in importance during 1901 is at least doubtful.

Faunal Distribution.

The distribution of insects is one of great interest and importance. Many of our worst pests will in all probability never extend as far north as Massachusetts, where the climatic conditions are unfit for their continued existence. Certain portions of the State, however, appear to be so different from others in these regards that some insects may thrive there while unable to live elsewhere. It is of the utmost importance, therefore, to be able to locate these regions and their approximate limits, that we may know what the range of new insect foes will probably be. To this task the entomological division is giving much attention, already with many interesting and valuable results.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the work of this division has been mainly that of taking observations of the various features of the weather, and transcribing the records in convenient form for reference and preservation. With the report of last year were published the means of many of the records for a period of ten years. These results are now assumed to indicate normal conditions at this station, and the monthly means are compared with them, for the purpose of determining variation from the normal.

Bulletins of four pages each have been regularly issued at the beginning of each month, giving the more important daily records, together with mean monthly conditions and remarks on any unusual features of the month. The usual annual summary will be prepared and published with the December bulletin.

The New England section of the United States Weather Bureau has furnished daily, except Sunday, throughout the year the local forecasts for the weather of the following day, and the signals have been displayed from the flag staff on the tower. At the request of the section director, the weekly snow reports are being sent to the Boston office this season, as has been done the past few years.

The observations for the determination of the amount of soil moisture by the electrical method were started, but, owing to the failure of the apparatus to give any concordant results, the work was abandoned after an unsuccessful attempt to remedy the defects. The electrodes tried were those that last year gave fairly satisfactory results; the reason for their failure this year is not apparent. It is evident to the division that further work with our present equipment would be unprofitable.

The true meridian established here two years ago has enabled the division to begin a series of observations on the declination of the needle. These observations are taken monthly, and the readings entered in the yearly record book. The results will be of value in deducing a formula for variation in declination for this locality, and also in making surveys with the compass.

The only addition to the equipment during the year consists of an "adder," for facilitating the computation of mean daily temperatures from the hourly readings on the Draper temperature chart.

At the opening of the college, in September, Mr. A. C. Monahan, the observer, retired from the division, and was succeeded by the assistant observer, Mr. C. S. Rice.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the experiment station has been carried on during the past year upon the same general lines as those which have been followed in recent years. The usual variety of problems has presented itself for experimental inquiry, and the work has been more extensive than in any previous year. As in previous years, a very large share of our attention has been directed to solving some of the many problems connected with the use of manures and fertilizers. Our experiments in this line employ three distinct methods, viz., plot experiments in the open field, experiments in cylinders plunged to the rim in the ground, and pot experiments. The results of the last two will not be discussed in this report.

Plot Experiments.

A considerable number of these has been carried out upon our own grounds. On these, we have used one hundred and sixty-five plots, varying in size from about one-fortieth of an acre in case of some experiments to two or three acres in others, the average size of the plots being perhaps about one-tenth of an acre. Fifty-five plots have been used in such experiments upon land hired for the purpose. The nature of the experiments carried out upon these plots will be made plain by the following statement: —

To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen, and the extent to which the introduction of a crop of the clover family can make the use of nitrogen unnecessary, — eleven plots.

To determine the relative value of muriate and of sulfate of potash used in connection with bone meal, — eleven plots.

To determine the relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen, and of muriate of potash and sulfate of potash as sources of potash for garden crops, — seven plots.

To determine the relative value of kainite, and of the muriate, high-grade sulfate, low-grade sulfate, carbonate, silicate and nitrate as sources of potash, — forty plots.

To determine the relative efficiency of equal money's worth of dissolved bone-black, ground South Carolina rock, ground Florida phosphate, Mona guano and phosphatic slag as sources of phosphoric acid, — six plots.

To determine the relative efficiency of equal quantities of phosphoric acid, furnished in the following materials: acid phosphate, dissolved bone-black, dissolved bone, fine-ground raw bone, fine-ground steamed bone, fine-ground South Carolina phosphate, fine-ground Florida phosphate, phosphatic slag, apatite, Navassa phosphate, — thirteen plots.

To determine the relative value of manure alone, as compared with a smaller quantity of manure and a moderate amount of potash, for the corn crop, — four plots.

To determine the relative value of mixtures of fertilizer materials, furnishing, on the one hand, nitrogen, phosphoric acid and potash in the same proportions as in average corn fertilizers, and a mixture of similar materials containing more potash, — four plots.

Soil test with mixed grass and clover, — fourteen plots.

Soil test and experiment to determine the effect of liming for onions, — twenty-four plots.

Experiment in manuring grass lands, — three plots.

Experiment to determine the value of nitrate of soda for the rowen crop, — twelve plots.

Experiment in the use of fertilizers for orchard trees, — five plots.

Experiment to determine the relative efficiency of manure hauled and spread as fast as made, compared with manure put into large piles and spread in the spring, — ten plots.

Alfalfa, on which the effect of liming the soil is being studied, occupies four plots.

One of the plot experiments upon hired land has for its object the determination of the value of nitragin, or germ fertilizer, for various legumes, and includes forty plots; while fifteen plots in another locality have been used in a soil test with grass as the crop.

Most of the problems upon which we hope to obtain light by means of these experiments have engaged our attention for a number of years. As might naturally be expected, the results are somewhat affected by season, as well as by numerous other causes which are not fully under control. Results in some cases have varied to some extent from year to year, and such variation must always be looked for in experiments of this character. This variation, of course, renders interpretation of the results a matter of much difficulty. Moreover, from the very nature of the questions engaging our attention, it is necessary that the work should continue over a considerable series of years before conclusions of general interest and importance can be drawn. It does not, therefore, seem best to publish in full the details concerning any considerable number of these experiments. Attention, however, will be called to some of the conclusions which it is believed are fully warranted by the results, not of the past year alone, but of a continuous line of investigations touching these points, many of which have continued for ten or more years.

I. — The Relative Value of Manures furnishing Nitrogen.

The experiments on which the conclusions now to be stated are based have been carried out on Field A, and a detailed description of the plan of experiment followed will be found in our twelfth annual report. These experiments were begun in 1890, and the crops grown have been oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover and potatoes. As the result of these experiments, we have found, taking into account all experiments from the beginning of the work up to date, that the various manures supplying nitrogen rank in the following order: nitrate of soda, barnyard manure, sulfate of ammonia and dried blood. If we allow numbers to express the relative efficiency of these materials, their standing is as follows: nitrate of soda, 100; barnyard manure, 90; sulfate of ammonia, 89; dried blood, 86; the plots receiving no nitrogen, 68.

It should be pointed out: (*a*) That the figure for barnyard manure is probably not a correct indication of the relative efficiency of the nitrogen it contains, because barnyard manure supplies humus and considerable quantities of lime, magnesia and other minerals which are not supplied by the fertilizers used on the other plots. These constituents of the barnyard manure are in almost all cases useful. The crops where manure is used, therefore, stand relatively higher than the availability of the nitrogen alone would warrant. (*b*) It is important to point out, further, that the relative standing of the sulfate of ammonia is lower than it undoubtedly would have been had lime been more largely used. Before these plots were limed the crops in some years were almost an absolute failure. Comparing the yields on the sulfate of ammonia with those on the nitrate plots for the years only which immediately follow the application of lime, we find, representing the yield on the nitrate of soda as 100, that the yield of the sulfate of ammonia is 101. The conclusion is inevitable, that, if we are to depend upon sulfate of ammonia as a source of nitrogen, we shall be obliged upon many of our soils to occasionally use considerable quantities of lime in connection with it. Since, however, a given quantity of nitrogen in the form of sulfate of ammonia costs more than the same quantity in the form of nitrate of soda, it is evident that the latter should usually be preferred. The nitrate of soda, however, is not so readily used in mixture with other fertilizers, on account of its tendency to become moist. Such materials as sulfate of ammonia and dried blood are far more likely to remain dry, and can therefore be more readily incorporated with other materials in manufacturing fertilizers or in making home mixtures.

II. — Crops of the Clover Family (Legumes) as Nitrogen Gatherers.

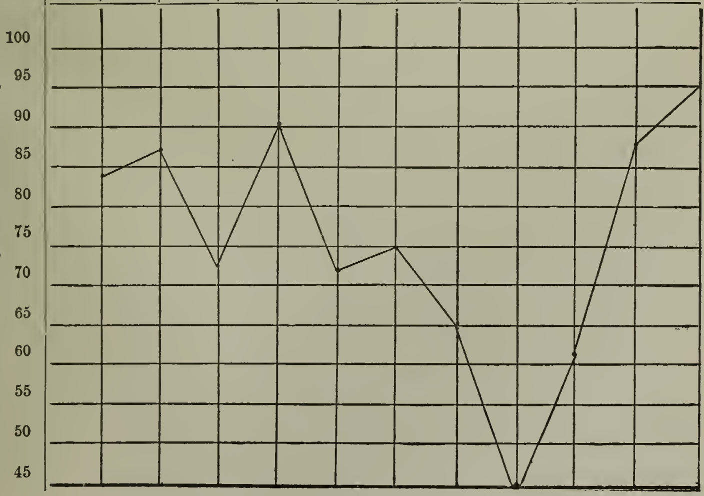
This experiment is carried out in connection with the experiments to determine the relative value of different materials furnishing nitrogen on Field A. Both soy beans and clover have been used, the former during three years, the latter one year; but it should be understood that the crops of both are harvested. We have aimed to test, not the effect of ploughing under these crops, but simply the improvement, if any, derived from their roots and stubble. The results indicate little or no improvement in the condition of the soil following culture of the soy bean, while a great improvement followed the turning under of the clover sod. The following table, with the curve below it, will, it is believed, make these facts clear: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

PLOTS.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
	Oats.	Rye.	Soy Bean.	Oats.	Soy Bean.	Oats.	Soy Bean.	Oats.	Oats.	Clover.	Potatoes.
Nitrogen plots, .	343	484	1,965	598	620	494	1,740	445	254	413	1,316
No-nitrogen plots, .	290	421	1,443	540	452	370	1,143	197	158	367	1,254

[Per cent. average no-nitrogen to average nitrogen.]

1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Oats.	Rye.	Soy Bean.	Oats.	Soy Bean.	Oats.	Soy Bean	Oats.	Oats.	Clover.	Potatoes.
84.5	87.0	73.5	90.5	72.9	75.0	65.7	44.3	62.2	88.9	95.3



Curve showing relation of average no-nitrogen to average nitrogen plots, the latter being considered in each year 100.

The plots, three in number, from which the average of the so-called no-nitrogen plots was obtained, have received no nitrogen-containing manure or fertilizer since 1884. The past season, therefore, is the sixteenth since these plots have been manured with anything containing nitrogen. The fact that after this long period potatoes on a clover sod give a crop amounting to 95.3 per cent. of that on plots which have yearly received a fair amount of manure or fertilizer containing nitrogen is certainly one of much significance, and strikingly illustrates the advantage which may be derived from the growth of clover under appropriate conditions. The actual yields of potatoes this year, although not large, were good; the no-nitrogen plots giving a yield at the rate of 209 bushels to the acre, and the nitrogen plots an average yield at the rate of 219.3 bushels per acre.

III. — The Relative Value of Muriate and High-grade Sulfate of Potash.

The experiments on which the following statements concerning relative value are based have been carried out on Field B, and have been in progress since 1892. The potash salts named are used in equal quantities, each continuously upon one-half of the plots, while all the plots have received a yearly application of fine-ground bone at the rate of 600 pounds per acre throughout the entire period. The potash salts were used yearly, at the rate of 400 pounds per acre, from 1892 to 1899. During the past year they have been applied at the rate of 250 pounds per acre. Full details concerning these experiments will be found in recent annual reports.

During the time that this experiment has continued the following crops have been grown on the field: potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. Crops have generally been good. Among these crops the potatoes,* clovers, cabbages and soy beans

* Potatoes have been grown upon our grounds under conditions making it possible to compare the yield of sulfate of potash with that of muriate of potash in fourteen different experiments; and as the average of all these experiments, if we represent the yield of sulfate of potash by 100, that of muriate is represented by the number 94.1, and in almost all instances the potatoes on the sulfate have been richer in starch and of better eating quality than those raised on the muriate.

have with very few exceptions done much the best on the sulfate of potash; while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate. The quality of the crops of potatoes and sugar beets produced by the sulfate of potash plots has been distinctly better than that of the crops produced on muriate of potash. Taking all the crops except the clovers into consideration, if we represent the efficiency of the high-grade sulfate of potash by the number 100, that of the muriate of potash is 98.1. Taking into account only those crops showing the preference for the sulfate of potash, and representing the efficiency of that salt by the number 100, the efficiency of the muriate of potash is 88.6. The present difference in price between the two salts is only about $5 per ton. The conclusion, therefore, appears to be warranted, that, under conditions similar to those prevailing in this experiment, the selection of the sulfate rather than the muriate is wise.

Further, in estimating the significance of our results, it should be kept in mind that the continued use of muriate of potash causes the loss with drainage waters of large amounts of lime. In the experiments on which the conclusions above stated are based we have yearly supplied a large amount of lime in the bone meal used, and accordingly the productiveness of the field even where the muriate of potash has been used has been fairly well maintained. Results on other fields on our farm indicate that when not used in connection with lime the muriate of potash stands much lower than the sulfate within comparatively few years. Whoever under ordinary conditions uses muriate of potash continuously, must sooner or later lime his land; and this is equally true, whether the farmer purchases muriate of potash and applies it by itself or in a home-made mixture, or if it is the source of the potash in a mixed fertilizer which he purchases. In deciding upon the purchase of any of the ordinary fertilizers upon the market, it is important to inquire whether the potash found in the fertilizer is present in the form of muriate or in the form of sulfate; and, other things being equal, the fertilizer containing its potash in the form of sulfate should be selected, unless the soil on which the material is to be used is exceptionally light. The soil in the experiments on which the conclusions here presented are based is a medium loam. On a lighter soil the results would possibly be more favorable to the muriate.

As has been stated, the yield of the clovers has not been taken into account in making the calculations upon which the statements concerning the relative efficiency of the two potash salts are based. The reason why they have not been so taken into account is because there have always been more or less weeds produced among the clovers, and these have not been separated. The amount of weeds has naturally been greater in proportion as the clovers have been thinner and poorer. The figures, therefore, showing yields on the several plots in the form of hay, including the weight of the dried weeds as well as the weights of the dried clovers, do not correctly represent the effect of the fertilizers; accordingly, these figures have been discarded. There is, however, not the slightest doubt that in its effects upon the growth of the clovers the sulfate of potash stands distinctly ahead of the muriate. In some years and upon some plots the difference has been very large, at other times it has been smaller, and in a few instances the weight of the harvested product grown on muriate of potash has slightly exceeded that grown on the sulfate. It is without hesitation, however, that farmers are advised to employ sulfate of potash rather than the muriate, where good clover crops are desired, particularly unless prepared to use lime as well as potash salts liberally. If lime be liberally used, as indicated by our experiments on other fields, good clover can be grown on muriate of potash; but the combined cost of the lime and muriate will in most cases exceed the cost of the sulfate.

IV. — Field C.

A. The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The experiments upon which the conclusions now presented are based have been in progress since 1891, each of the several sources of nitrogen being applied yearly throughout the entire period upon the same plot. The crops grown during this series of years have included spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn and celery, and each of these as a rule has been grown a number of years. Up to 1898, chemical fertilizers alone were employed in these experiments. During the past three years stable manure has been applied in equal quantities to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. Taking into account the period when chemical fertilizers only were used, and the crops (spinach, lettuce, onions, table beets, garden peas and early cabbages) whose period of growth is the comparatively early part of the season, we find the relative efficiency of the different materials used as the source of nitrogen: —

Nitrate of soda,	100.0
Dried blood,	86.6
Sulfate of ammonia,	83.6

For the same period, and taking into account those crops (tomatoes, garden beans and sweet corn) making much of their growth after hot weather fairly sets in, we find the relative standing as follows: —

Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	103.5

For the period since manure has been applied, and taking into account the early crops only (spinach, lettuce, table beets, onions, garden peas and potatoes), the relative standing is: —

Nitrate of soda,	100.0
Dried blood,	88.8
Sulfate of ammonia,	61.7

For the same period, taking into account the aggregate yield of all the late crops (tomatoes, cabbages, turnips, squashes and celery), the relative standing is: —

Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	91.9

With one exception, it will be seen that the nitrate of soda here, as in the case of the field crops, proves the most efficient source of nitrogen. Its superiority is, however, much more marked, as should be expected, because it is immediately available, for the early crops. For the late crops in one instance during the earlier years of the experiment the sulfate of ammonia exceeded the nitrate of soda in efficiency, but during the later years of the experiment it has stood behind, even for these crops. It should be stated, further, in comment upon these results, that on one-half the plots in these experiments muriate of potash is used in connection with the various nitrogen manures. The combination of sulfate of ammonia and muriate of potash, as has been repeatedly pointed out in former reports, is a bad one, owing to the possible formation and poisonous influence of chloride of ammonia. It should be further pointed out that this field has not received the application of any lime throughout the years during which it has been under experiment. The availability of the sulfate of ammonia would undoubtedly be increased by giving this soil a heavy dressing of lime, since the presence of lime promotes those changes which are essential to convert the nitrogen of the sulfate of ammonia into nitrates, which are the most readily available nitrogen compounds.

B. Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The period during which the experiments upon which the conclusions now to be stated are based and the crops grown are the same as in the case of the nitrogen fertilizers above discussed, and the relative standing of the two potash salts is shown for the same periods and crops.

Before Manure was used,—1891–97.

	Early Crops.	Late Crops.
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	91.3	91.5

After Manure was used, — 1898–1900.

	Early Crops.	Late Crops.
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	86.1	98.8

It should be noted that the muriate of potash stands much below the sulfate for all the periods, its inferiority being particularly marked in the case of the early crops. This marked inferiority in the latter years of the experiment for the early crops is doubtless in considerable measure due to the fact that the yields of such crops on the one plot where the muriate of potash and sulfate of ammonia are used together, which has always been exceedingly small, with the progress of time appear to be growing relatively worse. This is doubtless due in some measure to the fact that the continued use of muriate of potash has caused the loss of considerable lime, — an effect which had been noted and reported in a number of previous years.

The yields on the muriate, it may be said in conclusion, could undoubtedly be brought much nearer those on the sulfate by heavily liming the field.

V. — The Relative Value of Different Phosphates. (Field F.)

The phosphates under comparison in this experiment (which was begun in 1890) have been applied on the basis of equal money's worth, the idea being to determine whether it is more profitable to employ cheaper natural phosphates or one of the higher-priced dissolved phosphates. The plan of the experiment has been outlined in previous reports. It is necessary to state here, for clearness only, the following points: —

The phosphates compared on the basis of equal money's worth are dissolved bone-black, ground South Carolina rock, ground Florida rock, Mona guano and phosphatic slag. These phosphates were liberally applied during four years

(1890 to 1893, inclusive). Since 1893 no phosphate has been applied to any part of the field. All plots from the beginning were liberally manured with materials furnishing nitrogen and potash, and this manuring has continued on an even more liberal scale since 1893. The amounts of phosphoric acid supplied the several plots, the basis being equal money's worth, have of course varied widely. They are as follows: —

	Pounds.
Plot 1, phosphatic slag,	96.72
Plot 2, Mona guano,	72.04
Plot 3, ground Florida rock phosphate,	165.70
Plot 4, ground South Carolina rock phosphate,	144.48
Plot 5, dissolved bone-black,	49.36

The crop this year was cabbages, variety, Solid Emperor. The yield is shown in the following table: —

Comparison of Different Phosphates — Yield of Cabbages.

PLOTS.	Number over 2.25 Pounds.	Weight (Pounds).	Weight of Balance* (Pounds).
Plot 0,	3	8	95
Plot 1,	115	330	570
Plot 2,	73	250	580
Plot 3,	5	10	210
Plot 4,	111	550	950
Plot 5,	65	260	835

* Balance includes many small, hard heads, but too small for market.

The differences are very large, the ground South Carolina rock standing first, the phosphatic slag second, the Mona guano third, the dissolved bone-black fourth and the Florida phosphate last. The no-phosphate plot produced practically nothing. The plots are about one-seventh of an acre in area, and no plot has given what could be called a good crop. Last year the field was in oats, and there was but little difference between the yields of the different plots. The yield on all, even on the no-phosphate plot, was good.

In 1898 the crop on this field was corn, and the yield was good upon all plots except the no-phosphate plot and the

Florida phosphate plot, and there was no great difference between these yields. In 1897 the crop was Swedish turnips, and the relative growth on the different plots was about the same as this year in cabbages, the no-phosphate, the Florida phosphate and the dissolved bone-black giving the smallest yields, although the latter was not very much behind the balance of the plots.

Since the third year of the experiment the yields on the plots to which phosphatic slag, Mona guano and South Carolina rock phosphate have been applied have been substantially the same as on the dissolved bone-black plot, with the exception of the turnips and the cabbages, where the yields of these plots have been considerably greater than on the dissolved bone-black. All the crops grown upon the field, with the exception of the turnips and the cabbages, have given fairly good yields. The oat crop of last year was at the rate of about 40 bushels per acre; but even the no-phosphate plot gave practically the same yield as any of the others, so that the results with that crop really afford no light upon the particular question touched by this experiment. Taking into account all the crops which have been grown upon this field, except the Swedish turnips, which were affected by disease not apparently due to the fertilizer which had been used on a portion of the plots, and the yields of which, therefore, as expressed in figures, would be misleading, and representing the aggregate yield which stands highest by 100, the efficiency of the different phosphates is as follows: —

	Per Cent.
Phosphatic slag,	100.0
Ground South Carolina rock,	92.3
Dissolved bone-black,	90.7
Mona guano,	88.3
Florida phosphate,	71.5

There was at first no no-phosphate plot used in this experiment, but we have had a no-phosphate plot since 1895. Taking into account the yields of the several plots since 1895, and excepting the Swedish turnips, which were grown in 1897, for reasons above stated, the phosphates have the following relative rank: —

	Per Cent.
South Carolina rock phosphate,	100.0
Phosphatic slag,	99.0
Dissolved bone-black,	97.7
Mona guano,	95.4
Florida phosphate,	64.2
No-phosphate,	55.4

The crops which have been raised on the field in the order of their succession are as follows: potatoes, wheat, serradella, corn, barley, rye, soy beans, Swedish turnips, corn, oats and cabbages. All the plots in the field received an application of lime at the rate of one ton to the acre of quicklime, slaked, spread after ploughing and deeply worked in with a harrow in the spring of 1898.

This statement of the conditions of the experiment and of the relative yields on the different plots should perhaps be further supplemented by the statement that, supposing the crops harvested to have been of average composition and that there has been no waste, there would remain of the total phosphoric acid applied to the several plots the following amounts in each: —

	Pounds.
The phosphatic slag plot,	53.6
Mona guano,	29.7
Florida phosphate,	132.4
South Carolina rock phosphate,	102.0
Dissolved bone-black,	9.5

The following conclusions appear to be justified by the results which we have obtained: —

1. It is possible to produce profitable crops of most kinds by liberal use of natural phosphates, and in a long series of years there might be a considerable money saving in depending, at least in part, upon these rather than upon the higher-priced dissolved phosphates.

2. None of these natural phosphates appear to be suited to crops belonging to the turnip or cabbage family; but whether it is because these crops require the presence of an unusually large amount of soluble phosphoric acid, or whether it is because of some other effect of the dissolved phosphates, our experiments do not enable us to say. While we have obtained much the largest crops of turnips and cab-

bages on the natural phosphates, the yields have not been what could be considered good.

3. Between ground South Carolina rock, Mona guano and the phosphatic slag there is no considerable difference in the economic result.

4. The Florida phosphate, though used in amounts furnishing much more phosphoric acid than is furnished by either of the others, stands far behind them in yield, and would appear, therefore, to be rendered available only with extreme slowness.

In conclusion, it may be doubted whether, under the conditions prevailing in ordinary farm or garden practice, it would be wise to depend exclusively upon the natural phosphates. The best practice will probably be found to consist in using one of these in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

The phosphates under comparison on this basis include apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Navassa phosphate, dissolved bone-black, raw bone, dissolved bone, steamed bone and acid phosphate. The experiments have been in progress three years, each phosphate being applied yearly to the same plot. There are three no-phosphate plots, which serve as a basis for comparison. The plots are one-eighth of an acre each in area.

During the past year two crops have been grown upon this field: oats, which were cut and made into hay; and Hungarian grass, also made into hay. The yields have been large on all plots, varying from a little less than 4 tons per acre for the two crops on the poorest no-phosphate plot to rather over 5 tons per acre for the two crops on the dissolved bone-black which gave the largest yield. The only points to which it seems desirable to call attention are the following: —

1. The phosphatic slag evidently furnished phosphoric acid in an exceedingly available form, the yield this year being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate is apparently a very inferior material, the phosphoric acid evidently becoming available only with great slowness.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

Soil Tests.

During the past season two soil tests have been carried out upon our own grounds, both in continuation of previous work upon the same grounds. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. The fertilizers in these experiments are used in accordance with the co-operative plan for soil tests adopted in Washington in 1899. Each fertilizer wherever employed is always applied at the following rates per acre: —

Nitrate of soda, . .	160 pounds, furnishing nitrogen.
Dissolved bone-black, .	320 pounds, furnishing phosphoric acid.
Muriate of potash, .	160 pounds, furnishing potash.
Land plaster, . .	400 pounds.
Lime, ...	400 pounds.
Manure, . . .	5 cords.

Soil Test with Grass (South Acre).

The past is the twelfth season that the experiment on this field has been in progress. The field has been cropped in successive years as follows: corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, corn, and this year grass and clover seeded in early spring. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer. Three plots have yearly received a single important manurial element, nitrogen, phosphoric acid or potash, every year the same; three have received each year two of these elements; one has received all three yearly; and one each has received, yearly, lime, plaster or manure. The larger part of the field accordingly has remained either entirely unmanured or has had but a partial manuring, and the degree of exhaustion of most of the plots is considerable. The four nothing plots this year produced an average at the rate of 930 pounds of hay per acre. The following table shows the rate of yield of the several plots: —

Effect of the Fertilizers.

Hay (South Acre Soil Test, 1900).

FERTILIZERS USED.	Yield per Acre (Pounds).	Gain or Loss per Acre, compared with Nothing Plots (Pounds).
Plot 1, nitrate of soda,	2,460	1,660.00
Plot 2, dissolved bone-black,	1,000	200.00
Plot 3, nothing,	800	–
Plot 4, muriate of potash,	1,140	366.67
Plot 5, lime,	880	133.33
Plot 6, nothing,	720	–
Plot 7, manure,	4,160	3,440.00
Plot 8, nitrate of soda and dissolved bone-black,	2,540	1,440.00
Plot 9, nothing,	1,100	–
Plot 10, nitrate of soda and muriate of potash,	3,000	1,900.00
Plot 11, dissolved bone-black and muriate of potash,	1,600	500.00
Plot 12, nothing,	1,100	–
Plot 13, plaster,	900	—200.00
Plot 14, nitrate of soda, dissolved bone-black and muriate of potash.	2,300	1,200.00

The effect of each of the three elements of plant food, nitrogen, phosphoric acid and potash, is more clearly brought out in the tables below: —

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Muriate of Potash.	Phosphoric Acid and Potash.	Average Result.
Hay (pounds per acre),	1,660	1,240	1,533.33	700	1,283.33

Value of net average increment, ... $10 27
Financial result (gain), ... 7 07

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Potash.	Average Result.
Hay (pounds per acre),	200	—220	133.33	—700	—146.67

Value of net average decrease, ... $1 17
Financial result (loss), ... 4 37

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Phosphoric Acid.	Nitrate and Phosphoric Acid.	Average Result.
Hay (pounds per acre),	366.67	240	300	—240	166.67

Value of net average increment, ... $1 33
Financial result (loss), ... 1 87

	Results of the Addition to Nothing of—			
	Complete Fertilizer.	Manure.	Plaster.	Lime.
Hay (pounds per acre),	1,200	3,440	−200	133.33
Value of increment,	$9 60	$27 52	–	$1 07
Value of decrease,	–	–	$1 60	–
Financial result,	No gain or loss.	2 52 gain.	3 40 loss.	0.13 loss.

These results require little comment. A study of the figures shows that it is the nitrate of soda chiefly which causes an increase in the crop. Alone and in every combination it gives a large increase. It should be remembered, in estimating the significance of these figures, that the field was seeded last spring, and that accordingly the crop was comparatively small. The effect of the fertilizers will undoubtedly become more pronounced another season, when both grass and clover are fully established. *It is especially noteworthy that nitrate of soda alone applied to a plot which has now received no other fertilizer for twelve years gives a crop of hay amounting to almost* 1¼ *tons. This plot last year gave a crop of corn at the rate of something less than* 14 *bushels per acre. The plot to which muriate of potash alone has been applied during the past twelve years gave us last year a yield of corn at the rate of nearly* 50 *bushels per acre. The hay crop this year is* 1,140 *pounds.* These comparisons, bringing out the differing effects of the same fertilizer on the same field for different crops, and still other comparisons which might be made, illustrate in a striking manner the fact that the selection of fertilizers for our average soils should be made chiefly with reference to the crop.

All plots in this field were evenly seeded with a mixture of grass and clover seeds, sown crosswise, to insure even seeding of all plots. Both grass and clover seeds came up well, and the clover was thick at the start on all plots. At the present time there is practically no clover on any of the plots except the four to which potash has been applied and the one to which manure has been yearly applied.

Soil Test with Onions (North Acre).

This experiment is upon the land occupied last year in a similar soil test with onions. The field has been employed in soil test work for eleven years, the several plots having been every year manured alike, as described under soil test with grass. The previous crops in the order of rotation have been potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions, and onions. It will be remembered that the west half of each plot was limed in the spring of 1899 at the rate of 1 ton per acre of quicklime, slaked, and immediately spread and harrowed in. The fertilizers were employed this year in the same quantities as last, viz. : —

	Pounds.
Nitrate of soda (per acre),	320
Dissolved bone-black (per acre),	640
Muriate of potash (per acre),	320

The seed was sown at the rate of 5 pounds per acre. The variety was Danvers' Yellow Globe. Germination was prompt and perfect, but many of the plants upon the nothing plots and upon the unlimed portion of the plots receiving respectively muriate of potash, nitrate of soda, nitrate of soda and muriate of potash, and dissolved bone-black and muriate of potash, soon died; while such plants as survived upon these plots made but very little growth. The following tables give the results of the harvest: —

Effect of the Fertilizers.

Onions (North Acre Soil Test, 1900).

Plot.	FERTILIZERS USED.	Yield per Acre of Scallions and Tops (Pounds).		Gain or Loss per Acre, compared with Nothing Plots (Pounds).	
		Unlimed.	Limed.	Unlimed.	Limed.
1	Nothing,	460	1,600	-	-
2	Nitrate of soda,	3,100	1,780	1,640	20
3	Dissolved bone-black,	1,160	880	—1,300	—1,040
4	Nothing,	3,460	2,080	-	-
5	Muriate of potash,	3,200	3,400	—455	1,050
6	Nitrate of soda and dissolved bone-black.	1,720	760	—2,130	—1,860
7	Nitrate of soda and muriate of potash.	1,100	4,520	—2,945	1,630
8	Nothing,	4,240	3,160	-	-
9	Dissolved bone-black and muriate of potash.	5,320	1,720	1,500	—1,980
10	Nitrate of soda, dissolved bone-black and muriate of potash.	5,600	1,520	2,200	—2,220
11	Plaster,	1,760	1,960	—1,220	—2,070
12	Nothing,	2,560	4,320	-	-

Onions (North Acre Soil Test, 1900).

Plot.	FERTILIZERS USED.	Yield per Acre of Well-cured Onions (Bushels).		Gain or Loss per Acre, compared with Nothing Plots (Bushels).	
		Unlimed.	Limed.	Unlimed.	Limed.
1	Nothing, ...	6.15	41.54	-	-
2	Nitrate of soda, ...	50.00	155.00	21.67	83.21
3	Dissolved bone-black, . .	17.31	37.69	—33.20	—64.36
4	Nothing, ...	72.69	132.31	-	-
5	Muriate of potash, . . .	37.69	383.46	—26.45	257.31
6	Nitrate of soda and dissolved bone-black.	225.77	202.31	170.20	82.31
7	Nitrate of soda and muriate of potash.	9.23	310.77	—37.80	196.93
8	Nothing, ...	38.46	107.69	-	-
9	Dissolved bone-black and muriate of potash.	159.62	380.00	124.91	273.66
10	Nitrate of soda, dissolved bone-black and muriate of potash.	136.92	488.46	105.96	383.46
11	Plaster, ...	4.62	23.08	—22.59	—80.57
12	Nothing, ...	23.46	102.31	-	-

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Muriate of Potash.	Phosphoric Acid and Potash.	Average Result.
Scallions, unlimed (pounds), .	1,640	—830	—2,490	700	—245
Scallions, limed (pounds), . .	20	—820	580	—240	—115
Onions, unlimed (bushels), .	21.67	203.40	—11.35	—18.95	48.69
Onions, limed (bushels), . .	83.21	146.67	—60.38	109.80	69.83

Value of net average increment: unlimed, $12.66; limed, $18.16.
Financial result: unlimed, $6.26 gain; limed, $11.76 gain.

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Muriate of Potash.	Average Result.
Scallions, unlimed (pounds), .	—1,300	—3,770	1,955	5,145	507.50
Scallions, limed (pounds) . .	—1,040	—1,880	—3,030	—3,850	—2,450.00
Onions, unlimed (bushels), .	—33.20	148.53	151.36	143.76	102.61
Onions, limed (bushels), . .	—64.36	—.90	16.35	186.53	34.41

Value of net average increment: unlimed, $26.68; limed, $8.95.
Financial result: unlimed, $20.23 gain; limed, $2.55 gain.

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Phosphoric Acid.	Nitrate and Phosphoric Acid.	Average Result.
Scallions, unlimed (pounds), .	—455	—4,585	2,800	4,330	522.50
Scallions, limed (pounds), . .	1,050	1,610	—940	—360	340.00
Onions, unlimed (bushels), .	—26.45	—59.47	158.11	—64.24	1.99
Onions, limed (bushels), . .	257.31	113.72	338.02	301.15	252.55

Value of net average increment: unlimed, $0.52; limed, $65.66.
Financial result: unlimed, $5.88 loss; limed, $59.26 gain.

	Results of the Addition to Nothing of —			
	complete fertilizer.		land plaster.	
	Unlimed.	Limed.	Unlimed.	Limed.
Onions (bushels per acre), . .	105.96	383.46	—22.59	—80.57
Value of net increment, . . .	$27 55	$99 70	-	-
Value of decrease, ...	-	-	$5 87	$20 95
Financial result, ...	8 35 gain.	80 10 gain.	9 47 loss.	24 55 loss.

The yield upon the limed portion of many of the plots this year is, as was anticipated, much better than last year, although the tops on all parts of the field were somewhat prematurely killed by blight. The heavy application of lime made in that year appears to have corrected in large measure the faulty soil conditions. *We have this year a crop at the rate of nearly* 500 *bushels to the acre of well-cured onions upon the limed half of the plot, which has been yearly manured with nitrate of soda, dissolved bone-black and muriate of potash; while on the unlimed portion of the same plot we have a yield of* 136.9 *bushels to the acre. The lime has evidently proved highly beneficial.*

Particular attention is called to the fact that we nowhere obtained a fairly good crop except upon those plots to which potash has been yearly supplied. The limed portion of the plot, which has yearly been manured with muriate of potash alone, gives a yield at the rate of 383 *bushels to the acre; the nitrate of soda and the potash give a yield at the rate of about* 311 *bushels; the dissolved bone-black and potash, a yield at the rate of* 380 *bushels. These figures make it perfectly evident that potash is an exceedingly important manure* *for the onion crop. Its effects far exceed those of either of the other elements.*

Our results make it equally evident that the continuous use of muriate of potash makes the employment of lime an absolute necessity. The combined cost of the muriate of potash and the lime necessarily used with it is likely to be greater than would be the cost of some other source of potash.

That the nitrate of soda as well as the muriate of potash has proven in some degree injurious when used without lime is made equally evident by our results, for the yield on the combined nitrate of soda and muriate of potash without lime is much inferior to the yield on the muriate alone without lime. It is, indeed, almost the poorest in the field.

Especial attention is called to the fact, which was very evident on all the plots where it was used, that dissolved bone-black greatly promoted the perfect ripening of the crop. By far the best ripened crop on the unlimed portion of the field was the crop produced by nitrate of soda and dissolved bone-black. Any other dissolved phosphate would undoubtedly have a similar effect.

Attention is called, further, to the fact that the dissolved bone-black in large measure corrects the injurious effects following the use of muriate of potash. This is made especially evident by the comparison between the yields where dissolved bone-black was used together with nitrate of soda and muriate of potash and where the last two fertilizers were used alone. Where they were used alone, the crop, as has already been pointed out, was almost the poorest in the field, a large share of the plants dying at a very early stage in their growth; while where the dissolved bone-black was used together with these fertilizers a moderate crop was the result. It becomes evident, therefore, that where fertilizers containing a liberal amount of some dissolved phosphate are employed, liming is less necessary than where such phosphates are not employed. That this should be so is not strange, since all dissolved phosphates contain a large amount of sulfate of lime (land plaster), which, if used in large quantities, produces many of the effects ordinarily following the use of lime.

Practical Advice on Fertilizers for Onions.

Although further investigations are called for concerning the many questions connected with using fertilizers for onions, it is believed that the results thus far obtained justify the following advice: —

1. Mixed fertilizers which are to be used for the culture of onions where nothing else is employed should contain about 3 to 4 per cent. nitrogen, 5 to 6 per cent. available phosphoric acid and 8 to 10 per cent. potash. It is believed that the nitrogen of such fertilizers should be derived in about equal proportions from nitrate of soda, dried blood and dry ground fish or tankage. It is further believed that the source of potash should be either the sulfate or carbonate. Such a fertilizer might be required in amounts varying from 1 to 1½ tons.

2. If a home mixture of materials is to be made, it is believed that it should supply 60 pounds of nitrogen, from 90 to 100 pounds of phosphoric acid and 160 to 200 pounds of potash per acre. It is believed, further, that the nitrogen, as stated above, should be derived in part from nitrate of soda and in part from animal materials. It is believed that the phosphoric acid should be derived mainly from acid phosphate or dissolved bone-black, and that for potash either the high or low grade sulphate or the carbonate of potash-magnesia should be employed. As an illustration of a mixture which it is believed will suit average conditions, the following list of materials is given: —

	Pounds.
Nitrate of soda,	200
Dried blood,	250
Dry ground fish or tankage,	200
Acid phosphate,	700
For potash, either of the following: —	
High-grade sulfate,	350
Low-grade sulfate,	700
Carbonate of potash-magnesia,	950

These materials should be mixed just before use, spread after ploughing and harrowed in.

3. It is suggested, the suggestion being based upon our observations, that in case the onions do not ripen well, and where the proportion of scallions is large, the application of lime be tried, or the proportion of acid phosphate increased. If lime is to be used, it is recommended that about 1 ton of quicklime per acre be applied. This should be slaked with water, spread after ploughing, and deeply worked in with wheel harrow. The best season is autumn or very early spring.

"Special" Corn Fertilizer *v.* Fertilizer richer in Potash.

The experiments upon which it is now proposed to comment have for their object the effort to determine the most profitable combination of fertilizers to be used for the growth of corn. The plan of the experiment and the results up to the close of last season are given in full in our last annual report.

Results in recent years had led to the conclusion that this field might be benefited by liming. It accordingly received an application at the rate of 1 ton of air-slaked lime, applied May 14 and thoroughly worked in. The kinds and amounts of fertilizers used during the past season have been somewhat changed. To two of the plots (1 and 3) in the field we have applied materials supplying the same quantity of nitrogen, phosphoric acid and potash as would be furnished by the use of 1,800 pounds of fertilizer, having the average composition of the "special" corn fertilizers analyzed at this experiment station in 1899. This average is as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5- 3.7
Phosphoric acid,	9.0-13.0
Potash,	1.5- 9.5

The other plots in the field received an application of materials practically the same in kind and quantity as have been recommended in Bulletin No. 58 for corn on soils poor in organic matter. The principal difference between the manuring of these plots and the others is that they receive slightly more nitrogen, much less phosphoric acid and considerably more potash. The materials supplied to the several plots are shown in the following table: —

FERTILIZERS USED.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

The variety of corn grown this year was Sibley's Pride of the North. The growth was vigorous and healthy, and unaffected, so far as could be seen, by any abnormal conditions. The yields were as follows: —

Yield of Corn, 1900.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,510	1,460
Plot 2 (richer in potash),	1,435	1,540
Plot 3 (lesser potash),	1,590	1,675
Plot 4 (richer in potash),	1,515	1,600

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	77.50	6,270
Plots 2 and 4,	73.75	6,280

It will be noticed that the yield of grain on the "special" fertilizer exceeds that on the fertilizer richer in potash, the difference being at the rate of 3.8 bushels per acre; the fertilizer richer in potash gave slightly more stover. The difference in cost of the fertilizers applied on the two sets of plots is at the rate of a little more than $4 per acre. This is the apparent cost of the 3.8 bushels of corn. I say apparent, for the following reason: the field was seeded to mixed grass and clover the latter part of July, and at the present time the condition of plots 2 and 4, which received the fertilizer richer in potash, indicates a much heavier growth of clover next season than on the other plots.

It is believed that when this field is once more broken up and put into corn the yields of plots 2 and 4 will stand relatively better.

In conclusion, attention is called to the fact that the results on this field furnish important light upon the problem as to whether corn can be successfully grown on fertilizers alone. The present is the tenth year since this field has been under experiment, and throughout this time fertilizers only, and in very moderate quantities, have been employed. The result this year on the plots richer in potash is a crop at the rate of about 74 bushels of sound corn and of 3 tons of stover per acre, and a magnificent catch of grass and clover. The cost of the fertilizers employed this year on these plots is at the rate of $13.50 per acre, not including the lime. One ton of the latter was put on this year, but such application will not be required oftener than once in six or seven years.

Manure alone *v.* Manure and Potash.

This experiment, which was intended to illustrate the relative value in crop production of an average application of manure, as compared with a smaller application of manure used in connection with some form of potash, was begun in 1890. Full accounts of the results in the different years will be found in preceding annual reports, and summaries are found in the reports for 1895 and 1900. The field contains one acre and is divided into four plots of one-fourth acre each. Corn was the crop in 1899. The field was ploughed last fall and seeded to rye for winter protection. After ploughing this spring the field received a dressing of air-slaked lime at the rate of 1 ton to the acre; this was thoroughly worked in with a wheel harrow; the field was then manured as shown below: —

Plot 1, manure, 1½ cord; weight, 6,805 pounds.
Plot 2, manure, 1 cord; weight, 4,610 pounds; high-grade sulfate of potash, 40 pounds.
Plot 3, manure, 1½ cord; weight, 6,717 pounds.
Plot 4, manure, 1 cord; weight, 4,067 pounds; high-grade sulfate of potash, 40 pounds.

Samples of the manure used were analyzed, and the sulfate of potash was analyzed. The calculated amounts of plant food applied to the several plots are as follows: —

PLOTS.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1,	22.64	19.65	38.43
Plot 2,	14.21	13.70	40.67
Plot 3,	20.15	20.15	27.54
Plot 4,	12.20	12.20	36.67

The variety of corn grown this year was Sibley's Pride of the North. The growth was good and the crop large on all plots. The yield on the several plots is at the rate per acre shown in the following table: —

Yield of Corn (Rate per Acre).

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plot 1,	72.5	6,740
Plot 2,	72.0	7,020
Plot 3,	74.5	6,540
Plot 4,	72.8	6,580

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3, manure alone,	73.5	6,640
Plots 2 and 4, manure and potash,	72.4	6,800

The crops, as in previous years, are of substantially equal value, the manure alone giving 1.1 bushels more grain than manure and potash, while the latter gave 160 pounds more stover. The combination, 4 cords of manure and 160 pounds sulfate of potash per acre, will cost about $6.40 less than 6 cords of manure alone. We have now grown eight corn crops on this field, and the average yields are at the rate per acre for the two manurings: —

Average of Eight Crops.

	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone, ...	63.0	4,822
Less manure and potash, ...	58.7	4,497

The money cost of the materials applied to the plots receiving manure and potash for the ten years during which the experiment has continued is at the rate of about $81 less than on the other plots. The manure alone, however, has produced yields exceeding the combination of a smaller amount of manure and potash, at rates per acre amounting to shelled corn 34.4 bushels and stover 2,600 pounds. During two years since the experiment began the field has been in grass, and the yields on manure alone exceed those on manure and potash at rates per acre amounting to hay 2,244 pounds and rowen 1,170 pounds. Such an amount of corn and hay at average prevailing market prices would have been worth about $44.18. In using the large amount of manure alone, then, one would, in effect, allowing the manure to cost $5 to the cord on the land, have expended about $81 for products worth but little more than one-half that sum.

This field has now been seeded to mixed grass and clover seeds. The stand on all plots is good, but the clover is proportionally more abundant on the plots receiving the manure and potash.

It is believed that these experiments conclusively indicate that corn may be more cheaply grown on a combination of manure and potash than on manure alone.

The Relative Value for Green Manuring of the Soy Bean and Cow Peas.

So much has been said concerning the value of cow peas for green manuring purposes that it has seemed desirable to compare this crop with the soy bean for that purpose. Accordingly, two varieties of cow peas, the Wonderful and the Black, the former a late and the latter an early variety, have been grown under conditions allowing comparison with the medium green soy bean. The growth of all the crops was good and each occupied about one-fifth of an acre. The Wonderful cow pea when cut had only just begun to blossom, the Black had but a small proportion of its pods ripe, while all the pods on the soy bean were practically mature. The following table shows the results: —

Cow Peas and Soy Beans for Green Manuring.

VARIETY.	Pounds per Acre.		
	Green Weight.	Dry Matter.	Nitrogen.
Wonderful cow pea, ...	19,600	3,622	80.4
Black cow pea, ...	20,035	3,389	62.1
Medium green soy bean, ...	19,685	5,386	167.3

It will be noticed that the soy bean furnished much larger quantities both of dry matter and of nitrogen than either of the varieties of cow peas. It gave practically three-fifths more dry matter and more than double the nitrogen furnished by the better of the two varieties of cow peas. The roots of the bean were thickly studded with nodules, as also were the roots of the cow peas; and both must, therefore, have possessed the ability to draw upon the atmosphere for a considerable part of their nitrogen. It appears impossible to doubt that the manurial value of the soy beans must have been far greater than that of either of the varieties of cow peas.

In estimating the significance of these results, it should be kept in mind that the soil was a medium loam, retentive of moisture, and that the season had a fairly well-distributed rainfall. It is not impossible that on lighter and less retentive soils, or with deficient rainfall, the cow pea may compare more favorably with the soy bean as a green manuring crop, for the latter is somewhat impatient of drought and of soils deficient in moisture.

It may be of interest to state in this connection that a portion of the area in soy beans was allowed to ripen, and that the yield was about 36 bushels per acre of thoroughly ripened seed.

Nitrate of Soda for Rowen.

Many experiments both here and elsewhere have convincingly shown the great value of nitrate of soda for application to mowings in early spring. Not many experiments appear to have been tried to determine the effect of such applications for the second crop. Accordingly plots were laid out in July in two of our mowing fields, for the purpose of carrying out an experiment to test this question. There were two sets of these plots. One set included four plots, laid out in a permanent mowing which was seeded twelve years ago, the principal species at the present time being Kentucky blue grass. The first crop was cut June 25. The nitrate of soda was applied July 1 to two plots at the rate of 150 pounds per acre. The first crop of hay on this land was at the rate of 2.16 tons per acre. The rowen was cut on these plots on September 7. The results are shown in the following table: —

Nitrate of Soda for Rowen.

PLOTS.	Pounds per Acre.	
	Nitrate of Soda applied.	Rowen harvested.
Plot 1,	Nothing.	2,082
Plot 2,	150	3,117
Plot 3,	Nothing.	2,438
Plot 4,	150	3,035

The average of plots 1 and 3 is at the rate of 2,260 pounds of rowen per acre; of plots 2 and 4 it is 3,076 pounds per acre. The application, then, of 150 pounds of nitrate of soda, costing $3, gave an apparent increase of 816 pounds of rowen, at a cost for the fertilizer of .37 cents per pound.

The second set of plots occupied a portion of a field seeded to timothy in 1898. There were eight plots in this series. The first crop of timothy had been cut July 10, and the yield was at the rate of 2.6 tons per acre. The nitrate of soda was applied July 16. The following table shows the nature of the experiment and the results : —

Nitrate of Soda for Rowen.

PLOTS.	POUNDS PER ACRE.	
	Nitrate of Soda applied.	Rowen harvested.
Plot 1,	Nothing.	587
Plot 2,	150	1,394
Plot 3,	Nothing.	514
Plot 4,	150	679
Plot 5,	Nothing.	202
Plot 6,	200	1,137
Plot 7,	Nothing.	440
Plot 8,	250	1,816

The average yield of all the nothing plots was at the rate of 436 pounds per acre. The average of plots 2 and 4 was 1,036 pounds per acre, a gain of 600 pounds of rowen following the application of 150 pounds of nitrate, costing $3, the cost of the gain per pound being .5 cents. The application at the rate of 200 pounds produced an apparent gain of 701 pounds, at a cost of .57 cents per pound ; the application at the rate of 250 pounds produced an apparent gain of 1,380 pounds, at a cost of .36 cents per pound ; but we have some evidence indicating that this plot is naturally better than the average of the nothings.

In commenting upon these results, it should be stated at the outset that the season was not favorable for the production of a maximum effect from the application of the nitrate, as the rainfall was deficient, amounting, for the entire period during which the rowen upon the old mowing was growing, to 7.26 inches ;* during the period that the timothy was growing, to 6.66 inches.† The application of the nitrate produced an effect both upon color and growth almost imme-

* The average for this period for the ten years 1889-98 is 8.59 inches.

† The average for this period for the ten years 1889-98 is 8.39 inches.

diately following the first rain which fell after it had been made. It is believed that the gain in crop would have been much greater had the rainfall been larger.

Further experiment is needed to determine what amount of nitrate, if any, it will pay to use; but the opinion is here advanced that probably the most profitable application will be found not to exceed about 150 pounds per acre.

Experiment 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, with two slight modifications. We have three large plots (between two and one-half and four acres each) under this treatment. According to the system followed, 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 changes in manuring introduced this year consist, first, in the use of a small quantity of nitrate of soda in connection with the ashes on one plot and with the ground bone and muriate of potash on another. The experiment is further modified to a slight extent by the fact that a little more than one acre on plot 1, which contains about four acres, was used for experiment in the application of nitrate of soda for rowen, elsewhere described in this report, the nitrate being used at the rate of 150 pounds per acre. Our system of manuring is so planned that each year we have one plot under each of the three manurings. The manure is always applied in the fall, the other materials early in the spring. The ashes were put on this year April 5, the bone and potash April 16. The nitrate of soda was used with the ashes at the rate of 64 pounds to the acre, and was put on April 17. Nitrate of soda was used on plot 3, with bone and potash in the quantities above named, at the rate of 83 pounds per acre. It was applied April 19.

Plot 1, which this year received wood ashes and nitrate of soda, gave a yield at the rate of 2.164 tons of hay and 1.326 tons of rowen per acre. Plot 2, which was top-dressed in the fall of 1899 with manure, yielded hay 1.525 tons and rowen 1.150 tons per acre. Plot 3, which was manured with a combination of bone and potash in amounts named, and nitrate, gave yields of hay 2.228 tons and rowen (two crops on a part of the plot) 1.219 tons per acre. The average yield of the entire area for this year is 6,510 pounds, hay and rowen both included. The field has now been twelve 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, of 6,615 pounds per acre. The plots, when dressed with manure, have averaged 6,817 pounds per acre; when receiving bone and potash, 6,626 pounds; and when receiving ashes, 6,371 pounds. It will be noticed that, while the general average for this year, including all the plots, falls below the general average for the entire period, the average for this year of the two plots receiving bone and potash and ashes is above the general average for the entire period. It will be remembered, however, that these plots have this year, in addition to the usual amounts of bone and potash and ashes respectively, received a light dressing of nitrate of soda. It is possibly this difference in treatment which has produced the results just pointed out.

Poultry Experiments.

The experiments of the past season have, as in previous years, been devoted to the study of methods of feeding, as affecting egg-production. The only experiment the results of which it is proposed to report at the present time is one having for its object the determination of the relative merits of the system of giving a mash in the morning, as compared with the system of giving it late in the afternoon.

General Conditions.

Barred Plymouth Rock pullets, raised on the scattered colony plan, divided into two lots as equally matched in weight and development as possible at the beginning of the experiment, were employed. Twenty such pullets with two cockerels were put into each house. Our houses are detached, and include a closed room for nests and roosts, 10 by 12 feet, with two windows about 3 by 6 feet on the south, scratching shed, 8 by 12 feet, which is left either entirely open in fine weather or closed by folding doors with large glass windows in stormy weather, while the fowls are allowed the run of large yards whenever the weather permits.

Two tests were made: a so-called winter test, December 7 to May 20; and a summer test, May 29 to September 16. The feeds used in the two coops were of the same kinds, the intention being to give each lot of fowls as much food as would be readily consumed. The mash used in these experiments was commonly mixed with boiling water about twelve hours before use, but in some instances was given hot immediately after mixing. The morning mash was always given as soon after light as possible, the evening mash just before dark. The whole grain given to both lots of fowls was scattered in the straw in the scratching shed, for the fowls in one coop early in the morning, for those in the other coop about an hour before dark. Both lots of fowls were given a little millet seed scattered in the straw at noon, the object in view being to keep them industriously searching for food in the straw a considerable share of the time. About twice a week a small cabbage was given to each lot of fowls. The eggs were weighed weekly; all the fowls were weighed at intervals of about one month. Sitters were confined in a coop until broken up, being meanwhile fed like their mates. The prices per hundred weight for feeds upon which financial calculations are based are shown below: —

	Per Cwt.
Wheat,	$1 65
Corn and corn meal,	90
Millet,	1 00
Bran and middlings,	90
Gluten feed,	1 00
Gluten meal,	1 25
Animal scraps,	2 25
Clover,	1 50
Cabbage,	25
Oats,	1 12.5

The health of the fowls under both systems of feeding has been in general good, although, as is usually the case, there have been a few losses. Two fowls on the morning mash died in April, and post-mortem examination showed a catarrhal condition of the throat and intestines. Three fowls in the evening mash coop died; post-mortem examination of one showing enlarged liver and spleen and ulcerated alimentary canal, and in another case enlarged liver and intestinal parasites.

Winter Experiment.

All details necessary to a full understanding of the experiment will, it is believed, be found in the following tables: —

Foods consumed, Morning v. *Evening Mash, December 7 to May 20.*

KIND OF FOOD.	Morning Mash (Pounds).	Evening Mash (Pounds).
Corn,	261.00	239.50
Wheat,	130.50	120.00
Millet,	39.50	37.75
Bran,	46.00	45.00
Meat scraps,	45.00	43.00
Clover,	22.00	21.50
Corn meal,	112.00	107.00
Cabbage,	62.50	77.75

Average Weights of Fowls (Pounds).

DATES.	MORNING MASH.		EVENING MASH.	
	Hens.	Cocks.	Hens.	Cocks.
December 7,	4.61	7.75	4.33	7.13
February 6,	5.38	7.38	4.78	6.88
March 17,	5.69	7.38	5.28	8.88
May 21,	5.24	7.88	5.13	6.88

Number of Eggs per Month, Morning v. *Evening Mash, Winter Test.*

DATES.	Morning Mash.	Evening Mash.
December,	1	1
January,	19	27
February,	76	52
March,	283	229
April,	271	292
May,	143	157
Totals,	793	758

Morning v. *Evening Mash for Egg-production, Winter Test.*

	Morning Mash.	Evening Mash.
Total dry matter in foods (pounds),	593.28	556.11
Number of hen days, not including males,	3,228	3,158
Number of hen days, including males,	3,558	3,488
Gross cost of food,	$7 78	$7 36
Gross cost of food per egg (cents),	.97	.97
Gross cost of food per hen day (cents),	.22	.21
Number of eggs per hen day,	.25	.24+
Average weight per egg (ounces),	1.84	1.85
Total weight of eggs (pounds),	91.19	87.64
Dry matter consumed per egg (pounds),	.75	.73+
Nutritive ratio,*	1:6.3+	1:6.1+

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment was the same as in the winter, save in two particulars: first, in place of cut clover rowen in the mash, lawn clippings in such quantities as the fowls would eat before wilting were fed three times a week, to the hens in all the houses the same; and, second, the feeding of cabbages was discontinued. The yards, 1,200 square feet in area for each house, were kept fresh by frequent turning over of the soil. The tables give all details: —

Foods consumed, Morning Mash v. *Evening Mash, May 29 to September 16.*

KIND OF FOOD.	Morning Mash (Pounds).	Evening Mash (Pounds).
Bran,	41.80	40.70
Middlings,	41.80	40.70
Meat scraps,	32.00	32.00
Oats,	47.80	49.20
Corn meal,	41.80	40.70
Corn,	171.70	174.80

Average Weight of Fowls (Pounds).

DATES.	Morning Mash.		Evening Mash.	
	Hens.	Cocks.	Hens.	Cocks.
May 29,	5.69	8.00	4.94	6.75
July 30,	5.53	7.75	5.00	6.75
August 16,	5.11	8.00	4.74	7.00

Number of Eggs per Month, Morning v. *Evening Mash, Summer Test.*

DATES.	Morning Mash.	Evening Mash.
May,	28	24
June,	174	186
July,	163	181
August,	164	128
September,	54	51
Totals,	583	570

Morning v. *Evening Mash for Egg-production, Summer Test.*

	Morning Mash.	Evening Mash.
Total dry matter in foods (pounds),	337.02	338.11
Number of hen days, not including males,	1,719	1,722
Number of hen days, including males,	1,941	1,944
Gross cost of food,	$3 94	$3 95
Gross cost of food per egg (cents),	.68—	.69+
Gross cost of food per hen day (cents),	.20+	.20+
Number of eggs per hen day,	.34—	.33+
Average weight per egg (ounces),	1.83	1.90
Total weight of eggs (pounds),	66.68	67.69
Dry matter consumed per egg (pounds),	.51—	.59+
Nutritive ratio,*	1:5.5+	1:5.6

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that neither in the winter nor summer experiment was there any very considerable difference in the number of eggs produced. It is, however, possibly significant, and this fact is made evident by the tables showing monthly egg yields, that during the period of shortest days the fowls receiving the evening mash laid less eggs than the others.

The most striking result of the experiments is the great difference in the relative amounts of droppings voided during the night by the fowls under the two systems of feeding. It was noticed from the beginning, and the same remained true throughout the entire period, that the amount of droppings voided during the night by the fowls receiving the evening mash was very much greater than the amount voided by the other lot of fowls. Weights were taken on a number of different occasions, with the results shown below: —

Morning v. *Evening Mash.*

DATES.	Number of Days Droppings.	MORNING MASH.		EVENING MASH.	
		Number of Hen Nights.	Weight of Droppings (Pounds).	Number of Hen Nights.	Weight of Droppings (Pounds).
March 3, . . .	1	22	3.00	21	6.00
March 5, . . .	2	44	5.25	42	11.00
March 7, . . .	2	44	5.25	42	10.50
March 10, . . .	1	22	2.50	21	6.25
March 21, . . .	1	22	2.50	19	4.50

It will be noticed that the weight of the droppings voided during the night by the fowls receiving the evening mash during the period of nearly even days and nights during which these weights were taken is practically double the weight of the droppings of the other lot of fowls. The fact thus brought out is doubtless of much significance. It furnishes conclusive evidence that the digestive process in the case of a soft food like a mash is very rapid. The fact that digestion among birds is relatively much more rapid than with most classes of animals has been already many times pointed out. Forbush, in his paper in the report of the secretary of the State Board of Agriculture for 1899, gives valuable data bearing upon this subject concerning a number of the smaller birds and crows. Our experiments indicate that the ordinary domestic fowl, as might have been supposed would be the case, is also able to digest soft foods with a degree of rapidity which seems astonishing. There has long been a general impression, and the usual practice in feeding fowls is evidence of this, that it is better to give the more solid food at night, especially during the winter, since it will "stay by" the fowls better. Our experiments indicate that this impression is well founded, and that the usual practice is correct, although they cannot be considered to prove it, because, of course, it may be that a period of comparative rest for the digestive organs during the night is better than the condition of more continuous work for these organs which would follow the use of solid food at night.

We have not obtained a sufficient difference in egg-production to be considered significant, but it is believed that the experiment, so far as it goes, indicates that it is better that the mash should be fed in the morning. It is conceivable, however, that, if the mash be given in too large quantities, the fowls will gorge themselves, will then as a consequence become inactive, and remain comparatively inactive during a considerable part of the morning; whereas, if they be given whole grain, for which they are required to scratch, they are of necessity more active. The relative weights of the fowls, particularly during the winter, afford some indication that we to some extent experienced this difficulty; for it will be noticed that the fowls receiving the morning mash, especially during the period of shortest days, weighed considerably more than the fowls receiving the evening mash.

It must, however, be further pointed out that the average difference in weight during the summer months was also considerable, amounting to about one-half pound at the time of each of the weighings. During the earlier part of this period, however, the fowls receiving the evening mash were producing the greater number of eggs, which difference may perhaps account for their decreased relative weight.

It is concluded that, so far as the results of this experiment enable one to judge, the morning mash is preferable to the evening; but it is evident that additional investigation is required in order to throw further light upon the subject.