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FORTY-NINTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS

FOR FISCAL YEAR ENDED NOV. 30, 1911.

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APPROVED BY
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The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1911.

To His Excellency EUGENE N. FOSS.

SIR: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the forty-ninth annual report of the trustees, for the fiscal year ended Nov. 30, 1911, this being the report to the corporation of the president and other officers of the college.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my annual report as president of the Massachusetts Agricultural College.

Acting in accordance with a plan approved by the administrative officers of the college and by the trustees, the scope of the report has been considerably broadened. Each administrative officer has been asked to present a résumé of the year's work coming under his jurisdiction, a statement of immediate needs, and the suggestion of some fundamental problems. This material has been freely utilized, without particular credit, in the preparation of this report.

The report divides into three fairly distinct portions: —

1. A discussion of some fundamental problem of the college.
2. A review of the year.
3. A statement of immediate needs.

The report is followed by the usual data concerning students, gifts, etc., and by the annual report of the treasurer of the institution.

It is a part of the plan hereafter to discuss at some length in each annual report one or more of the fundamental problems which the college has to face. This year it seemed best to consider the general function, or mission, of the college.

THE FUNCTION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

After nearly forty-five years of active service by the college it may seem invidious, at first thought, to incorporate in a report of the president of the institution a discussion of its main purpose. So long a period of work must surely have revealed both the task of the college and the attitude of our people toward its service. But as "new occasions teach new duties" to individuals, so new conditions create new demands upon institutions, often call for new methods, and may even develop entirely new functions. There is no merit in change for its own sake; but change is pretty sure to be a concomitant of growth. Hence, from time to time the function of an educational institution needs restating if not reshaping. The excuse for introducing this subject in this report lies, therefore, in the belief that the time has come to plan large policies for the future in the light of a clear-cut modern statement of the fundamental purpose and task of the college.

An institution of education supported by the government gains its main purpose from four sources: first, from legislation; second, from the historic policy of the college itself; third, from the realization of some fundamental need of society, that may be met by the college; fourth, from the changing aspects of this fundamental need, as expressed in new demands for service, which in turn call for new methods and even new types of work.

The legislation which calls a college into existence is considered by some a sufficient statement of its purpose. The State laws incorporating the college utilized the Morrill act of 1862 for the purpose of stating the main work of the college. The Morrill act is, then, virtually the legal charter of the college. So we are repeatedly asked to read the Morrill act of 1862 for the statement of the work of this institution. From the legal point of view, the Morrill act is, and forever must be, the starting point from which the work of the college proceeds and spreads. Nevertheless, it cannot be considered a sufficient statement of the service demanded of this college by the present age. This is not to deny the value of the Morrill act; it is not to impugn its worth; it is not to repudiate its statements; it is simply to assert that with the lapse of time, the rise of new ideas, the need of adaptation to modern conditions, the Morrill act does not in itself, alone, give us the cue to the complete function of the college. Indeed, I question whether it was ever meant to do so.

It is sometimes stated that the Morrill act, in its definition of the work of the land-grant colleges, is clear and specific. I cannot agree with that statement. The law has actually been interpreted in such a way that the institutions based on the law have developed widely varied policies. They are all one in the emphasis on including preparation for the industrial vocations, but they are widely divided as to the scope of other work performed. It will not do to impugn the motives or the intelligence of those who have managed these institutions in such diverse ways. We have here simply an illustration of the possibilities of differing interpretations of the Morrill act. I think one of the finest compliments that can be paid to the act is to say that it was so broadly drawn that the States could adapt the work of their colleges to varied needs and ideals. But this fact again enforces the former statement that the unsupported language of the Morrill act itself is not to-day a sufficient guide for the total work of our own agricultural college.

Furthermore, we must remember that legislation itself is only an expression, and almost without exception an incomplete expression, of some need of society. Hence, a law like the Morrill act must be interpreted in terms of both the fundamental and the changing needs of those political units that furnish the funds for the support of the college thus called into existence. In other words, the needs of Massachusetts for to-day and to-morrow must help interpret the laws of yesterday, with respect to the work of this college.

It is almost impossible to conceive that a college can labor for forty-five years, with reasonable success, and yet be on the wrong track. Time itself, as well as experience, justifies policies. Hence precedents count for something, and we have no right to break with the past abruptly. Historic policies should never become swathes that bind us irrevocably to the past; they are rather foundations for our building which we may not safely disregard.

But, after all, the real test of the work of our college is neither a law nor an historic policy, but this: Is the college meeting the *need* of the people of the State? In other words, what is the social purpose of the college, its real excuse for existence? Why is the State still willing to pay the cost of its support? Why may we confidently argue for the continued investment, in equipment and maintenance, of such large amounts of the public funds?

And, finally, we must seek constantly to meet new issues as they arise and thus keep the college abreast the times.

The limits of this report forbid an exhaustive development of the four propositions just laid down as to the source of an authoritative policy. We may, however, give attention to a few preliminary considerations growing directly out of these propositions: —

1. The Massachusetts Agricultural College is a *college*. It is not a school. Governor Andrew, in his message to the Legislature of 1865, said, "I should deeply regret to see an institution which bears the name of Massachusetts, and will be held to be representative of the Commonwealth, especially of the highest aspirations of her yeomanry, allowed, for want of generous support, to degenerate into a mere industrial school." In spite of this statesmanlike utterance of nearly a half-century ago, we occasionally hear suggestions that the college is getting too far away from its constituency, and that in order to meet this constituency its standards of admission should be kept low. One cannot help sympathizing with the democratic notion that lies back of these sincere suggestions, but they are based upon the fallacy that a high grade of work will separate the college from its real task. As Governor Andrew so well said, this college represents the highest aspirations of the rural people of Massachusetts, and we can never admit that the highest aspirations of the rural people may be expressed in inferior scholarship. Without question, there is need of institutions of lower grade for the teaching of agriculture, but these should be provided, as Massachusetts has now so wisely ordered, through agricultural high schools and agricultural departments of public schools. But the agricultural college is the educational leader for the building of a highly developed rural civilization within the State.

Now the college is our most characteristic expression of such leadership. Emphasis upon the fact that this institution is a college calls, therefore, for college standards of admission and graduation, — college standards with respect to quality, though not necessarily with respect to subject matter. Within recent years the college has placed itself squarely in line with this policy, and now requires practically the same standards of admission as regards quality of work as are demanded by the typical New England college. We believe, also, as regards requirements for graduation, that, on the whole, the four years of work at the Massachusetts Agricultural College represent as good quality as will be found in the average college. Maintenance of college standards, therefore, of the college atmosphere, and of the college point of view must be our policy.

2. On the other hand, the Massachusetts Agricultural College is not, at present, a State university and, in my judgment, it ought not to be made a State university. It may seem idle to discuss this question. Nevertheless, nearly half of the institutions established under the Morrill act of 1862 are State universities. In Massachusetts we hear more or less said about the need of a State-supported university, and occasionally the suggestion is advanced that our college is the natural nucleus for such an institution. I do not purpose to discuss the question as to the need of a State university in Massachusetts, but I feel very strongly that it would be a great mistake to attempt to make a State university out of the Massachusetts Agricultural College. Its location is not favorable for such an institution. Its history and traditions are not in harmony with this form of development.

3. The Massachusetts Agricultural College is an *agricultural* college. This statement raises a question subsidiary but related to the idea of a State university. Practically all of the land-grant colleges which are not State universities have developed departments of mechanic arts, and many of them other branches of study. Our own college, all through its history, has given more or less attention to civil engineering. The general policy of the college at this point was, however, settled before the college opened for students, through a legislative arrangement by which the Massachusetts Institute of Technology secured a portion of the federal grant on the theory that the mechanic arts work should be given at the institute and agriculture at Amherst. The result of this legislation is that probably the Massachusetts Agricultural College is the only one of the land-grant colleges which may be called strictly an agricultural college. From time to time in its history suggestions have been made relative to broadening its scope beyond agriculture, emphasizing general science, etc. But I feel very keenly that we ought to emphasize now and forevermore the proposition that our college is an agricultural college and nothing but an agricultural college. I am aware that there are difficulties in carrying out this policy. The first thought that comes to mind when one speaks of an agricultural college is that its chief function is especially to train farmers. But we are located in an urban State. Many vocations which the college naturally fits for, like landscape gardening for instance, are followed in the city and not in the country, though even in landscape gardening

the work is so intimately bound up with the subject matter of agriculture that we are compelled to broaden our definition of agricultural education to include training of this sort. That statement leads us really to the heart of this whole matter: Gradually there is forming a new definition of agricultural education. The agricultural college should fit men for farming, but it is a question whether that is its chief mission. There is such an insistent call for trained men in various other forms of leadership in agriculture and country life that we cannot expect that all, or perhaps even a majority, of our graduates shall go directly to the farm. Apparently an increasing proportion of our graduates are going directly to the farm simply because they are beginning to find that they can be just as successful there as anywhere else, and because they like the independence of the farmer's life.

To put the matter in a nutshell, agriculture is broadening so rapidly, the need for trained men is developing so many new vocations, that if our college, in its research, in its teaching, in its extension work is to cover *adequately* the whole field of modern agriculture, it has a work to do which will tax to the utmost the skill of its faculty and the willingness of the Legislature to make appropriations. From the standpoint of public finance and policy, then, as well as from the standpoint of interior purpose and fundamental function, we must insist that the *Massachusetts* Agricultural College shall always be the Massachusetts *Agricultural* College.

4. Our people must also understand, and this is particularly true of the Legislature, that the Massachusetts Agricultural College is "a college of the Commonwealth." Its property is owned by the Commonwealth; its support has always come solely from the Commonwealth or the nation; its trustees are appointed by the Governor of the Commonwealth; it is answerable for its finances and its policies directly to the representatives of the Commonwealth; indeed, for all practical purposes its trustees are the agents of the Commonwealth. It is not a private institution. It has a public function. It grows only as public support for it grows. It is absolutely dependent upon the pleasure of the Commonwealth, or, if you please, upon the Legislature. We stand or we fall in accordance with the will of the people of the State.

I am sometimes asked why private individuals do not make endowments or gifts for the college. I suppose it is because of the fact just mentioned, that we are a college of the Commonwealth. I hope the time may come, however, when people of means will appreciate the tremendously significant problem which the college is set to solve, and the great difficulty of even a wealthy State like Massachusetts providing all the needs that arise in the development of an institution of growing numbers and importance. We have not only the problem of maintenance, but the problem of adequate buildings. At present we are dependent entirely upon the village of Amherst for the housing of the students. It is a serious question how far we may call upon the State to provide dormitories, not because it is not a legitimate call, but because we need other things. I wish it might be possible for dormitories to be built as the result of private gifts. There are many other uses to which private gifts could be put, and I hope that people who are interested in the development of the agricultural industry and rural life in Massachusetts can come to see that State support for the college may well be supplemented by private gifts for many good causes that are likely to be overlooked by the Legislature.

Statement of Purpose of the College.

In the light of these observations, can we state in one sentence the real purpose and function of the college? May we not put it this way? The *Massachusetts Agricultural College is designed primarily to benefit the agriculture and rural life of Massachusetts, and incidentally that of the nation.* It is often said that Massachusetts is not an agricultural State, and it is perfectly true. But agriculture is, nevertheless, an important and significant industry, and the cities are coming to realize that its development means something for them as well as for the farmers. The farmers themselves are beginning to see that the more intensive forms of agriculture are the ones that pay the best, and it does not take much of a prophet to suggest that the characteristic feature of Massachusetts agriculture of the future is that it is to be an intensive agriculture. Now an intensive agriculture always means education. While the industry in Massachusetts may be relatively small, it is also relatively important, and calls for the very best type of agricultural education that American genius can evolve. Moreover, an effort to help Massachusetts agriculture must be designed to result not only in better farming, but in a more efficient distribution of soil products to consumers, as well as in better conditions of living, and in better rural communities. Now whatever an educational institution of college grade can do for such objects as these comprises the task of our college. Probably in practice it is a varying task, — one thing to-day, another thing to-morrow. But the one main purpose is expressed in the thought that the college is the organ, or servant, of the Commonwealth on behalf of Massachusetts agriculture and country life. "I serve" should be its motto; and this thought of service to the rural interests of Massachusetts and the nation should govern the policies of the college and pervade its atmosphere.

How the Mission of the College may be achieved.

It will be necessary to leave for discussion in subsequent reports the details of methods by which this general function of the college may be realized. Space must be given here, however, to an outline of these methods, for they illustrate and enforce the main thesis or contention of this study.

There are three main types of service which the college may render: —

1. Investigation.
2. Instruction.
3. Extension service.

Investigation may be called the search for truth about agriculture and rural affairs; instruction, the incarnation of this truth in trained leadership; extension service, the dissemination or democratization of this truth, — its distribution among all the people interested.

Thus the college has a threefold task; not three tasks, but one task, to be fulfilled in these three fairly distinct methods or types of work. Let us discuss each one of these with as much brevity as possible.

Of course the characteristic work of this college, as of any college, is to teach the students who resort to it. But it is peculiarly true of an agricultural college that it cannot teach until it has something to teach. Hence, logically, the first business of the college is to investigate. It seems best, therefore, to place research first in the order of present discussion.

Investigation.

There are laws governing the operations of soil and the growth of plants and animals. Experience and observation enable men to follow these laws to a degree, — but only to a degree. Few farmers have time for prolonged or systematic study or the training or facilities for it. Men must be set apart for this work, — men specially trained, with time and apparatus. Thus the agricultural experiment station came into being. This work of investigation divides itself into several types as follows: —

1. *Research.* — This is a study of the fundamental laws that underlie the operations of the soil and the growth of plants and animals. The aim of research in agriculture is to gain exact knowledge of general principles that may be applied to the business of growing food and other supplies coming from the soil.

2. *Experimentation.* — Once the general principles or laws are discovered, the method of their application to actual operations must be worked out. Expert farmers will accomplish a good deal of this experimentation, but not all of it. Hence, the college, through its experiment station, must continuously carry on these experiments.

3. *An Agricultural Survey.* — We now recognize the need of knowing not only the general laws of nature and their applications to methods of culture, but that each farmer needs to know how to make the application under his peculiar conditions of soil, climate, topography, market and transportation facilities, etc. It may be argued that it is not the business of the State to tell each farmer how to run his farm. That is true. But so long as there are unsolved problems lying before our farmers, which can be solved only in the light of the knowledge which the average farmer cannot gain for himself, then the college must help. We must remember that we are rapidly coming to a time when each acre of Massachusetts soil must be put to its best possible use, and the only satisfactory way of determining this best possible use is by experience based on scientific study of the conditions of that acre. Now, for want of a better term, we call the search for truth about these exterior and local conditions that surround the farmer at his work an "agricultural survey."

4. *The Economic Phase.* — Another need enters at this point

that calls for an enlargement of the scope of agricultural investigation. Production of crops and animals is only a hemisphere of the agricultural industry. These products are to be sold at a profit, if possible. At any rate, they are to be transported with economy and distributed where they are wanted, and the consumer must have them fresh and wholesome and at a price not prohibitive. Many factors enter into this problem of distributing the products once grown: the nearness to market, transportation, the character of the market, competition for the market, the function and rewards of the middlemen, the development of agricultural credit, business co-operation among farmers, etc. These economic considerations, just because they are vital to the success of agriculture, are a subject for thorough investigation by the agricultural college.

5. *The Social Phase.* — But, after all, there is an even larger issue. Our greatest concern is with the quality of people developed by the rural mode of living. Hence, the conditions of rural life — moral, religious, recreational, sociable — are of significance. So with the institutions of the rural community, — schools, churches, organizations, means of communication, — how do they do their work, how can they be improved? Just because these things, too, are vital to the welfare of the Commonwealth, they must be studied.

Instruction.

We may now consider the methods by which the instruction of the college shall minister to its chief purpose. There are three main outcomes to be cherished in the course of study, and I state them in inverse order with respect to human destinies, but in direct order with respect to immediate purposes and policies. They are, first, preparation for the agricultural vocations; second, preparation for citizenship, particularly rural citizenship; third, the all-round development of the man.

Preparation for the Agricultural Vocations. — This is the immediate business of the college on the teaching side. The courses of study, the methods of teaching, the atmosphere of the institution, should all make for this end. The term "agricultural vocations" is, perhaps, somewhat misleading, but must answer until we find a better one. It is not the same as farming. The term does not imply that all of these vocations are pursued in the open country, but it includes those vocations the adequate preparation for which must embrace a thorough study of the soil, or of plants, or of animals, for the purpose of using that knowledge for economic ends; and also the vocations of a professional character which have to do directly with the life of the rural people. The men called for in these agricultural vocations may be grouped roughly as follows: —

(*a*) Independent farmers.

(*b*) Farming experts or managers.

(*c*) Specialists in agricultural practice or science, such as teachers and investigators and extension workers, employed in agricultural colleges, experiment stations, the United States Department of Agriculture, etc.

(*d*) Professional experts, such as landscape gardeners, foresters, and arboriculturists, who deal so intimately with agricultural materials that, although their vocations are not essentially rural vocations, the best training is found in connection with the agricultural teaching.

(*e*) Business experts in lines related to agriculture, such as the fertilizer business.

(*f*) Rural social engineering, that is, professions in which social service to the rural people is the keynote, such as teachers in agricultural high schools, country clergymen, rural Y. M. C. A. secretaries, etc.

It must be understood that this is only a rough grouping and, indeed, a tentative list. New vocations are developing constantly. Institutions other than agricultural colleges are taking on some of these lines of work. But in general this division indicates our goal; namely, that of the definite preparation of men for these fields of work.

Training for Citizenship. — The most efficient service to society which can be rendered by most men is the honorable pursuit of a useful vocation, and it becomes the fundamental task of the agricultural college to inspire its graduates with the thought that they are to follow their chosen vocation, not primarily as a means of making money, but primarily as a means of service to society. This may sound theoretical and academic, but it is sound sociology, sound pedagogy, sound ethics, sound religion.

Nevertheless, each individual has obligations to the community that lie outside his vocation. No matter how isolated his life may be, nor how busily he may be engaged in the exacting duties of his vocation, he is obliged by many considerations, not the least of which is his education at State expense, to give an intelligent and honest account of himself as a member of society, as a political citizen. It hardly needs arguing that the man who in college gives some attention to the problems of citizenship is thereby the better fitted to fulfil his obligations as a citizen. This is particularly true of those problems that have to do with local community life, — things that many college men regard as beneath them and of small consequence, and yet which are absolutely vital to the permanence of society. It is especially incumbent upon the man who follows his vocation in a rural environment that he shall understand the peculiar needs of the rural community as well as those larger general needs which incorporate themselves in State and national policies. The agricultural college, therefore, must try to make sure that every graduate has secured some grip both upon the problems of the rural community and upon the general problems of the day, — problems social, economic, governmental, ethical.

The Man himself. — Without question, the man must be greater than his work and perhaps even greater than his citizenship. But I think we have not yet sufficiently realized the possibilities of vocation in the making of a man, and hence we have not realized the culture-value of the training for vocation. As a matter of fact, those qualities of mind and character that we like to think of as belonging to the superior man, such as sound physical health, intellectual vigor, ripe culture, high ideals and noble thinking are cultivated, in no small degree, by the right sort of pursuit of the day's work and by the right sort of service to one's family, neighborhood, town, State and nation. I believe, therefore, that whenever we have organized our agricultural vocational courses in the proper way, whenever the materials of study in those courses have been adequately elaborated, and assuming that all the subjects are properly taught, we will find that the man thus trained, granted that he has within him the seeds of culture, will become a cultivated, well-rounded man.

More than knowledge of problems, greater than an interest in politics, is the *spirit* of community service, the willingness to sacrifice something of one's financial gains, of one's time and energy and leisure and comfort for the sake of leading one's community on to higher levels; for the sake of solving its problems.

An agricultural college cannot give its chief attention to the training of men for the utilization of their leisure. Leisure is important, even vital, to the ripening of a man's powers, but leisure is not the characteristic attitude of a leader, and that is what colleges are for primarily, — to train leaders. An agricultural college must train for efficient work and public service and not for leisure. Yet there is no reason why the men who follow the agricultural vocations may not have leisure. They must have it. Leisure feeds the highest impulses of the soul. Leisure is essential to the enlargement of the spirit. An agricultural college should have teachers and offer courses, and require men to take those courses, that will tend to give the individual student, no matter what his vocation, some grasp of the eternal verities, some hold on the essential things of life, some knowledge of the sources of personal power, great inspiration, a grip on the problems of human duty and human destiny. This may be secured through literature, or through philosophy, or through history; but we cannot afford to give the baccalaureate degree to any man who has not at least opened the door and peered into that high-vaulted chamber which contains the choicest treasures of human thought and aspiration.

The Extension Service.

We come now to the third phase of the task of the college, — the dissemination of truth to all the people of the State. This task, perhaps, raises issues. There are those who deny that it is a primary function of an agricultural college. Some are willing to admit that the experiment station should send out bulletins describing its work and results, and that occasionally a professor should give a public lecture, but deny the task which is represented by the apt phrase of one of our own trustees, "the State is our class room." With respect to agriculture and rural matters the State of Massachusetts *is* our class room. I hold that the function of extension service on the part of the agricultural college is coordinate with its function of investigation and of teaching resident students, and the reason lies less in any logical formula than it does in a practical need and a practical means of meeting that need. What I mean is this: the ultimate purpose of the agricultural college is the benefit of the agriculture of the State. One means of benefit is investigation; another is by training leaders; but another, and, in some respects, the most important, is by reaching with information and inspiration every worker in the land. It is the logical outcome of the social, or State, function of the institution.

There are those who will say, "Very well, we admit the significance of the task but let the work be done by some other agency than the agricultural college." I reply, why *should* it be done by some other agency than the agricultural college? It is the one institution that investigates and discovers principles and facts about agriculture. It is the one institution that is training leaders and experts. It is the one institution to which the people of the State look for educational leadership in agriculture.

But there is a positive and very practical reason why the agricultural college should develop extension teaching. If that teaching is developed by any other agency in the State, it necessarily means duplication of agencies, because the kinds of teaching needed by the great masses of the people of the State are the kinds of teaching that are given in the college, and it would be unbusinesslike, uneconomic, and would lead to friction if a second institution should be developed with a large corps of workers specifically for the purpose of popular education in agriculture, but apart from the research, the teaching, the atmosphere and the inspiration of the agricultural college.

There are other minor reasons why the extension service should become organic in the agricultural college. It reacts on the research and teaching, bringing them into more intimate touch with the realities and the fundamental needs of agriculture and country life. It gives the institution that State-wide and social leadership which makes it the center of light and leading in agricultural affairs. The people themselves expect that the college shall distribute what it knows for the benefit of the people who cannot come to the college. The college has always done this sort of work to a degree, and its validity has never been questioned. Indeed, if the college were to deny its duty to perform this service, I venture the prediction that it would not be long before the people of the Commonwealth would refuse to support it. It is because they cherish the belief that the college exists to serve them directly and immediately, as well as through the training of a comparatively few individual leaders, that they are willing to pour out money in its behalf.

Obviously this extension service should be so organized that it shall not interfere with the work of research or of teaching. Temporarily, because of lack of men, it may have this bad effect, but this is only a passing phase and can be remedied as soon as we have adequate appropriations and can develop what shall practically be an extension service faculty.

The Relationships of the College.

This discussion of the fundamental task of the Massachusetts Agricultural College leads to some observations concerning its relationship to other institutions of the Commonwealth which have tasks of a somewhat similar character.

The Public School System.

If this were a State university of long standing it would without doubt be considered the crown of the public-school system. It is not a university, but a college for a specific purpose. Nevertheless, in so far as that purpose is germane to the general educational interests of the Commonwealth, to that extent the college finds its place in the system. For practical purposes this may not mean a great deal. The fact, however, ought to be generally recognized, particularly by the school authorities of the Commonwealth. On the part of the college this fact requires that our entrance requirements shall be of such a character that they fit as closely as possible the actual high school conditions that prevail in the major portion of the high schools. It may be remarked in this connection that there is no sound reason why, as is sometimes suggested, this college should fit itself to the smaller or to the less efficient high schools. Its obligation, rather, is to the great body of high school pupils. We have tried to carry out this principle, and the present entrance requirements were not adopted until they had been submitted to all the high school principals of the State, and a number of suggestions made by these principals were incorporated.

Relation to the Teaching of Agriculture in the Public High Schools.

The Commonwealth has embarked upon a plan of developing, in systematic fashion, the teaching of agriculture in agricultural departments of public high schools, or in separate agricultural high schools or in both. It is evident that the task of administering the new plan lies wholly with the State Board of Education. On the other hand, the work of preparing teachers of agriculture must lie chiefly with the agricultural college, with, possibly, some co-operation from the normal schools of the State. This division of responsibility seems to be so clear that there is little need for enlarging on the principles thus laid down. There are, however, two phases of the situation that call for remark. There is a great deal that can be done in the way of agricultural education with young people still of school age and with the teachers, particularly the grade teachers, who are endeavoring to develop school garden work or some other form of elementary agricultural teaching. This is one feature of agricultural college extension teaching. In some States this work has been done by the State department of education, but it seems to me so clearly an extension-teaching function that I believe it ought to be developed by the State college of agriculture. For illustration, under the direction of Professor Hart some 19,000 boys and girls, during the season of 1911, grew corn and potatoes under the direction of the college. We do not claim that this work is as yet thoroughly organized; indeed, only a beginning has been made, but it ought to be encouraged and developed by the college, of course with the approval of the State educational authorities.

The other matter has to do with the general scheme for agricultural education in the public schools. The State Board of Education must take the responsibility for this plan because it is to administer it, but the ultimate plan itself ought to be the product of a very closely knit co-operative study, especially as it is pioneer work and there are so few American precedents to guide us.

Relationship to the Normal Schools.

The extent to which the agricultural college and the normal schools may co-operate seems to be uncertain. The normal school stands essentially for training in principles of education and methods of teaching. The agricultural college stands primarily for the organization of the materials of agricultural education. Teachers of agriculture in high schools and special schools are clearly to be sought in the agricultural college. There would seem to be a call, also, for men trained in normal schools, who take a year or two at the agricultural college for positions in agricultural teaching of high school grade. It is doubtful whether many grade teachers who are endeavoring to give some agricultural work will take regular courses at the agricultural college. The attendance at our summer school of agriculture, however, seems to show that these teachers desire to supplement their normal school training with the more technical studies that are offered by the agricultural college.

Relationship to the State Board of Agriculture.

During the past five years there has existed some slight misunderstanding as to certain relationships between the Board of Agriculture and the college. I think that this relationship is working itself out, and that a clearer understanding is already evident. I should like, in some future report or in some other public way, to discuss this matter more at length, but at this time merely suggest a valid general principle, which, if applied, would solve all our difficulties with respect to possible duplication of work. To put the matter in a word, I believe that the chief function of the agricultural college is educational and that the chief function of the Board of Agriculture is administrative. It is true that in the earlier days the Board of Agriculture had educational functions, but that was before the day of the agricultural college, or at least before facilities for widespread popular education by the college were developed. New conditions bring new work. Can we not, therefore, make this general principle our starting point for the enlargement, without any conflict or overlapping, of the work of both the Board of Agriculture and the college; namely, that administrative work, police work and control work belong primarily to the Board of Agriculture, and educational work belongs primarily to the agricultural college?

It may be thought that all this means the limitation of the work of the Board of Agriculture. I do not think so. All indications point to the fact that the government is going to play an increasingly larger share in our agricultural progress. The State government, therefore, through a board or department of agriculture, is sure to develop increasingly important and diverse functions. The administration of laws for the protection of the farmer, the offering of prizes and other means of stimulating agriculture and leadership, assistance by the State in solving such problems as the farm labor question, in developing schemes for business co-operation, and in other enterprises in which the government of the State is willing to play a part, belong not to the educational but to the administrative agency. On the other hand, wherever teaching is to be done, information to be given or educational forces to be invoked on behalf of the farmers, it would seem clear that the agricultural college is the natural center for such dissemination.

Of course, there are chances for some overlapping, even under the application of this principle. For example, the dairy bureau in enforcing laws finds that one of the most powerful aids to enforcement is simply teaching the people what is the right way to do. Therefore, as an incident of law enforcement, some educational propaganda is legitimate and even necessary. On the other hand, the extension men of the college frequently find opportunity for the definite work of organizing new enterprises in country communities as the natural outgrowth of the extension teaching. But if the general principle is adhered to, I see no real difficulty with respect to these apparent exceptions.

There are at least two pieces of work, which have been in operation for a long time, that clearly contravene this principle as at present administered. The Massachusetts experiment station is charged with the duty of enforcing the laws concerning fertilizers and feedstuffs. On the other hand, the State Board of Agriculture is charged with the management of farmers' institutes. In the one case, the college, through its experiment station, takes on police duties; on the other hand, the Board of Agriculture carries on a definite educational work. It seems to me, however, that there is no need for any misunderstanding here. Both of these means of work have been established so long and have become so thoroughly rooted in the respective fields in which they were planted that good judgment would dictate they should not be disturbed, at least for the present.

This frank discussion has been introduced not so much because there is danger of serious misunderstanding, but because the agricultural movement is going ahead so fast that the more closely we can tie the work together, and the more clearly defined the task of each agency, the better results we will get for Massachusetts agriculture. The principle of division of labor seems so simple and so clear that I venture to suggest it at this time in the hope that it may work out into a generally accepted plan of co-operative endeavor.

In so far as the State, through any other agency such, for instance, as the State Board of Health, enters the field of agriculture or country life, the same principle would hold; namely, that the State Board should assume the administrative function and the college should exercise the educational function. I speak of this particularly because I believe that the time will come when the whole question of rural sanitation ought to be made a very important feature of our agricultural propaganda, and I should like to see the agricultural college play a definite part in this very important matter.

The Relationship of the College to Voluntary Associations.

The relationship of the college to voluntary associations designed to benefit agriculture and country life is, perhaps, of less interest as a matter of discussion, although it is of a great deal of importance practically. Take, for instance, the grange. The grange is very thoroughly a friend of the college, and we have made every effort to reciprocate by assisting the grange in its educational work whenever possible. The fundamental reason, however, for assisting the grange, or the village improvement society or any other local body is, that it is always sound policy for the college in its educational work to develop as little machinery as possible, and to seek to reach the people who need its help, whenever it can be done, through agencies already in operation. It is quite possible, for example, to work out a plan by which the grange and the college could co-operate in a very effective system of agricultural teaching, which would materially increase the efficiency of the college in reaching the people at their homes, and which would also manifold the educational work of the grange, this work being, of course, the dominant purpose of the grange.

In this connection I wish to call your attention to two remarkable actions recently taken by the Massachusetts State Grange. The grange has offered two scholarships in our winter school to successful contestants in the writing of essays on some agricultural topic. They are also taking steps to organize a large loan fund, from which loans may be made to young men and women belonging to the grange who have to pay their own way through college. While the benefits of this fund are not to be confined to students of the agricultural college, undoubtedly quite a proportion of these students will come to this college.

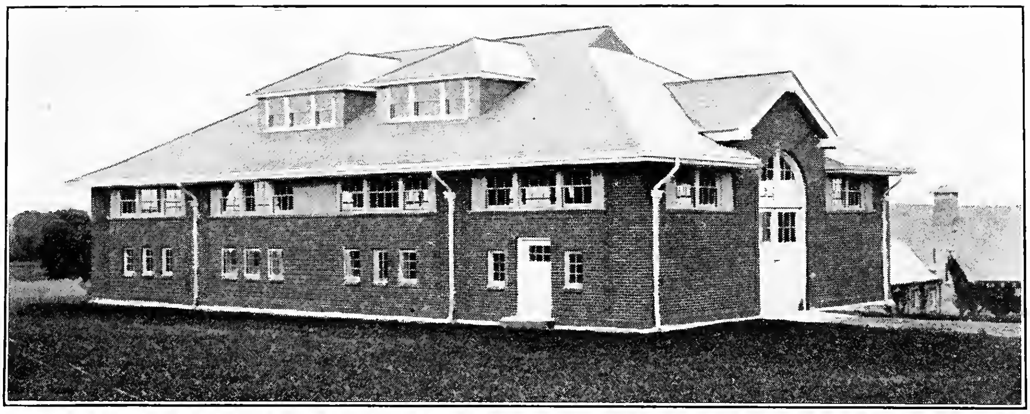
A REVIEW OF THE YEAR.

Attendance.

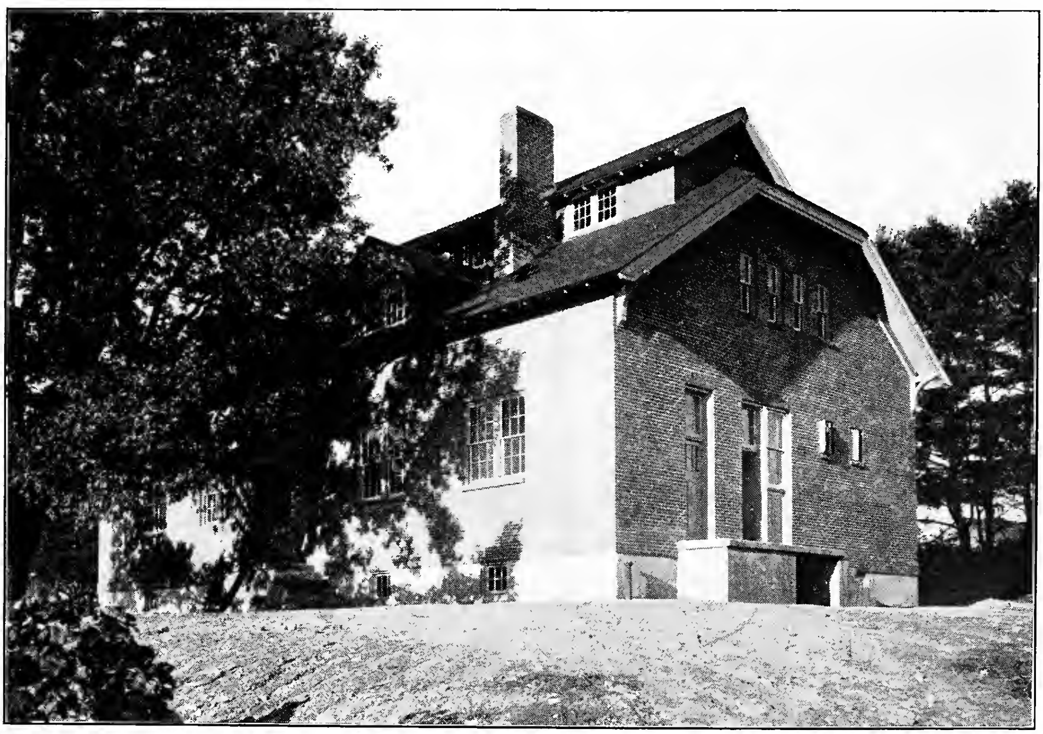
The attendance of students enrolled in the four-years course at this date is 477, an increase of 75 over the enrolment of a year ago. In addition to this enrolment of four-year men, there are 15 members of the graduate school and 29 students doing work of college grade, who are registered as unclassified students. Therefore, the total number of students doing work of college grade is 521 for the present year, a gain of 87 for the year. The entering class this fall numbered 168, an increase of 10 over the number entering last year. (See Table I.)

Nearly 87 per cent. of those entering this year come from Massachusetts; 5 other States send students and also 2 foreign nations. Every county in Massachusetts, with the exception of Nantucket, is represented in the present freshman class, Middlesex County sending the largest number, which is 36 or nearly 25 per cent. of the total number entering. (See Table V.)

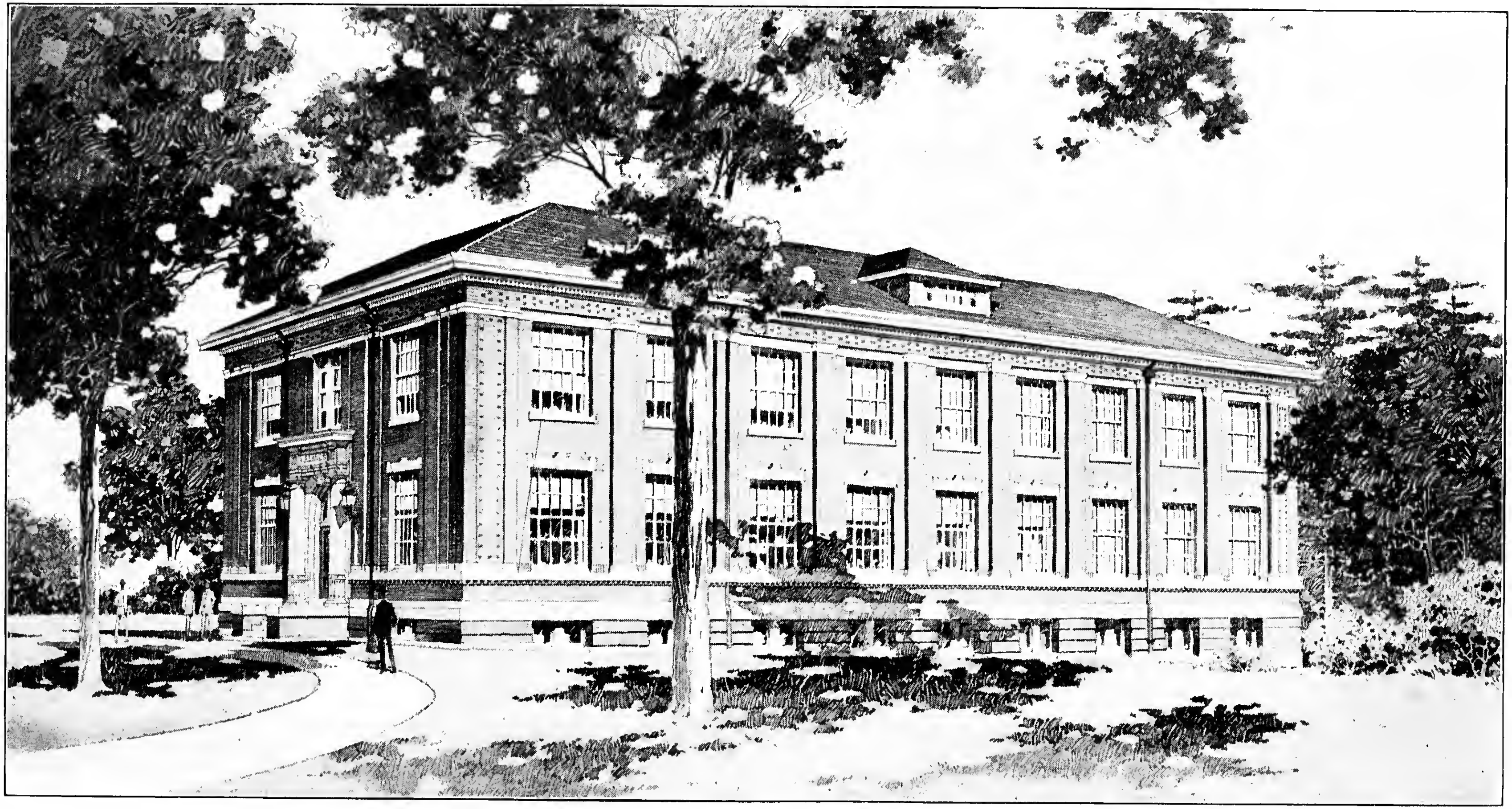
Over one-fifth of the class are undecided as to their intended vocation; approximately one-third of the entire class express their intention of following some line of professional agriculture or horticulture as their life work; and about two-fifths more signify their intention of entering some vocation in practical agriculture or horticulture. Nearly 94 per cent. of those having made a decision, therefore, intend to follow an agricultural vocation. Less than one-fourth of the fathers of the members of the freshman class are engaged in agriculture or horticulture, and a little over one-fourth are business men. Approximately one-fourth of the class come from farms, and nearly two-fifths have had no farm experience whatever. The average age of the entering class is 19.17 years. (See Table V.)



Stock Judging Pavilion, Grinnell Arena, erected in 1910–11.



Fruit Storage Building and Laboratory, erected in 1910–11.



THE FLINT LABORATORY, M. A. C. — Dairy Building.

Appropriations.

The trustees presented to the Legislature in 1911 requests for special appropriations amounting to $192,500; of this amount, $122,500 was granted. An increase of $90,000 in current annual appropriations was asked, and had this been granted the total income from the State for this purpose would have been $232,000; the increase granted, however, was $34,500, making the total for the present year $176,500. (See Table II.)

The most important item granted in the special appropriations was that of $75,000 for a dairy instruction building and laboratory. Following is a brief description of the building: —

The New Dairy Building.

The dairy building now under construction is to be known as the "Flint Laboratory," named in honor of the Hon. Charles L. Flint, fourth president of the Massachusetts Agricultural College. This building is the first of the proposed "agricultural group." The plan for this group makes a large agricultural building the central figure of the group, flanked by the dairy building on the west and a proposed farm mechanics' building on the east.

The dairy building will be 120 feet long, 62 feet wide, with a basement and two stories. The construction is "fireproof," being of reinforced concrete and brick with a slate and gravel roof. The partitions will be made of 4-inch terra-cotta blocks, with a hard cement plaster on each side. The finish will be smooth and sanitary. An 8-foot corridor will run the full length of the building on each floor. Large glass windows will be placed in the corridor walls so that the work being done in the different rooms can be seen to advantage from the corridor, without the visitors interfering in any way with the students.

The basement will contain a laundry, a locker room that will accommodate lockers for 150 men, a shower bath, a cheese manufacturing and a cheese curing room, storage rooms, and a dairy mechanics room, as well as a room with an artificial refrigerating plant. The refrigerating plant is designed to furnish refrigeration for the cold box or refrigerator, as well as to make artificial ice if desired.

The first floor will have two offices in the front, with the milk-handling laboratories back of them. A space 104 feet long by 24 feet wide on the north side of this floor will be given exclusively to the separating of milk, ripening of cream and making of dairy butter. On the south side will be found a complete market milk equipment, including a 16 by 16 foot refrigerator and a 27 by 24 foot ice cream manufacturing room. The refrigerator will be equipped in such a way that either artificial refrigeration or natural ice can be used.

The second floor will have an office and a department reading room. On this floor there will also be a dairy bacteriological laboratory that will accommodate 20 men at one time; a Babcock laboratory, 62 by 24 feet, that will accommodate 30 men; and a special feature in a dairy equipment museum, 57 by 24 feet, for which it is hoped a permanent exhibit of dairy apparatus may be obtained, as well as loans of "up-to-date" dairy appliances for exhibition during the time that the short-course students and farmers' week visitors are here. If this can be done the four-years men will have advantages along this line far above those ordinarily afforded.

This building is designed for instruction to meet Massachusetts dairy conditions, — market milk and farm dairy work. The laboratories will accommodate 100 men at one time if desired. This equipment, together with our certified milk equipment, which we will use even more in the future as a laboratory, will give the college, perhaps, the best college market milk equipment in the country.

Commencement.

The last annual commencement occurred June 21. At that time the college conferred the degree of B.Sc. on 43 men, the degree of M.Sc. on 2, and the degree of Ph.D. on 2. Eugene Davenport, dean of the College of Agriculture of the University of Illinois, gave the commencement address, taking for his subject, "The Agricultural College as a Public Service Institution." The attendance at the alumni dinner was 206, this being the largest number present on such an occasion in the history of the institution.

Summer School.

The registration in the summer school of 1911 was 153, a number considerably smaller than the registration of the preceding year. The comparatively small attendance was undoubtedly due to the fact that last summer the registration fee was raised from $1 to $5. Those attending the summer school, however, seemed to have come with serious and definite purposes, and, on the whole, the school was perhaps more satisfactory than those held in former years. Owing to lack of funds for enterprises of this sort, it has been decided to omit the summer school for 1912.

In connection with the last summer school there was held another conference of rural social workers. There were present at this conference about 250, representing the grange, the Y. M. C. A., the rural school, etc. In this connection there was also held an exhibit of rural social work, which was probably the first time that the exhibit idea had been applied to the sociological side of rural affairs on so large a scale. The usual course for rural clergymen was also included in the summer school.

The Winter School.

The attendance at the winter school of 1911 was 113. Previous to that the largest attendance had been 66. The poultry course, which was given during the last two weeks of the winter school, had a registration of 74. The winter school itself was concluded by a "farmers' week," which furnished a most admirable program and brought to the college 830 people, who came for a part or all of this four days' special instruction.

Tuition Fee.

The trustees have voted to require a tuition fee of nonresidents of the State registering for work of college grade. Beginning next September, therefore, such students will be charged a fee of $40 a year.

The Year in the Departments of Instruction.

In General. — During the year no radical changes have taken place in the method or scope of instruction. Perhaps the most significant improvement has come through the addition of a number of instructors in the required subjects of the freshman and sophomore years, made possible by the increased appropriations of one year ago. This has allowed the scheduling of relatively small sections. It is needless to say that, other things being equal, the teaching efficiency must be increased by this arrangement. A table is presented showing the numbers in the various sections of the required work of the freshman and sophomore years one year ago and the present semester.

	1910.	1911.
Sophomore class: —		
Enrolment,	110.0	127
Number of sections,	4.0	6
Average number in section,	27.5	21
Freshman class: —		
Enrolment,	158.0	168
Number of sections,	5.0	8
Average number in section,	31.6	21

In the Division of Agriculture. — The work in the division of agriculture has been strengthened materially during the year by the addition of the new men mentioned in another place in this report, and by the development of a number of new courses.

The new poultry department has been put on a sound footing; buildings have been erected and stock and equipment have been purchased. The demand for instruction in poultry husbandry, both by regular students of the institution and throughout the State, is very gratifying.

The work in animal husbandry has been considerably enlarged, and a new instructor taken on.

In the department of dairying much time has been devoted to the completion and perfection of plans for the new dairy instruction building.

The college farm has again shown an increase in sales without a corresponding increase in expenditure. It is the ambition of the division to make the farm entirely self-sustaining.

In the Division of Horticulture. — No important changes in the courses of study or teaching policy have been made during the year. Some changes in personnel are recorded in the statement regarding new appointments. Important plans are under way for additional experimental work, and interesting developments have been found in the plant breeding work. The greatest improvement in the physical equipment of the division has been the erection of the new cold-storage plant for use in the departments of pomology and market gardening.

In the Division of Science. — The various departments in the new division of science have been carried on without notable change, except with respect to the formal organization into a division.

The department of chemistry has been reorganized, and the research and teaching sides of chemistry are now under one head. The announced object of the department is (1) to give all students in the college a reasonable understanding of the general principles of chemistry in its application to agriculture; (2) to co-operate with other departments of the college so that students may have an understanding of chemistry in its particular relation to the other arts and sciences, such as agriculture, horticulture, botany, biology, entomology, etc.; and (3) to train students for positions as chemists in experiment stations, the United States Department of Agriculture, fertilizer and feed factories, in dairy work, sugar work and the like.

The department of entomology has completed one year of work in the new building, and finds the building excellently adapted to departmental needs. A new course in forest insects has proved popular, and additions to the teaching force have made possible a greater attention to graduate teaching.

The teaching force in the department of mathematics is now adequate to permit comparatively small sections and, in the judgment of the department, the efficiency of the freshman work has been thereby materially increased. The class in senior engineering is the largest ever taking that elective course since it was introduced.

The subject of physics has been given full departmental standing during the year, and justifies its place not only because of the importance of physics as a science in itself, but also because special emphasis is laid on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, and zoölogy, thus furnishing an extra tool by which the student's work in all these subjects may be made more effective.

The department of veterinary science has been enabled to develop the accessory work in bacteriology to a considerable degree on account of the addition of Dr. Gage to the teaching force.

In the Divisions of the Humanities and Rural Social Science. — The work in economics and sociology has been given prominence by the organization of a department, as is the case with rural sociology. Other than the addition of numerous courses in these two departments no radical changes have been made during the year.

The Graduate School.

During the parts of the two college years covered by this report, 24 persons registered as graduate students. Of these, 19 were candidates for advanced degrees, the others taking such subjects as they desired, whether graduate or undergraduate in grade. Two were given the Ph.D. degree, and 2 the M.Sc. degree, at the last commencement. Seven persons presented themselves for the first time for graduate work this fall, making, with former students still at work, a total of 18 graduate students this fall. Of these, 3 are not candidates for advanced degrees.

No new policies have been initiated, the temporary organization of the school being such as to render these inadvisable. Despite this, one change should be made. The school was originally organized when no divisions of the college were in existence, and some of the present divisions were only departments. New departments in those divisions have not been recognized by the trustees in connection with graduate work, and the professors in charge of those departments feel that, in consequence, they are not on the same plane with other departments, and are not inclined to take graduate students so long as this inequality obtains. This seriously hampers the success of the graduate school, and I, therefore, recommend for the consideration of the trustees the following action taken by the faculty committee on graduate school: —

Any department of the college, properly equipped and prepared to do so, may present to the committee on graduate school a full statement of the lines of work it is prepared to offer for graduate work, and on approval by the committee and endorsement by the trustees, such departments may be added to the list of those giving graduate courses, the rating of these courses as majors or minors for the degrees of M.Sc. or Ph.D. to be determined by the committee on graduate school.

The school is suffering at the present time from a lack of policies and advertising. A close, thorough organization of the work should be brought about; the scope of majors and minors determined more minutely; the latitude of choice of minors fixed; and the whole school pushed ahead more vigorously. I strongly recommend that steps be taken to give the school ample authority to develop in these and other directions.

The Experiment Station.

A number of minor changes in the station staff have taken place during the year, which are recorded in another part of this report. There has been one important building change; namely, the repairs and improvements at the station laboratory. The entire building has been renovated, the plumbing much improved, and heat from the central plant introduced; two new laboratory rooms have been provided for research work, and a large room set aside for library and reading purposes. These improvements furnish temporary relief from the overcrowded and inconvenient conditions hitherto prevailing. A substantial building has been erected on the college cranberry bog near Wareham, with sufficient capacity to handle the entire crop, and to furnish laboratory and living rooms, at a cost of about $2,100.

The following publications have been made during the year: —

Twenty-third annual report, 451 pages.

Bulletins: Inspection of commercial fertilizers, 76 pages. Inspection of commercial feedstuffs, 56 pages (No. 136). Inspection of commercial feedstuffs, 32 pages (No. 139). Rational use of lime, 20 pages. Tomato diseases, 32 pages. Meteorological bulletins, twelve, 4 pages each.

Circulars: Rules relative to testing dairy cows, 6 pages. The chemical analysis of soils, 4 pages. Balanced rations for dairy stock, 7 pages. Lime and sulphur solutions, 4 pages.

Additional publications: six papers printed in Part I. of the annual report, and one from Part II., have been published as separates.

The mailing list has been thoroughly revised in co-operation with every postmaster in the State. Many names dropped on account of death, removal, etc. Total number dropped, 1,110. New names added, 1,291. Lists at present: —

Residents of Massachusetts,	12,903
Residents of other States,	2,567
Residents of foreign countries,	242
Newspapers,	519
Libraries,	317
Exchanges,	142
Cranberry growers,	1,400
Beekeepers,	2,880
Meteorological,	583
Total,	21,553

A digest of the main lines of work for the year will be of general interest: —

No very fundamental changes have been made in lines of work in progress, but in many instances inquiries have been considerably broadened in scope. This is especially true of the cranberry investigations, in connection with which arrangements have been completed for meteorological observations in connection with the United States Weather Bureau. Color vision of the honey bee is a new subject taken up during the year.

Control Work. — The passage of a new fertilizer law has been secured. This becomes operative December 1. Fertilizer samples collected during the year, 1,061.

Feed Law. — A new feed law has been prepared which will be introduced in the Legislature this winter. Samples collected and examined duiing the year, 731.

Dairy Law. — A new dairy law prepared last year failed of enactment. It will be reintroduced.

The work of testing pure-bred cows continues to increase. It employs the entire time of two men, while from three to five men are needed during about five months every year.

Seed Work. — Purity tests, 62; germination tests, 355; samples separated, 138.

Results of the Lines of Work in the Experiment Station.

Although the report of the director of the station, printed as a separate document, should be referred to for all matters concerning details of the station work, it may not be out of place to recite some results which, in the opinion of the director, have been attained by the year's work and are of general public interest.

Alfalfa. — Both home and co-operative experiments in general, satisfactory. In interpreting significance of results it seems important to remember that the much better success than was obtained in earlier years may, perhaps, be connected with the comparatively small rainfall. Still, the outlook is regarded as hopeful.

Asparagus. — The substation work at Concord has made excellent progress in the direction of producing a rust-resistant variety.

In the fertilizer work it has been made very apparent that the tendency to rust has been reduced by such use of fertilizers (especially nitrate of soda) as is calculated to promote uniform steady growth.

Cranberry. — Crop of the year excellent and will sell for a total sum of about $4,800. This will leave in the neighborhood of $3,500 net proceeds above the cost of harvesting, packing, etc., which becomes available to help meet costs of experimental work.

Numerous important lines of experiment have been introduced. Among the more important are overhead sprinkling system in its relation to frosts, crop production, etc., fertilizer experiments; general investigation as to insects and relation of the honey bee to pollination.

Among the significant results of the year has been the demonstration of the great importance of the honey bee in insuring pollination.

General Results in the Department of Agriculture deserving Special Mention. — Demonstration that sulfate of potash is far superior to muriate as a source of potash for the raspberry and for alfalfa.

Demonstration that for the onion crop no combination of fertilizer employed in addition to stable manure at the rate of 30 tons per acre is beneficial.

Demonstration that for alfalfa and oats as a nurse crop the various forms of fine-ground bone and basic slag meal are superior to fine-ground rock phosphates as sources of phosphoric acid.

Remarkable improvement in the character of pasture sod, and great increase in production of feed as result of top-dressing with moderate amounts of slag meal and double sulfate of potash magnesia.

Results in the Chemical Department. — Experimental and research work considerably hindered by repairs in progress, and none of the subjects which engaged special attention has been brought to a conclusion.

Results in the Horticultural Department. — Careful study as to the climatic adaptations of apple varieties has been completed. This work shows the great importance of exact climatic adaptation and the meteorological principles upon which this depends. It will have an important practical application in fruit growing.

Results in the Veterinary Department. — Experiments in feeding milk from tuberculous cows to calves and young stock have been completed. None of the animals contracted tuberculosis.

The Extension Service.

The extension service has had two full years of operation. It is needless to say that I regard this phase of our college activities as of the utmost consequence, directly to the Commonwealth and indirectly and incidentally to the college itself. I hope in a future report to discuss at some length the problem of an adequate extension service on behalf of Massachusetts agriculture and rural life. I now recommend that you authorize the publication of a fairly full report of the work of the past two years as a separate document. In the hope that this may be done, I will here simply call attention to a table of statistics of the extension activities printed as Table III. in another part of this report, and to a brief statement of results that I believe it is fair to credit to the work thus far accomplished.

What the Extension Service has accomplished.

1. It has systematized the scattered work heretofore done by the several members of the faculty.

2. Through the various short courses thorough instruction has been given to several hundred people who could come to the college for but a short time.

3. Through the lectures, demonstrations, demonstration or-

chards, dairy improvement associations, traveling libraries, and personal visits to farms, trains, fair exhibits, extension schools and other similar activities, reliable information has been carried to thousands who could not come to the college for it.

4. Through the correspondence courses men and women have been able to pursue systematic study and still attend to business or professional duties.

5. By means of the summer school and the conference for rural social workers, teachers, clergymen and others concerned in building up the educational and social life of rural regions have obtained a new conception of the function of the various organizations in the community, and the part they may play in community betterment. Many communities have taken on new life due chiefly to the inspiration received by some person at the summer conference. This influence has by no means been confined to Amherst or to Massachusetts.

6. Agriculture, in the broader sense, in this State, has received much stimulation at the hands of the faculty, through the several extension activities.

7. Through the extension service the equipment of the college and the knowledge possessed by the experts on the faculty are made more useful to the citizens of the State who support the college.

8. Through the extension service the college becomes more nearly a "public service institution." It gives men and women who come to it a useful and practical education, which will fit them for the several pursuits and professions of life. It carries on experiments and research work to determine facts which later can be used for the education of students and in the upbuilding of the agriculture of the State. But more than this, the college is prepared, through its extension service, to carry the teachings of the college and the results of the work of the experiment station, by means of men especially trained for the task, to every community that asks for these helps.

New Appointments.

The following appointments took effect during the winter of 1911: —

John Allan McLean was elected associate professor of animal husbandry to fill the position made vacant by the resignation of Mr. Ray L. Gribben, as instructor in the same subject. Professor McLean is a graduate of McMaster University, Toronto, Can., in 1902, and from the Iowa State College in 1905. The five years subsequent to his graduation from Iowa State College he devoted to teaching, occupying positions at the agricultural colleges of Colorado, Iowa and Mississippi.

John C. Graham was elected associate professor of poultry husbandry. For fourteen years Professor Graham was principal of the high school in Oshkosh, Wis.; in the winter of 1911 he received the degree of B.S.Agr. from the University of Wisconsin.

Guy C. Crampton was appointed associate professor of entomology. Dr. Crampton is a graduate of Princeton University in 1904, received the degree of A.M. at Cornell University, and the degree of Ph.D. after two years' study in Germany. He has taught several years with marked success.

The following appointments took effect September 1: —

Robert J. Sprague was appointed head of the division of the humanities and professor of economics and sociology. Dr. Sprague graduated from Boston University in 1897. He subsequently pursued graduate work at that institution, receiving the degree of A.M. in 1899 and Ph.D. in 1901; he also received the degree of A.M. from Harvard University in 1900. He has had a wide experience in teaching, and has studied, worked or traveled in Germany, Italy, Canada and the British Islands. For five years prior to his appointment here he was professor of economics and sociology at the University of Maine.

Edward M. Lewis was appointed assistant professor of English and assistant dean. Professor Lewis graduated from Williams College in 1896. Subsequently he studied at Harvard University. He received the degree of A.M. from his alma mater in 1899. Two years later he received a diploma from the Boston School of Expression. He taught elocution at Columbia University for two years, and for the past eight years has taught public speaking and oratory at Williams College. For some years, also, he has taught public speaking at Yale Divinity School.

Curry S. Hicks was appointed assistant professor of physical education and hygiene to fill the vacancy caused by the resignation of Dr. Percy L. Reynolds. Professor Hicks graduated from the Michigan State Normal College in 1908. Later he studied physical education at Amherst College, and last year was employed at the Michigan State Normal College as director of athletics and physical examiner.

Charles A. Peters, a graduate of Massachusetts Agricultural College in the class of 1897, was elected assistant professor of inorganic and soil chemistry. Dr. Peters has studied chemistry in Germany, also at Yale University, having earned the degree of Ph.D. in that subject; he has had a wide and successful experience in teaching, having been employed for several years at the University of Idaho.

Frederick L. Yeaw, a graduate of Massachusetts Agricultural College, in the class of 1905, was elected assistant professor of market gardening to take the place of Mr. Charles S. Heller who resigned in the summer. Professor Yeaw has been for five years employed as plant pathologist for the experiment station of the University of California, having had charge of the sub-station located at Davis.

George E. Gage was appointed assistant professor of animal pathology. Unique and full training in bacteriology and physiology fits Dr. Gage for this work. He had been engaged for some time by the experiment station of Maryland.

Dean George F. Mills returned to his college duties in September, after a leave of absence of one year.

Professor S. Francis Howard is on a leave of absence this year, and is spending the time in graduate study in chemistry at Johns Hopkins University.

In August Professor Frederick B. McKay resigned as assistant professor of English and public speaking. This position is being filled by Mr. Howard deF. Widger, a graduate of Yale University in 1910. Mr. Widger spent last year at Columbia University Law School.

An assistant director of extension work was appointed in June, Earnest D. Waid being elected to that position. Mr. Waid graduated from the Ohio State College in 1906, and since that time has been engaged in extension work in Maine and Ohio.

Albert R. Jenks, a graduate of Massachusetts Agricultural College in 1911, has been elected supervisor of correspondence courses in the extension service.

In the early spring Charles J. Robinson, extension instructor in dairying and animal husbandry, resigned. His position has been filled by the appointment of George F. E. Story, a graduate of Ohio State University in 1910.

Charles H. White, formerly connected with the extension service as field agent, was made district field agent for Worcester County, with headquarters at North Uxbridge.

New Instructors and Assistants.

The following instructors also became connected with the teaching force September 1: —

Position.	Name.	Institution from which graduated, and Degrees.	Year.
Instructor in physics, . .	Charles A. Butman, .	Massachusetts Institute of Technology; three years' graduate work at Clark and Yale Universities.	1908
Instructor in English, .	Willard A. Wattles, . .	University of Kansas, M.A.,	1911
Instructor in French, . .	William L. Harmount, .	Yale University, . .	1903
Instructor in German, .	Arthur N. Julian, . .	Northwestern University, .	1907
Instructor in animal husbandry.	Elvin L. Quaife, . .	Iowa State College, B.Sc. Agr.	1911
Instructor in mathematics,	William L. Machmer, .	Franklin and Marshall, M.A.,	1911
Instructor in landscape gardening.	Arthur K. Harrison, .	Associated with Mr. Manning.	
Assistant in mathematics and in military science.	Samuel R. Parsons, .	Massachusetts Agricultural College, B.Sc.	1911
Assistant in botany, . .	Frederick A. McLaughlin,	Massachusetts Agricultural College, B.Sc.	1911
Assistant in agronomy and secretary to director of experiment station.	Herbert J. Baker, . .	Massachusetts Agricultural College, B.Sc.	1911
Assistant in chemistry, .	Harold S. Adams, . .	Williams College, A.B., .	1911

Rudolf W. Ruprecht, a graduate of the Rhode Island State College in 1911, is filling the additional position of assistant chemist in the experiment station, made necessary by the increased amount of work to be done in connection with the collection and analysis of fertilizers.

Sumner C. Brooks resigned as assistant in botany in the experiment station, and this position is being filled by Edward

A. Larrabee, who graduated from Massachusetts Agricultural College in 1911.

Just prior to Nov. 30, 1911, Joseph F. Merrill and Clement L. Perkins, assistants in the department of plant and animal chemistry of the experiment station, resigned to accept more lucrative positions elsewhere. Their successors have not yet been appointed.

Changes in Title of Officers of the Institution.

Name.	Former Title.	Present Title.
Edgar L. Ashley,	Instructor in German,	Assistant professor of German.
Joseph S. Chamberlain,	Associate professor of chemistry,	Associate professor of organic and agricultural chemistry.
Elmer K. Eyerly,	Assistant professor of political science and lecturer in rural sociology.	Associate professor of rural sociology.
Philip B. Hasbrouck,	Registrar of the college, associate professor of mathematics, and adjunct professor of physics.	Professor of physics and registrar of the college.
Joseph B. Lindsey,	- - -	Goessmann professor of agricultural chemistry.
Anderson A. Mackimmie,	Instructor in French,	Assistant professor of French.
George F. Mills,	Dean of the college, head of the division of the humanities, and professor of languages and literature.	Dean of the college, professor of languages and literature.
Charles Wellington,	Professor of general and agricultural chemistry.	Professor of chemistry.

New Administrative Organization.

By vote of the trustees at the June meeting the various departments of the college already organized, together with several others organized by the same action, were grouped into divisions. Each division has a head who acts as general administrative officer with more or less control over general policies, the extent of this control depending very largely upon the extent of the business transactions of the division. The head of the division of science is denominated the chairman of the division, and is appointed for two years on nomination by the heads of the departments in the division. The general departments of library, military science, and physical education are responsible directly to the president of the college, who for the present also retains the headship of the division of rural social science.

The original argument for developing this form of administrative organization lay in the fact that it was necessary to differentiate the departments of agriculture and horticulture into numerous departments. The question immediately arose, shall these departments be absolutely unrelated, or shall they be closely correlated? Obviously, groups of departments which in one case — horticulture — represent annual sales of $7,000, and in another case — agriculture — annual sales approaching $25,000, can best be handled by one administrative officer. The division idea, therefore, suggested itself as the solution of this problem. There are other forms of correlation, however, that are important, especially with respect to instruction. As the college grows it is evident that it will become more and more difficult for many problems to be discussed in general faculty meetings, particularly where those problems are of a character to interest special groups of men. The logical thing, therefore, seemed to be to organize the entire institution on the division basis. So far as possible, administrative details will be handled by the respective heads of divisions, in order that the instructors may give the larger share of their time and energy to the teaching work.

An important use of this new form of administrative organization has developed through the occasional convening of the various administrative officers, in an informal and unofficial way, as a sort of "cabinet" to the president for the discussion of general administrative questions.

It is intended that each department shall retain departmental integrity, and if the division system after a term of years is found not to meet the needs of the situation it can easily be abandoned.

Organization of Types of Work.

In the discussion of the mission of the college, I referred to the threefold division of our work as to types, — research, instruction and extension service. In this institution the instruction may be divided into two main groups, — the undergraduate instruction and the graduate school. These four types of work also find their appropriate administrative organization under the administrative leadership of "directors," as follows: —

The dean of the college is the director of the undergraduate work or instruction so far as it applies to the relation of students to the work of the institution. At present the general questions of courses of study and methods of instruction are handled through a faculty committee.

The director of the experiment station is the director of all the research work of the institution, although for present purposes the agricultural survey is placed under the general charge of the extension service.

The director of the graduate school has general charge of the graduate teaching.

The director of the extension service is charged with the duty of developing the exterior activities of the institution.

The development of this general plan, and particularly the enlargement of the extension service, brings up a very important detail in the problem of administrative organization. Shall the extension service be organized as a separate faculty, or shall it be closely knit with the departmental organization of the institution? The plan which I strongly advocate is that of making each college-teaching department an administrative unit for all types of work. Theoretically, then, each department of the institution will have, or at least may have, four outlets for its energies: first, teaching of undergraduate students; second, teaching of graduate students; third, research and survey work; fourth, exterior teaching, or extension service. If the department is officered by only one or two men, manifestly either some types of work will be neglected or each man will be required to perform two or more types. As soon as a department, however, attains sufficient size to require the services of a large number of men, it is highly important that each man be employed for the specific purpose of giving the larger share of his time to some one type of work. What might be called a model department would have at least one man giving the bulk of his time to research, another to instruction of undergraduate students, another to the extension service. Of course, the number of men will depend upon the kind of work in the department, the resources of the college, and the demands of students and farmers generally for this special sort of work. I regard it as desirable that each man in the department should give a little time to some other work than that which represents his chief interest; for instance, that the research man in every department should give at least one teaching course, preferably to advanced undergraduates or graduate students. If he can lecture occasionally to bodies of farmers, so much the better; but his time and energy should not be too much divided among many interests. So I think that every instructor ought to be given time and opportunity for at least minor pieces of research, and if his subject reaches the popular need, should be called upon occasionally for extension service. It is, perhaps, rather difficult for the extension man to find opportunities for research or for regular instruction in the college, although he may assist in the short-course work. Under this scheme the head of a given department may unify all the types of work that belong to the subject matter of his department. There is the objection, of course, that this is a rather complex organization, but it seems to be the only logical outcome of the desire to organize an institution like ours on a businesslike administrative basis.

The Administrative Officers.

The following is the schedule of the present administrative organization of the institution: —

The president.
The dean of the college.
The director of the experiment station.
The director of the graduate school.
The director of the extension service.
The registrar.
The treasurer.
The head of the division of agriculture.
The head of the division of horticulture.
The chairman of the division of science.
The head of the division of the humanities.
The head of the division of rural social science.
The assistant dean.

The following is the schedule of —

Organization for Teaching Purposes.

Classification.	Incumbent.	Academic Rank.
I. Division of Agriculture,	James A. Foord,	Head of division.
1. Agronomy,	Sidney B. Haskell,	Assistant professor.
	William P. Brooks,	Lecturer.
	Herbert J. Baker,	Assistant.
2. Animal husbandry,	John A. McLean,	Associate professor.
	Elvin L. Quaife,	Instructor.
3. Dairying,	W. P. B. Lockwood,	Associate professor.
	G. F. E. Story,	Extension instructor.
4. Farm administration,	James A. Foord,	Professor.
5. Poultry husbandry,	John C. Graham,	Associate professor.
II. Division of Horticulture,	Frank A. Waugh,	Head of division.
1. Floriculture,	Edward A. White,	Professor.
2. Forestry,	Frank F. Moon,	Associate professor.
	Frank W. Rane,	Lecturer.
3. Landscape gardening,	Frank A. Waugh,	Professor.
	Arthur K. Harrison,	Instructor.
4. Market gardening,	Frederick L. Yeaw,	Assistant professor.
5. Pomology,	Fred C. Sears,	Professor.
	Alvah J. Norman,	Extension instructor.
III. Division of Science,	James B. Paige,	Chairman of division.
1. Botany,	George E. Stone,	Professor.
	A. Vincent Osmun,	Assistant professor.
	F. A. McLaughlin,	Assistant.
	M. T. Smulyan,	Graduate assistant.
	R. G. Smith,	Graduate assistant.
2. Chemistry,	Joseph B. Lindsey,	Professor.
	Charles Wellington,	Professor.
	J. S. Chamberlain,	Associate professor.
	S. F. Howard,	Assistant professor.
	Charles A. Peters,	Assistant professor.
	William A. Turner,	Assistant.
	Harold S. Adams,	Assistant.
3. Entomology,	Henry T. Fernald,	Professor.
	Guy C. Crampton,	Associate professor.
	Burton N. Gates,	Assistant professor.[1]
	William S. Regan,	Graduate assistant.
4. Mathematics,	John E. Ostrander,	Professor.
	C. Robert Duncan,	Instructor.
	William L. Machmer,	Instructor.
	Samuel R. Parsons,	Assistant.
5. Physics,	Philip B. Hasbrouck,	Professor.
	Chester A. Butman,	Instructor.
6. Veterinary science,	James B. Paige,	Professor.
	George E. Gage,	Assistant professor.
7. Zoölogy and geology,	Clarence E. Gordon,	Assistant professor.
	Leonard S. McLaine,	Graduate assistant.
IV. Division of the Humanities,	Robert J. Sprague,	Head of division.
1. Economics and sociology,	Robert J. Sprague,	Professor.
2. History and government,	Elmer K. Eyerly,	In charge.
	George N. Holcomb,	Lecturer.
3. Languages and literature,	George F. Mills,	Professor.
English,	Robert W. Neal,	Associate professor.
	Edward M. Lewis,	Assistant professor.
	Willard A. Wattles,	Instructor.
	Helena Goessmann,	Assistant.
Public speaking,	H. deF. Widger,	Instructor.
German,	Edgar L. Ashley,	Assistant professor.
	Arthur N. Julian,	Instructor.
French,	A. A. Mackimmie,	Assistant professor.
	William L. Harmount,	Instructor.
V. Division of Rural Social Science,	Kenyon L. Butterfield,	Head of division.
1. Agricultural economics,	Alexander E. Cance,	Assistant professor.
2. Agricultural education,	William R. Hart,	Professor.
	Floyd B. Jenks,	Assistant professor.
3. Rural sociology,	Elmer K. Eyerly,	Associate professor.
VI. General Departments: —		
1. Military science,	George C. Martin,	Professor and captain.
	Samuel R. Parsons,	Assistant.
2. Physical education,	Curry S. Hicks,	Assistant professor.
3. Library,	Charles R. Green,	Librarian.

[1] Beekeeping.

Visits by Important Bodies.

To an increasing degree the college is becoming the objective for visits by important organizations or groups. The following is a list, doubtless incomplete, of such visits during the past year: —

	Date.
Connecticut Valley Breeders' Association,	Jan. 24.
Massachusetts Dairymen's Association,	Mar. 15.
Home and School Garden Club,	Aug. 4.
Potato Culture Club,	Oct. 7.
Massachusetts Fruit Growers' Association,	Oct. 9.
Massachusetts Press Association,	Oct. 9.
Executive Committee of State Y. M. C. A.,	Oct. 11.
Massachusetts State Poultry Association,	Oct. 11, 12.
Hampshire, Hampden, and Franklin Bee Keepers' Association,	Oct. 14.
Committee representing the Boston Gardeners' and Florists' Association,	Oct. 31.
Committee representing the Massachusetts Horticultural Society,	Oct. 31.
Officers of State Board of Education,	Nov. 21.

Construction and Repairs.

That part of the treasurer's work which consists in the oversight of college service, such as heating, lighting, etc., and the construction and repairs of buildings, has grown enormously during the past few years, and the demands on "general maintenance" have raised some rather important problems in administration. It has been very difficult to secure adequate help, and almost impossible to carry out promptly all of the projects assigned.

Two important buildings have been completed during the year: namely, the animal husbandry building and the cold storage building. The new dairy building has been begun, the building contract being given to H. Wales Lines Company of Meriden, Conn.; the heating and ventilating to Nichols & Drown Company of Lynn, Mass.; and the plumbing to William H. Mitchell & Sons of Boston. It is expected that the building will be completed by early summer.

The largest improvement project was in connection with the west experiment station building. Other improvements and many repairs, however, have been made or are still in process. For example, in the chemical laboratory the room formerly used for mathematics has been refitted for work in chemistry. In the social union room at North College a new fireplace has been built, the east and north entrances of the room closed; and an arch put in between the lounging room and the trophy room. A marked improvement has thus been accomplished. In the department of poultry husbandry there were erected and partially equipped a feed house, a brooder house, and a laying house. The task of repainting all of the college buildings has been begun, and this much-delayed improvement we hope may be completed before commencement.

New granolithic walks have been put in as follows: from the main walk east of the chapel to the ravine, and from South College past North College, across the ravine, to the dining hall. Walks have also been made connecting the president's house with the campus. A "stepping-stone" walk has been put in front of the new entomological building; these stepping stones are 20 inches square, laid 6 inches apart. Work has just started on the new apiary, located on the site of the "old creamery" building.

The new waiting station has been placed on the botanic walk, adjacent to the trolley line of the Amherst & Sunderland Railroad Company. This is "a long-felt want," and will be appreciated by the great number of people using it. The design was made by students in the department of landscape gardening.

Percy C. Schroyer, a graduate of the Michigan Agricultural College, in the class of 1908, has been engaged as assistant engineer.

IMMEDIATE NEEDS OF THE COLLEGE.

The most effective way of stating the present needs of the college is to outline the reasons which underlie the action of the trustees in formulating the legislative budget for the ensuing year. However, numerous suggestions have come to me from the officers of the college, and while not all of the needs thus expressed have found a place in the legislative budget, it will be of interest to quote some of them here, as showing how difficult it is for the college to keep pace with the requirements made by its rapid expansion. The following are among "the immediate pressing needs," suggested by various administrative officers of the institution: —

"Greatly increased library facilities."

"Additional recitation and lecture rooms, particularly for the departments in the division of the humanities."

"Additional instructors, so that certain sections in required work may be made smaller."

"Increased scholarship requirements."

"The limiting of the number of subjects that may be taken by the student, and avoiding such multiplicity of subjects that a student may get a hazy idea of many subjects instead of a clear, well-defined idea of a few things."

"A new chemical laboratory."

"Provision for new lines of investigation in the experiment station, the most important of which are in the following subjects: poultry farming, horticulture, animal diseases, market gardening."

"Additional land for use in experimental work, especially in the agricultural department, the department of pomology and the department of entomology; the latter department needs a small area to be under its exclusive control."

"Various minor improvements at the experiment station which have been submitted in the form of projects."

"The employment of an additional assistant in animal nutrition to work in connection with Dr. Lindsey."

"Employment of an assistant for seed work with a view to studying the seed situation in its possible bearing upon the necessity of a seed law."

The Legislative Budget of 1912.

The budget to be presented to the Legislature of 1912, as approved by the board of trustees at its meeting in Boston, November 3, may be summarized as follows: —

Requested Increases in Current Funds, Available for Fiscal Year, Dec. 1, 1912, to Nov. 30, 1913.

Items.	Present Appropriations.	Increase asked.	Total asked.
Administration,	$25,000	$5,000	$30,000
Maintenance and equipment,	58,000	37,000	95,000
Investigations,	10,500	14,000	24,500
Instruction,	60,000	23,000	83,000
Short courses and extension teaching,	20,000	30,000	50,000
Inspection service,	3,000	-	3,000
	$176,500	$109,000	$285,500

Requests for Appropriations for Special Purposes, 1912.

Agricultural building and equipment,	$200,000
Student dormitory,	25,000
Addition to French Hall,	25,000
Addition to Draper Hall,	25,000
Dwelling house for registrar,	8,000
Tenement house for farm help,	6,000
Sewers,	10,000
New equipment,	31,525
Repairs and minor improvements,	20,760
General improvements,	35,135
Total,	$386,420

Statement of Reasons for Requested Increases in Current Funds.

Administration. — Under the new legislative classification the appropriation for general administrative purposes is $25,000 a year. This includes the salaries of the general administrative officers of the college, the maintenance expense of their respective offices, and general charges that belong to the institution as a whole, such as, for illustration, publicity, commencement, etc. The current apportionment for the next fiscal year will show that the amount of $25,000 is not enough to carry the present charges. The charges will increase steadily year by year, and our request for an increase of this item to $30,000 a year is clearly justified by the situation.

Maintenance and Equipment. — The present appropriation under this item is $58,000 a year. The trustees have voted to ask the Legislature for an increase of $37,000, or a total of $95,-

000. Attention should be called to the fact that $30,000 of this increase is intended to cover permanent current appropriations of $15,000 each for repairs (and minor improvements), and for teaching equipment. It seems obvious enough that we should have at our disposal a reasonable sum each year for this purpose. The needs are sure to recur. They are not *special* needs. They are *current* needs. The Legislature cannot possibly judge wisely respecting the details of these expenditures. For two years prior to this we have asked the Legislature for these additions to our current income; so far without success. However, it is only businesslike that these additions should be made.

Instruction. — During the past few years the instruction force of the college has expanded quite rapidly, due to two main causes, the first of which is the increase in students. The attendance of students of college grade has increased more than 135 per cent. in the last five years. Necessarily this has called for more teachers, the addition of needed courses of study, and has also enlarged the work of existing departments. Furthermore, in order to keep pace with the rapidly developing field of agricultural instruction, a number of entirely new departments have been added. It will not be necessary in the future to add instructors at as rapid a rate as we have done during the past four years, but because of all the reasons just given for the recent expansion, there are still some important places to be filled. The estimates of the various departments call for additional instructors whose probable salaries would aggregate about $30,000 a year. The trustees have voted for an increase of $23,000. This is none too much. Instruction is the heart of the college. If we are inadequately equipped at this point we cannot possibly do the best work.

Investigation. — The income of the institution from the national treasury for experiment station work is fixed by law and can be changed only by congressional action. Under these conditions, as new needs arise they must be met, if at all, by appropriations from the State treasury. The trustees, therefore, acting on requests of various departments of the experiment station, are asking that the present State appropriation of $10,500 a year for investigation be increased to $24,500 a year. These investigations include an agricultural survey, experiments in floriculture, market gardening, veterinary science, and particularly important experiments in the department of poultry husbandry. These projects for new types of investigation are heartily supported by committees representing various producers' organizations of the Commonwealth.

Short Courses and Extension Teaching. — The present appropriation of $20,000 a year for extension service is entirely inadequate to meet the demands. The trustees have voted to ask the Legislature for $50,000 a year to carry on this important work. While it is not possible at this time to indicate the precise outlines of the plan for the best use of this added appropriation, I take pleasure in including at this point a statement from the director of extension service, giving his judgment as to the most important lines of work which should be developed in the near future: —

Administration of the Work. — Salaries, additional office equipment, traveling expenses, clerical help.

The Development of the Correspondence Courses. — Salary of supervisor, office equipment, clerical help, so that at least 1,000 may register in these courses.

Itinerant Instruction. — The extension schools, fair exhibits, educational trains, lectures, demonstrations, etc., require money for apparatus, and to defray the expenses of carrying on these, which are, perhaps, among the most important of our projects.

Demonstration Orchards. — To continue to plant these orchards and to provide help to supervise the growing of them.

Traveling Instructor. — To pay salary and expenses of a man provided with an automobile or covered "van," equipped with all kinds of demonstrating apparatus, to travel from town to town, giving demonstrations to small groups of farmers.

Demonstration Plots. — To provide funds so that demonstration plots showing results of the use of fertilizers, seed selection, rotation of crops, etc., can be placed all over the State and properly supervised by a representative from the college.

Supervisor of Co-operative Work with Other State Institutions. — Funds to pay salary and traveling expenses of a man, with the best of practical training, to take up this co-operative work that has been asked for by the other State institutions.

Support for the Massachusetts Agricultural College Agricultural Improvement Association. — Funds to provide selected seeds, printed instructions, and other material to be used as a basis for improving the agricultural industry of the State.

Extension Instructor in Rural Engineering and Sanitation. — To provide salary and traveling expenses of a man, trained in the problems of farm buildings, power on the farm, heat, lights and rural sanitation.

Extension Instructor in Town Improvement and Civic Betterment. — Funds to pay the salary of a man to work with village improvement officers, town officers and others on such subjects as beautifying the town, public roads, drives, parks, school grounds, cemeteries, streets, trees, etc., and to organize and federate all the forces of the community to work for one common end.

Extension Instructor in Agricultural Education. — To pay the salary and traveling expenses of a man to help school boards in the organization of agricultural work in high schools, and to take up and develop further the boys' and girls' club work which has already started so finely.

Extension Instructor in Home Economics. — To provide salary and expenses of a woman trained in this subject, especially from the rural standpoint, to give instruction in the short courses, to teach in the extension schools, to give lectures and demonstrations on foods and their value, cooking, canning, preserving, sanitation, labor-saving conveniences, household equipment, and to help in the introduction of these subjects into the smaller towns.

District Field Agents. — To pay salaries of several men to be located in good agricultural centers, to act as district field agents, devoting their entire time to the building up of the agriculture of the section in which they work.

Extension Instructor in Poultry Management. — To provide salary and expenses for a trained poultry man to give his time to helping the poultry interests of the State. At present, we cannot accept one-tenth of the calls made upon us.

Extension Instructor in Dairying. — Funds to pay salary and traveling expenses of a man to help teach this subject in the extension schools, and to give lectures and demonstrations and advice relating to dairying, both to producer and consumer.

Extension Instructor in Farm Management. — To pay salary and expenses of a man who shall help the farmers all over the State, in soil improvement, use of fertilizers, growing of field crops and in the general equipment and management of the farm.

Extension Instructor in Animal Husbandry. — Funds to pay salary and expenses of a man to organize breeders' and dairy improvement associations, advise as to feeding, and to give lectures and demonstrations on the care, management, selection, etc., of live stock.

Short Courses. — To provide funds for the further development of the several winter courses, and the continuation of the summer school and the conference for rural leaders.

Appropriations for Special Purposes.

1. For erecting and equipping an Agricultural Teaching and Laboratory Building, $200,000. — Although the college has been open to students nearly forty-five years, it has never had a building devoted specifically to agricultural teaching.

Practically every agricultural college in the country finds it necessary and desirable to make such a building one of the most important on the campus.

The rapid increase in our agricultural students has crowded the agricultural departments out of their old quarters. It is almost impossible to do efficient teaching under present conditions.

The winter short-course students are also inadequately provided for.

The proposed building will have three stories and a basement, and contain offices, class rooms, laboratories for the departments of farm administration, agronomy, animal husbandry, poultry husbandry and agricultural engineering. It is proposed to erect a fireproof building and to equip it in harmony with the recent developments in these lines of work.

2. For erecting a Student Dormitory, $25,000. — This item was in our legislative budget one year ago. The need for it has grown, even with the year, as we have over 80 more men of college grade registered this autumn than a year ago. Students find it difficult to get rooms at any price, and room rents in private houses are such as to make it a serious problem for many students who are working their way through college.

3. For erecting and equipping an Addition to French Hall, $25,000. — French Hall is a teaching building attached to the modern range of greenhouses, and was built about three years ago. It was so planned that only half of the building, as it should eventually stand, was erected, and it is now proposed to complete the building. Our division of horticulture has expanded, both in number of departments and in number of students taking the work, to such a degree that both teachers and students are seriously inconvenienced by the present crowded condition.

Furthermore, until we get a satisfactory building for the divisions of the humanities and rural social science, instructors in those divisions have to find class rooms wherever most available. Probably for several years this addition to French Hall will have to be used considerably by departments not connected with the division of horticulture.

4. For erecting an Addition to Draper Hall, $25,000. — This item has been asked for twice before. The present dining hall will not hold the student body. Moreover, the serving-room accommodations are entirely inadequate even for the present seating capacity of the dining hall. Hence the service is relatively costly and slow.

5. For erecting a Dwelling to be occupied by the Registrar of the College, $8,000. — The trustees are not ready to adopt the general policy of erecting residences upon the grounds for members of the teaching staff. They feel that it is extremely desirable for the president to live upon the grounds, as is now the case. There are a few other administrative officers, also, whose presence on or near the grounds seems to be a distinct advantage. One of these is the registrar of the college, who has to be consulted frequently by students. The registrar now occupies a cottage at the entrance of the grounds, which is scarcely habitable. It will not pay to repair it, and it is not right to ask an officer of the institution to reside there under such conditions. The business-like thing, therefore, seems to be to erect a dwelling on college property, to be occupied by the registrar of the institution, on terms that will represent a reasonable interest to the college on the investment.

6. *For erecting and equipping a Tenement House for Farm Help, $6,000.* — With the development of the live-stock interests, and particularly of the dairy herd, it has become imperative that quite a number of men should be housed near the college barns. Quarters formerly used for this purpose have been moved by the exigencies for new buildings, and other quarters must be provided.

7. *For providing Sewers for the College Estate, $10,000.* — The college does not have an adequate system of sewage disposal. The minor sewers have become too small for present use. The recently erected buildings have been provided with cesspools, but it is clearly evident that a thoroughly modern and complete sewerage system should be installed. It is both necessary and desirable that this system should be worked out in harmony with the plan of the town of Amherst for disposing of sewage in that part of the village which adjoins the college estate. Plans are being matured for this co-operation, and it is desired to begin work on the sewers at the earliest possible moment.

8. *New Equipment for Farm, Dairy Building, Dining Hall, College Service, and for Miscellaneous Teaching Equipment for Various Departments, $31,525.* — The college ought to have an annual income of not less than $20,000 for keeping up the teaching equipment. In lieu of this regular income we are obliged to ask the Legislature each year for a list of items needed to keep the equipment of college service — farm, horticulture and laboratories — up to par.

9. *For Repairs and Minor Improvements, $20,760.* — The same observations apply with respect to general repairs. The inventory of college buildings Dec. 1, 1911, exceeded $500,000. Twenty thousand dollars a year for general repairs is, therefore, 4 per cent. of the inventory value of the college buildings.

10. *For General Improvements, $35,135.* — This includes an addition to the poultry plant, an addition to the young stock barn, portable hog houses, a piggery, the development of the campus and miscellaneous improvements.

All of which is respectfully submitted,

KENYON L. BUTTERFIELD,

President.

AMHERST, Dec. 1, 1911.

STATISTICS OF THE COLLEGE.

TABLE I. — *Attendance.*

	Registration Nov. 30, 1910.		Registration Nov. 30, 1911.	
Senior class,	47		85	
Junior class,	87		97	
Sophomore class,	110		127	
Freshman class,	158		168	
	402		477	
Graduate students,	15		15	
Unclassified students,	17		29	
Total doing work of college grade,		434		521
Short courses: —				
Winter school,	64		113	
Poultry course,	51		74	
Summer school,	229		153	
Beekeepers' course,	20		16	
		364		356
Total,		798		877

TABLE II. — *Legislative Budget, 1911.*

ITEMS.	Amount asked.	Amount granted.
1. Special appropriations: —		
Improvements, west experiment station,	$7,500 00	$7,500 00
Enlargement of Draper Hall,	25,000 00	-
Dormitory,	25,000 00	-
Dairy building and equipment,	75,000 00	75,000 00
Department equipment,	15,000 00	10,000 00
Repairs,	20,000 00	15,000 00
General improvements,	25,000 00	15,000 00
	$192,500 00	$122,500 00
2. Increase in current annual appropriations: —		
Administration,	$4,250 00	$4,250 00
Maintenance and equipment,	43,250 00	13,250 00
Investigation,	5,000 00	-
Instruction,	22,500 00	12,000 00
Short courses and extension,	15,000 00	5,000 00
Inspection service,	-	-
	$90,000 00	$34,500 00
Previous appropriation,	142,000 00	142,000 00
Total,	$232,000 00	$176,500 00

TABLE III. — *Statistics of the Extension Service, 1910–11.*

	Enrollment.		
	1910.	1911.	Total.
Ten weeks' winter course,	65	113	–
Special poultry course,	51	74	–
Farmers' week course,	559	830	–
Beekeepers',	19	16	–
Summer school,	228	153	–
Conference rural social workers,	325	247	–
Correspondence courses,	106	370	–
Totals,	1,363	1,803	–
Total number enrolled in short courses at the college (two years),	–	–	3,166

Several organizations have held meetings two days in length at the college; no accounting is made of the attendance at these.

Statistics of Extension Work done away from the College.

	1910.	1911.	Total.
Lectures and demonstrations: —			
Requested,	123	600	723
Impossible to give,	69	222	291
Lectures and demonstrations given,	54	378	432
Attendance (no actual account, but fully),	–	–	20,000
Education trains: —			
Boston & Albany: —			
Days on road,	4	None.	–
Stops made,	18	None.	–
Springfield trolley: —			
Days on road,	3	None.	–
Stops made,	13	None.	–
Lectures and demonstrations given on both trains,	250	None.	–
Total attendance at lectures (hundreds of others visited the train),	–	–	9,000
Exhibits at fairs, expositions, etc.: —			
Exhibits at fairs,	6	10	16
Lectures and demonstrations given,	32	69	101
Attendance both years,	–	–	3,000
Demonstration orchards: —			
Requests for orchards on file,	31	99	130
New orchards planted,	4	4	8
Renovation plots,	2	2	4
Massachusetts Agricultural College Agricultural Improvement Association: —			
Membership,	–	110	110
Boys' and girls' corn and potato clubs: —			
Number of clubs,	125	350	–
Number enrolled,	8,300	16,900	–
Total number enrolled in two years,	–	–	25,200
Conferences for community betterment: —			
Number held,	2	4	6
Total number attending,	–	–	1,000
Dairy improvement association: —			
Number organized,	–	2	2
Requests for others,	–	3	3
Number of members,	–	52	52

Statistics of Extension Work done away from the College — Con.

	1909-10.	1910-11.	Total.
Massachusetts Poultry Association, meetings at college: — Attendance,	75	75	150
Beekeepers' convention: — Attendance,	-	75	75
Polish farmers' day: — Attendance,	-	95	95
Total number known to have been actually reached through the extension work during the two years,	-	-	61,848

Table IV. — *Public Speakers for the Year.*

A. Speakers at Sunday Services for Year ending Nov. 30, 1911.

1910.

Dec. 4. — Dr. Samuel A. Eliot, Boston.
Dec. 11. — Rev. Thomas Van Ness, Boston.

1911.

Jan. 8. — Rev. Herbert A. Jump, New Britain, Conn.
Jan. 15. — Rev. Philip S. Moxom, Springfield.
Jan. 22. — Rev. Clarence F. Swift, Fall River.
Feb. 12. — Rev. Albert P. Fitch, Cambridge.
Feb. 19. — Rev. John W. Ballantine, Stafford Springs, Conn.
Feb. 26. — Rev. Jason N. Pierce, Oberlin, O.
Mar. 5. — Princ. H. S. Cowell, Ashburnham.
Mar. 12. — Rev. Herbert J. White, Hartford, Conn.
Mar. 19. — Rev. O. P. Gifford, Brookline.
Sept. 17. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College.
Nov. 5. — Dr. L. Clark Seelye, Northampton.
Nov. 12. — Pres. M. L. Burton, Northampton.
Nov. 19. — Hon. George H. Utter, Westerly, R. I.
Nov. 26. — Mr. Frank P. Speare, Boston.

B. Speakers at Wednesday Assemblies for Year ending Nov. 30, 1911.

1910.

Dec. 7. — Mr. Harry Kimball, Boston.

1911.

Feb. 15. — Mr. J. B. Lewis, Boston.
Mar. 1. — Prof. Frank A. Updyke, Hanover, N. H.
Mar. 15. — Prof. Henry B. Wright, New Haven, Conn.
April 5. — Mr. George H. Cooper, Pittsfield.
April 12. — Prof. E. A. Ross, Madison, Wis.
May 10. — Prof. Edward M. Lewis, Williamstown.

1911.

May 17. — Dr. Charles W. Eliot, Cambridge.
May 31. — Hon. George H. Utter, Westerly, R. I.
Sept. 20. — Dean George F. Mills, Massachusetts Agricultural College.
Sept. 27. — Mr. Evan F. Richardson, Millis.
Oct. 4. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College.
Oct. 11. — Mr. Albert E. Roberts, New York, N. Y.
Oct. 18. — Dean George D. Olds, Amherst.
Oct. 25. — Prof. George M. Harper, Princeton, N. J.
Nov. 1. — Pres. Kenyon L. Butterfield, Massachusetts Agricultural College.
Nov. 8. — Prof. Edward M. Lewis, Massachusetts Agricultural College.
Nov. 15. — Hon. Frank A. Hosmer, Amherst.
Nov. 22. — Prof. J. W. Crook, Amherst.

TABLE V. — *Statistics of Freshmen entering Massachusetts Agricultural College in September, 1911.*

A. Home Addresses (classified by Towns and Cities).

Amherst,	4	Granby, Conn.,	1	Peabody,	2
Arlington,	2	Hanson,	1	Peterboro, N. H.,	1
Ballston Spa, N. Y.,	1	Hanson (South),	2	Pittsfield,	1
Barranquilla, Colombia, S.A.,	1	Hingham,	2	Plymouth,	1
Barnstable (West),	1	Kingston,	2	Revere,	2
Barre,	1	Lancaster,	1	Rock,	1
Becket,	1	Lancaster (South),	1	Rockport,	1
Beverly,	1	Lanesville,	1	Rutherford, N. J.,	1
Boston,	13	Lee,	1	Sandwich,	1
Bridgeport, Conn.,	1	Leominster,	1	Sheffield,	1
Brockton,	2	Lincoln (South),	1	Shelburne,	1
Brookfield (North),	1	Littleton,	1	Sherborn,	2
Brookline,	1	Ludlow,	1	Somerville,	3
Brooklyn, N. Y.,	2	Lynn,	1	South Hadley Falls,	1
Buckland,	1	Malden,	1	Southington, Conn.,	1
Buffalo, N. Y.,	1	Marshfield,	1	Springfield,	3
Burlington,	1	Mattapan,	1	Springfield (West),	1
Campello,	2	Melrose,	9	Sudbury (South),	1
Canton, China,	1	Melrose Highlands,	2	Sunderland,	2
Catasauqua, Pa.,	1	Mendon,	2	Swampscott,	1
Chelsea,	3	Middletown, Conn.,	1	Taunton,	1
Chesterfield,	1	Milford,	1	Topsfield,	1
Chicopee Falls,	1	Montague,	2	Wakefield,	2
Dana (North),	1	Natick,	1	Waltham,	5
Darien, Conn.,	1	Newburyport,	4	Ware,	1
Dartmouth (North),	2	New Haven, Conn.,	2	Warren,	1
Deerfield,	1	Newton,	1	Wellesley,	1
Dover,	2	Newton (West),	1	Westford,	1
Doylestown, Pa.,	1	Newtonville,	1	Weymouth (East),	1
Dracut,	1	New York, N. Y.,	2	Winchendon,	1
Duxbury (South),	1	Northampton,	2	Winthrop,	3
Enfield,	1	Norwood,	1	Worcester,	7
Evans Mills, N. Y.,	2	Oak Bluffs,	1		
Georgetown,	1	Orange,	1		
Glens Falls, N. Y.,	1	Oxford,	1		

B. Home Addresses (classified by Countries and States).

	Number.	Per Cent.		Number.	Per Cent.
China,	1	.60	New York,	9	5.39
Connecticut,	7	4.19	Pennsylvania,	2	1.20
Massachusetts,	145	86.82	South America,	1	.60
New Hampshire,	1	.60			
New Jersey,	1	.60		167	100.00

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	2	1.38	Middlesex,	36	24.83
Berkshire,	6	4.14	Nantucket,	–	–
Bristol,	1	.69	Norfolk,	6	4.14
Dukes,	1	.69	Plymouth,	13	8.97
Essex,	13	8.97	Suffolk,	22	15.17
Franklin,	8	5.52	Worcester,	21	14.48
Hampden,	6	4.14			
Hampshire,	10	6.89		145	100.01

D. Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	132	79.04
Both parents foreign born,	22	13.17
Father (only) foreign born,	8	4.79
Mother (only) foreign born,	5	3.00
	167	100.00

E. Education of Father.

	Number.	Per Cent.
Common school,	82	49.10
High school,	44	26.35
Business school,	13	7.79
College or university,	21	12.57
No statistics,	7	4.19
	167	100.00

F. Religious Census.

	Membership.		Preference.		Totals.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	15	8.98	1	.60	16	9.58
Catholic,	11	6.59	3	1.80	14	8.38
Congregational,	46	27.54	17	10.18	63	37.72
Episcopal,	13	7.79	2	1.20	15	8.98
Hebrew,	5	3.00	-	-	5	3.00
Methodist,	13	7.79	7	4.19	20	11.97
Miscellaneous,	3	1.80	6	3.59	9	5.39
Presbyterian,	4	2.40	-	-	4	2.40
Unitarian,	4	2.40	10	5.98	14	8.38
Universalist,	3	1.80	4	2.40	7	4.19
	117	71.09	50	29.94	167	99.99

G. Occupation of Fathers.

	Number.	Per Cent.
Agriculture and horticulture (practical),	37	22.16
Artisans,	33	19.76
Business,	50	29.94
Deceased or no statistics,	15	8.98
Miscellaneous,	14	8.38
Professional,	16	9.58
Retired,	2	1.20
	167	100.00

H. Intended Vocations of Students.

	Number.	Per Cent.
Agriculture or horticulture (practical),	69	41.31
Agriculture or horticulture (professional),	52	31.14
Professions,	5	3.00
Undecided or no statistics,	38	22.76
Engineering,	3	1.80
	167	100.01

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	43	25.75
Not brought up on a farm and having had practically no farm experience,	64	38.32
Not brought up on a farm, but having had some farm experience,	60	35.93
	167	100.00

J. Miscellaneous Statistics.

Average age,	19.17 years.
Number applying for student labor,	99 (59.28 per cent).
Number boarding at Draper Hall,	129 (77.24 per cent).

TABLE VI. — *Statistics of Freshman Class.*

Number of applications,			281
Admitted,		188	
Matriculated,	168		
Failed to report,	20		
Total,		188	
Rejected,		93	
Total,			281
Admitted on certificate,			110
Admitted on examination,			29
Admitted on certificate and examination,			29
			168
Admitted without condition,			115
Admitted with condition,			53
			168

TABLE VII. — *Gifts.*

Massachusetts Agricultural Experiment Station. — List of Gifts for the Year ending Nov. 30, 1911.

German Kali Works, New York City,	200 pounds kainit. 1 ton high-grade sulfate of potash. 1,200 pounds carbonate of potash.
The Jarecki Chemical Company, Cincinnati, O.,	200 pounds calcined phosphate.
Vermont Marl Company, Brattleborough, Vt.,	11 tons shell marl.
Wilcox Fertilizer Company, Mystic, Conn.,	300 pounds dry-ground fish. 125 pounds dry-ground acid fish.
Rogers & Hubbard Company, Middletown, Conn.,	200 pounds dissolved bone.
Werner Extract Company, Mechanicsville, Ill.,	200 pounds Werner's phosphate.
Alphano Humus Company, New York City,	150 pounds Alphano humus.
J. Bolgiana & Son, Baltimore, Md.,	1 packet seed of "My Maryland" tomato.
S. D. Woodruff & Sons, Orange, Conn.,	3 pounds sample "Woodruff" potatoes.
W. Atlee Burpee & Co., Philadelphia, Pa.,	Novelties in vegetable and flower seeds.
Joseph Dixon Crucible Company, Boston, Mass.,	1 gallon Dixon's sillica-graphite paint.
Detroit White Lead Works, Detroit, Mich.,	2 gallons Jap. asphalt paint.
L. W. Ferdinand & Co., Boston, Mass.,	1 quart can glue cement.
Frederick Feeder Company, Perkasie, Pa.,	2 automatic feeders.
Poultry Dust Bath Company, Whiting, Ind.,	100 pounds Dustyne.
National Safety Soap Company, Wilmington, O.,	1 "Kling" hame fastener.
Sterling Chemical Company, Cambridge, Mass.,	5 gallons Sterlingworth San José scale killer. 5 gallons Sterlingworth lime and sulfur wash.
Boston Dry Food Hopper Company, Boston, Mass.,	5 feed hoppers.
Robert Essex Incubator Company, Buffalo, N.Y.,	1 Essex model incubator. 2 Essex model brooders.

Library. — List of Principal Gifts for the Year ending Nov. 30, 1911.

American Guernsey Cattle Club, Wm. H. Caldwell, M. A. C., 1887, Secretary,	Guernsey herd registers.
American Jersey Cattle Club, New York City,	Jersey herd register, 1902–10, 10 volumes.
American Shorthorn Breeders' Association,	Herd books.
Amherst Club, Amherst, Mass.,	Wallace's Year Book of Trotting and Pacing, 2 volumes.
Bowker, William H., Boston, Mass., M. A. C., 1871.	Government documents and miscellaneous books.
Depew, Hon. Chauncey M.,	Complete set of his writings, 8 volumes.
Chamberlain, Dr. J. S., Amherst, Mass.,	Experiment station bulletins.
City Library Association, Springfield, Mass.,	Proceedings of the American Association for the Advancement of Science.
Filer, H. B., M. A. C., 1906,	Buffalo park reports, 4 volumes.
Holstein-Friesian Association of America,	Herd books.
Indiana Academy of Science,	Proceedings, 16 volumes.
Iowa Academy of Science,	Proceedings, 16 volumes.

Library. — List of Principal Gifts for the Year ending Nov. 30, 1911 — Con.

Jones, Hon. J. W., Columbia, Tenn.,	American jack stock studbook, volumes 1–8.
Kansas Academy of Science,	Transactions, 15 volumes.
Lodge, Hon. Henry Cabot,	United States government publications.
Massachusetts State Board of Agriculture,	11 cases of early American agricultural periodicals, etc.
Massachusetts State Library,	Massachusetts public documents.
Michigan Academy of Science,	Proceedings, 12 volumes.
New York State Library,	New York public documents.
Percheron Society of America,	Percheron studbooks.
Queensland Department of Agriculture,	Queensland Agricultural Journal, 16 volumes.
Reliable Poultry Journal Publishing Company, Quincy, Ill.,	16 volumes.
Root, A. J. & Co., Medina, O.,	Bee books.
Smithsonian Institution, Washington, D. C.,	Harriman Alaska Expedition, 11 volumes.
Stoeckel, Hon. Carl, Norfolk, Conn.,	Litchfield County University Club publications, volumes 1–4.
Stone, Dr. George E., Amherst, Mass.,	Magazines and bulletins.
United States Department of Agriculture, Washington, D. C.,	Foreign and domestic agricultural publications.
United States Monetary Commission, Washington, D. C.,	Complete set of publications.
University of Wisconsin, Madison, Wis.,	Transactions of the Wisconsin Academy of Arts and Sciences, and publications of the University of Wisconsin.
Waugh, Mrs. F. A., Amherst, Mass.,	Magazines and books.
Williams, Mrs. Mary E., Amherst, Mass.,	Books.

Academic Departments. — List of Gifts for the Year ending Nov. 30, 1911.

Col. John E. Thayer, Lancaster, Mass.,	Valuable collection of 234 bird skins.
New York Zoölogical Society,	Skeletons of an American deer and a South American tapir.
James A. Hyslop, M. A. C., 1908,	Collection of skins of 17 small mammals and 14 birds from Washington State.
Rev. J. M. Lewis, North Westport, Mass.,	A new variety of the common mouse.
William R. Bent, M. A. C., 1912,	Duck skin.
R. R. Parker, M. A. C., 1912,	Marine worms and fishes.
G. A. Post, M. A. C., 1913,	Ostrich egg from east coast of Africa; also small collection of miscellaneous birds' eggs.
Dr. H. T. Fernald, Amherst, Mass.,	Albino shrew.
G. N. Willis, M. A. C., 1905,	Miscellaneous birds' eggs.
D. N. West, M. A. C., 1902,	Natural asbestos rock and samples in processes of manufacture from Black Lake, Quebec, Can.
A. F. McDougall, M. A. C., 1913,	Quartz crystals and small collection of invertebrate fossils.
M. S. Hazen, M. A. C., 1910,	Samples of crushed Florida phosphate rock dust, and acid phosphate; shark's teeth from phosphate rock; specimens of coal, minerals, etc., from coal mines near Moosic, Pa.
J. A. Harlow, M. A. C., 1912,	Quartz crystals.
Ozone Pure Airifier Company, Chicago, Ill.,	Ozone Pure Airifier.
Field Force Pump Company, Elmira, N. Y.,	Nozzles.
Goulds Manufacturing Company, Seneca Falls, N. Y.,	Nozzles.
Perth-Amboy Chemical Company, New York, N. Y.,	Formaldehyde.
Root Company, Medina, O.,	Collection of smokers and sundry tools; feeders; collection of standard beehives enameled for exhibition purposes; mounted specimens of their products, such as sections, etc.; transportation cages for live bees; queen mailing boxes and complete queen rearing outfit. Total value about $50.
W. T. Falconer Manufacturing Company, Jamestown, N. Y.,	Collection of hives, sections, wax foundation, and beekeepers' implements.
E. M. Nichols, Lyonsville, Mass.,	Samples of hives; collection of bottom boards and covers; feeders, etc.
The American Paper Products Company, St. Louis, Mo.,	Samples of "Appco Shipsafe," honey transportation cases.
J. E. Crane, Middlebury, Vt.,	One Crane honey shipping case.
E. H. Dewey, Great Barrington, Mass.,	Two Dewey foundation fasteners.

Academic Departments. — *List of Gifts for the Year ending Nov. 30, 1911* — Con.

D. S. Hall, South Cabot, Vt.,	Models of Hall's frames.
J. L. Byard, Southborough, Mass.,	One colony of superior Italian bees.
A. A. Byard, West Chesterfield, N. H.,	Newly invented Byard foundation fastener.
American Sugar Refining Company, Granite Street, Boston, Mass.,	Exhibit of 12 samples of sugar products.
Arthur C. Miller, Providence, R. I.,	Miller's newly invented foundation fastener and hive tool.
American Can Company, Chicago, Ill.,	Large collection of types of cans for shipping honey.
O. M. Smith, Florence, Mass.,	Smith's hive tool.
H. H. Jepson, Boston, Mass.,	Various minor implements.
New York State Association of Beekeepers' Societies (through courtesy of W. F. Marks, Clifton Springs, N. Y.),	1 writing tablet as a sample of propaganda used in increasing interest in bees and honey among school children.
Dr. James B. Paige, M. A. C., 1882,	1 swarm catcher.
O. F. Fuller, Blackstone, Mass.,	1 complete outfit for commercial queen rearing.
L. A. Aspinwall, Jackson, Mich.,	1 Aspinwall hive.
Jesse Carpenter, Jr., M. A. C., 1912,	Washington insects.
W. E. Dickinson, M. A. C., 1907, Hakalau, Hawaii,	Hawaiian mantid.
H. T. Cowles, M. A. C., 1910, San Tusco, P. R.,	Porto Rican insects.
W. V. Tower, M. A. C., 1903, San Juan, P. R.,	Porto Rican lepidoptera. West Indian scale insects.
Dr. G. C. Crampton, Amherst, Mass.,	Cuban lepidoptera.
P. P. Cardin, M. A. C., 1909, Santiago de las Vegas, Cuba,	Cuban insects.
C. W. Hooker, Mayaguez, P. R.,	Coleoptera, etc., from Wisconsin.
C. C. Gowdey, M. A. C., 1908, Entebbe, Uganda,	African insects.
Dr. H. T. Fernald, Amherst, Mass.,	Nantucket insects.
R. H. Van Zwaluwenburg, M. A. C., 1913, U. J.,	Mexican insects.
C. A. Frost, M. A. C., South Framingham, Mass.,	Ichneumonidæ.
C. C. Gowdey, M. A. C., 1908, Entebbe, Uganda.,	Indian scale insects.
J. N. Summers, M. A. C., 1907, Melrose Highlands, Mass.,	European and American coleoptera.
United States Bureau of Entomology (through H. P. Wood, M. A. C., 1907),	Collection of ticks.
W. S. Regan, M. A. C., 1908, Amherst, Mass.,	Work of the carpenter worm.
United States Bureau of Entomology, Melrose Highlands, Mass.,	Imported parasites of the gypsy and brown-tail moths.
Dr. F. H. Chittenden, Bureau of Entomology, Washington, D. C.,	Southern truck crop insects.
Dr. G. C. Crampton, Amherst, Mass.,	Hemiptera from Syria.
H. A. Ballou, M. A. C., 1895, Barbados, W. I.,	Insects from Barbados.
Dr. G. C. Crampton, Amherst, Mass.,	Hymenoptera from the Riviera.
Q. S. Lowry, M. A. C., 1913,	Mantispa and eupsalis.
T. H. Jones, M. A. C., 1908, Washington, D. C.,	Entomological books.
C. W. Hooker, Mayaguez, P. R.,	Entomological pamphlets and photographs.
Field Force Pump Company, Elmira, N. Y.,	"Empire King" pump and accessories.
Deming Company, Salem, O.,	Barrel pump and nozzle frame.
Turner Brass Works, Sycamore, Ill.,	Two types of gasoline torch.
California Spray Chemical Company, Watsonville, Cal.,	Sample of zinc arsenite.
Frank N. Hale, Woonsocket, R. I.,	Sample of entomoid.
Merrimac Chemical Company, Boston, Mass.,	Samples of Swift's arsenate of lead.
Sherwin-Williams Company, Cleveland, O.,	Sample of soil fungicide and insecticide.
Carbolineum Wood Preserving Company, New York, N. Y.,	Sample of "Avenarius Carbolineum."
Manhattan Oil Company, New York, N. Y.,	Sample of "Spray on."
Hon. E. B. White, Leesburg, Va.,	Pure-bred two-year-old Percheron stallion (loan).
Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.,	Pure-bred Morgan stallion, Red Oak (loan).
L. A. Nichols, M. A. C., 1871, Chicago, Ill.,	3 100-foot steel tapes. 4 jointed range poles. 4 sets marking pins.
C. B. Travis, Brighton, Mass.,	20 eggs for hatching. 2 white Leghorn males. File of "Farm Poultry."
Rockandotte Farm, Southborough, Mass.,	50 eggs for hatching.
Henry D. Smith, Rockland, Mass.,	Discount on heating apparatus, brooder house, amounting to about $70.
DeLaval Separator Company,	2 separators (1 hand, 1 power) (loan). 1 cutaway separator (for demonstration) (loan).
Sharpless Separator Company,	2 separators (1 hand, 1 power) (loan).
Vermont Farm Machine Company,	1 hand separator with belt attached (loan).
International Harvester Company,	1 hand separator (loan).
Creamery Packing Manufacturing Company,	Several sanitary pipe fittings (loan).
P. R. Zeigler & Co.,	1 sterilac milk pail.

Report of the Treasurer

For the Fiscal Year ending Nov. 30, 1911.

Balance Sheet.

			Dr.	Cr.
1910.				
Dec. 1.	To cash on hand,		$5,664 38	
	To cash on deposit,		19,980 42	
1911.				
Nov. 30.	To special appropriation receipts, State Treasurer,		90,065 88	
	By special appropriation disbursements,			$94,745 20
	To experiment station receipts,		63,277 10	
	From State Treasurer,	$13,500 00		
	From United States Treasurer,	30,000 00		
	From other sources,	19,777 10		
	By experiment station disbursements,			64,986 68
	To current accounts receipts,		216,555 22	
	From United States Treasurer, Morrill fund,	$16,666 66		
	From United States Treasurer, Nelson fund,	16,666 67		
	From State Treasurer, endowment fund,	10,613 32		
	From State Treasurer, maintenance,	35,000 00		
	From State Treasurer, scholarship,	15,000 00		
	From State Treasurer, instruction,	47,500 00		
	From State Treasurer, Extension department,	15,000 00		
	From State Treasurer, agricultural education department,	5,000 00		
	From State Treasurer, veterinary department,	1,000 00		
	From State Treasurer, student labor,	7,500 00		
	From State Treasurer, graduate school,	2,500 00		
	From other sources,	44,108 57		
	By current account disbursements,			215,941 81
	To student trust funds receipts,		66,308 10	
	By student trust funds disbursements,			62,251 38
	By experiment station trust funds disbursements,			257 40
	By cash on hand,			8,229 09
	By cash on deposit,			15,439 54
			$461,851 10	$461,851 10

Statement of the First National Bank of Amherst with the Massachusetts Agricultural College.

		Dr.	Cr.
1910.			
Dec. 1.	Balance on hand,	$40,168 47[1]	
1911.			
Nov. 30.	Deposits,	468,207 93	
	Interest,	497 79	
	Disbursements as per warrants,		$468,897 79
	Balance on hand,		39,976 40[1]
		$508,874 19	$508,874 19

[1] These amounts are greater Dec. 1, 1910, by $20,188.05, and Nov. 30, 1911, $24,536.86, on account of outstanding checks.

Special Appropriations.

Name of Appropriation.	Date made.	Amount of Appropriation.	Amount previously expended.	Amount expended during Fiscal Year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Zoölogy building,	1909	$80,000 00	$66,771 03	$13,246 32	$80,017 35	$80,017 35[1]	-
Animal husbandry building,	1910	10,000 00	4,166 35	5,833 65	10,000 00	10,000 00	-
Investigation as to cranberry growing,	1910	15,000 00	12,799 31	2,200 69	15,000 00	15,000 00[2]	-
Laboratory for pomology,	1910	12,000 00	1,223 38	10,776 62	12,000 00	12,000 00	-
Land,	1910	17,500 00	11,797 11	-	11,797 11	11,797 11	$65 98
Poultry husbandry,	1910	5,000 00	-	5,001 00	5,001 00	5,001 00[1]	-
Repairs and improvements,	1910	25,000 00	16,640 06	8,359 94	25,000 00	25,000 00	-
Teaching and office equipment,	1910	10,000 00	2,984 13	7,015 87	10,000 00	10,000 00	-
Equipment for laboratory for entomology and zoölogy,	1910	15,000 00	5,872 19	9,127 81	15,000 00	15,000 00	-
Dairy building,	1911	75,000 00	1,804 87	11,014 99	12,819 86	7,948 24	67,051 76
Equipment,	1911	10,000 00	-	3,355 23	3,355 23	2,804 29	7,195 71
Repairs,	1911	15,000 00	-	4,579 31	4,579 31	3,839 63	11,160 37
Small buildings,	1911	15,000 00	-	7,792 32	7,792 32	6,484 28	8,515 72
West experiment station,	1911	7,500 00	200 00	5,105 18	5,305 18	4,420 15	3,079 85
Architects' fees,	-	-	1,150 57	1,197 79	2,348 36	-	-
Farm buildings,	-	-	-	138 48	138 48	-	-
		$312,000 00	$125,409 00	$94,745 20	$220,154 20	$209,312 05	$97,069 39

[1] From State Treasurer and other sources.

[2] $12,736.25 was paid by State Treasurer direct.

Current Accounts.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1910, to Nov. 30, 1911.	Receipts from Dec. 1, 1910, to Nov. 30, 1911.	Apportionment for Year ending Nov. 30, 1911.	Balance to Credit.
Administration,	$6,233 96	$2 36	$10,000 00	$3,768 40
Agricultural division,	22,788 40	19,052 37	4,000 00	263 97
Agricultural economics,	91 28	-	100 00	8 72
Agricultural education,	5,705 78	17 67	4,968 70	—719 41
Botanical,	1,442 56	769 55	700 00	26 99
Chemical,	3,520 50	2,328 43	800 00	—392 07
Dean's office,	202 45	-	200 00	—2 45
Entomological,	1,084 82	275 79	850 00	40 97
Extension work,	20,811 41	2,864 87	12,534 60	—5,411 94
Floriculture,	3,499 93	2,761 82	1,100 00	361 89
Forestry,	392 77	50	500 00	107 73
General horticulture,	2,585 00	659 80	2,000 00	74 80
General maintenance,	39,136 73	10,573 42	35,000 00	6,436 69
Graduate school,	1,339 18	120 00	3,586 81	2,367 63
Grounds,	1,900 61	1 70	2,200 00	301 09
Library,	5,542 46	436 91	5,000 00	—105 55
Landscape gardening,	433 72	256 93	250 00	73 21
Language and literature,	598 99	-	900 00	301 01
Market gardening,	4,413 12	2,293 74	2,400 00	280 62
Mathematics and physics,	361 75	10	500 00	138 35
Military,	1,939 42	24 79	1,900 00	—14 63
Physical education,	497 60	119 00	400 00	21 40
Political science,	85 07	-	25 00	—60 07
Pomology,	3,425 41	1,156 58	1,800 00	—468 83
President's office,	873 68	28 44	900 00	54 76
Registrar,	302 13	-	300 00	—2 13
Salaries,	84,132 15	-	85,034 00	901 85
Treasurer's office,	764 18	-	800 00	35 82
Veterinary,	1,343 35	17 50	1,771 45	445 60
Zoölogy,	493 40	346 30	100 00	—47 10
State Treasurer: —				
Endowment fund,	-	10,613 32	-	-
Maintenance,	-	35,000 00	-	-
Scholarship,	-	15,000 00	-	-
Instruction,	-	47,500 00	-	-
Extension department,	-	15,000 00	-	-
Agricultural education,	-	5,000 00	-	-
Veterinary,	-	1,000 00	-	-
Student labor fund,	-	7,500 00	-	-
Graduate school,	-	2,500 00	-	-
United States Treasurer: —				
Morrill fund,	-	16,666 66	-	-
Nelson fund,	-	16,666 67	-	-
	$215,941 81	$216,555 22	$180,620 56	$16,011 50
Balance beginning fiscal year, Dec. 1, 1910,	-	25,211 22[1]	-	—7,224 18
Balance on hand Nov. 30, 1911,	25,824 63	-	-	-
	$241,766 44	$241,766 44	$180,620 56	$8,787 32

[1] This amount is greater by $3,155.78 on account of architects' fees, which amount has been transferred to the accounts under special appropriations.

Summary.

	Disbursements.	Receipts.
By cash on hand Dec. 1, 1910,	-	$25,211 22
By institution receipts Nov. 30, 1911,	-	44,108 57
By State Treasurer's receipts Nov. 30, 1911,	-	139,113 32
By United States Treasurer's receipts Nov. 30, 1911,	-	33,333 33
To total disbursements,	$215,941 81	-
	$215,941 81	$241,766 44
Bills receivable Dec. 1, 1910, deducted,	-	2,187 72
Bills payable Dec. 1, 1910, deducted,	1,668 77	-
	$214,273 04	$239,578 72
Bills receivable Nov. 30, 1911,	-	2,265 82
Bills payable Nov. 30, 1911,	3,059 45	-
Balance,	24,512 05	-
	$241,844 54	$241,844 54

Comparative Disbursements and Receipts for 1910-11.

Accounts.	Disbursements.		Receipts.	
	1910.	1911.	1910.	1911.
Administration,	$4,729 04	$6,233 96	$30 07	$2 36
Agricultural division,	22,028 79	22,788 40	16,339 90	19,052 37
Agricultural economics,	112 60	91 28	-	-
Agricultural education,	5,047 21	5,705 78	15 91	17 67
Botanical,	994 05	1,442 56	259 34	769 55
Chemical,	2,137 73	3,520 50	2,075 14	2,328 43
Dean's office,	232 36	202 45	36	-
Entomology,	515 29	1,084 82	251 61	275 79
Extension work,	12,336 03	20,811 41	1,745 63	2,864 87
Floriculture,	2,987 80	3,499 93	2,495 93	2,761 82
Forestry,	-	392 77	-	50
General horticulture,	2,436 18	2,585 00	805 51	659 80
General maintenance,	32,405 40	39,136 73	10,739 37	10,573 42
Graduate school,	1,413 19	1,339 18	-	120 00
Grounds,	1,444 30	1,900 61	54 10	1 70
Library,	5,083 89	5,542 46	567 51	436 91
Landscape gardening,	258 21	433 72	123 90	256 93
Language and literature,	539 69	598 99	1 00	-
Market gardening,	4,970 60	4,413 12	2,604 94	2,293 74
Mathematics and physics,	251 74	361 75	1 12	10
Military,	1,657 52	1,939 42	53 25	24 79
Physical education,	566 41	497 60	137 85	119 00
Political science,	7 05	85 07	-	-
Pomology,	3,237 78	3,425 41	1,398 70	1,156 58
President's office,	721 91	873 68	15 25	28 44
Options on land,	125 00	-	115 00	-
Registrar,	249 12	302 13	-	-
Salaries,	71,124 91	84,132 15	143 32	-
Treasurer's office,	753 75	764 18	34 69	-
Veterinary,	777 42	1,343 35	5 90	17 50
Zoölogy,	392 73	493 40	275 41	346 30
State Treasurer: —				
Endowment fund,	-	-	10,613 32	10,613 32
Maintenance,	-	-	33,000 00	35,000 00
Scholarship,	-	-	15,000 00	15,000 00
Instruction,	-	-	40,000 00	47,500 00
Extension department,	-	-	8,125 00	15,000 00
Agricultural education,	-	-	5,000 00	5,000 00
Veterinary,	-	-	1,000 00	1,000 00
Student labor fund,	-	-	7,500 00	7,500 00
Graduate school,	-	-	2,500 00	2,500 00
United States Treasurer: —				
Morrill fund,	-	-	16,666 67	16,666 66
Nelson fund,	-	-	13,333 33	16,666 67
	$179,537 70	$215,941 81	$193,029 03	$216,555 22
Balance beginning of fiscal year,	-	-	11,719 89	25,211 22
Balance at close of fiscal year,	25,211 22[1]	25,824 63	-	-
	$204,748 92	$241,766 44	$204,748 92	$241,766 44

[1] This amount is greater by $3,155.78 on account of architect's fees, which amount has been transferred to the accounts under special appropriations.

Experiment Station.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1. 1910, to Nov. 30, 1911.	Receipts from Dec. 1, 1910, to Nov. 30, 1911.	Apportionment for Year ending Nov. 30, 1911.	Balance to Credit.
Administration,	$1,669 79	$123 79	$2,085 00	$539 00
Agriculture,	4,864 07	2,128 14	2,300 00	—435 93
Asparagus,	748 63	-	500 00	—248 63
Botanical,	1,577 35	20 82	1,500 00	—56 53
Chemical,	9,809 16	7,165 66	2,400 00	—243 50
Cranberry,	4,038 98	4,232 00	1,000 00	1,193 02
Entomological,	588 10	2 50	700 00	114 40
Fertilizer,	-	6,094 83	-	6,094 83
Freight,	294 49	-	450 00	155 51
Feed law,	2,891 44	3,000 00	-	1,676 45
Graves orchard,	194 79	-	300 00	105 21
Horticulture,	1,439 97	4 36	1,350 00	—85 61
Library,	161 56	-	300 00	138 44
Meteorology,	322 16	-	400 00	77 84
Publications,	1,726 40	-	3,000 00	1,273 60
Salaries,	33,899 31	-	36,136 19	2,236 88
Treasurer's office,	182 12	-	350 00	167 88
Veterinary,	238 16	5 00	250 00	16 84
Hatch fund,	-	15,000 00	-	-
Adams fund,	-	15,000 00	-	-
State fund,	-	10,500 00	-	-
Tobacco experiments,	340 20	-	200 00	—140 20
	$64,986 68	$63,277 10	$53,221 19	$13,789 90
Balance beginning of fiscal year,	-	5,799 94	-	—1,210 40
Balance on hand Nov. 30, 1911,	4,090 36	-	-	-
	$69,077 04	$69,077 04	$53,221 19	$12,579 50

Experiment Station Trust Fund.

Account.	Disbursements for Year ending Nov. 30, 1911.	Balance brought forward Dec. 1, 1910.
Cranberry growers' contribution account,	$257 40	$257 40

Comparative Disbursements and Receipts, 1910-11.

Accounts.	Disbursements.		Receipts.	
	1910.	1911.	1910.	1911.
Administration,	$1,722 57	$1,669 79	$32 80	$123 79
Agriculture,	5,286 14	4,864 07	2,963 67	2,128 14
Asparagus,	736 59	748 63	-	-
Botanical,	1,283 19	1,577 35	28 70	20 82
Chemical,	9,228 18	9,809 16	6,660 08	7,165 66
Cranberry,	1,504 29	4,038 98	1,958 54	4,232 00
Entomology,	562 81	588 10	1 20	2 50
Fertilizer,	-	-	5,880 00	6,094 83
Freight,	445 03	294 49	85	-
Feed law,	3,580 61	2,891 44	3,000 00	3,000 00
Graves orchard,	350 81	194 79	119 00	-

Comparative Disbursements and Receipts, 1910-11 — Con.

Accounts.	Disbursements.		Receipts.	
	1910.	1911.	1910.	1911.
Horticulture,	$1,530 18	$1,439 97	$2 37	$4 36
Library,	289 62	161 56	-	-
Meteorology,	299 03	322 16	-	-
Publications,	1,953 86	1,726 40	-	-
Salaries,	31,438 00	33,899 31	15 52	-
Treasurer's office,	370 74	182 12	-	-
Veterinary,	218 64	238 16	-	5 00
Hatch fund,	-	-	15,000 00	15,000 00
Adams fund,	-	-	14,000 00	15,000 00
State fund,	-	-	10,500 00	10,500 00
Tobacco experiments,	317 78	340 20	-	-
Cranberry association,	544 17[1]	-	544 17	-
Expert services,	12 40	-	85 00	-
	$61,674 64	$64,986 68	$60,791 90	$63,277 10
Balance beginning of fiscal year,	-	-	6,682 68	5,799 94
Balance on hand Nov. 30, 1911,	5,799 94	4,090 36	-	-
	$67,474 58	$69,077 04	$67,474 58	$69,077 04

[1] Transferred to cranberry growers' contribution account.

Agricultural Division.

Disbursements and Receipts for Fiscal Year ending Nov. 30, 1911.

	Disbursements.	Receipts.
Office,	$370 30	$27 54
Academic: —		
Maintenance,	$120 25	$10 10
Equipment,	103 95	1 50
Miscellaneous,	164 60	-
Student labor,	219 22	-
	$608 02	$11 60
Farm: —		
Labor,	$10,393 69	$3,098 73
Dairy,	1,769 76	12,194 08
Teams,	527 12	125 00
Horses,	501 33	908 72
Cattle,	4,627 06	710 08
Swine,	199 29	151 15
Field crops,	1,037 92	1,518 33
Repairs,	538 67	-
Improvements,	282 19	20
Student labor,	1,164 00	9 84
Contingent,	119 34	16 91
Tools,	271 17	50
Freight and express,	96 06	-
Poultry,	282 48	279 69
	$21,810 08	$19,013 23
Division totals,	$22,788 40	$19,052 37

Summary.

	Dr.	Cr.
By total division receipts,		$19,052 37
By bills receivable,		1,167 78
By net apportionment,		4,000 00
To total disbursements,	$22,788 40	
To bills payable,	153 13	
To balance,	1,278 62	
	$24,220 15	$24,220 15

Inventory of Quick Assets.

	Nov. 30, 1910.	Nov. 30, 1911.
Inventory of produce,	$4,999 13	$4,728 73
Inventory of cattle,	10,042 00	10,823 00
Inventory of swine,	340 00	485 00
Inventory of horses,	4,400 00	4,080 00
Inventory of poultry,		614 25
	$19,781 13	$20,730 98

Horticultural Division.

Disbursements and Receipts for Fiscal Year ending Nov. 30, 1911.

	Disbursements.	Receipts.
Floriculture,	$3,499 93	$2,761 82
Forestry,	392 77	50
General horticulture,	2,585 00	659 80
Grounds,	1,900 61	1 70
Landscape gardening,	433 72	256 93
Market gardening,	4,413 12	2,293 74
Pomology,	3,425 41	1,156 58
	$16,150 56	$7,131 07

Summary.

	Dr.	Cr.
By total division receipts,		$7,131 07
By bills receivable,		861 39
By apportionment,		10,250 00
To total division disbursements,	$16,650 56	
To bills payable,	101 83	
To balance,	1,490 07	
	$18,242 46	$18,242 46

Inventory of Quick Assets.

	Nov. 30, 1910.	Nov. 30, 1911.
Inventory of supplies,	$496 00	$1,064 00

Inventory — Real Estate.

Land (Estimated Value).

Baker place,	$2,500 00
Bangs place,	2,350 00
Clark place,	4,500 00
College farm,	37,000 00
Harlow farm,	3,284 63
Kellogg farm,	5,868 45
Louisa Baker place,	5,636 91
Old creamery place,	1,000 00
Pelham quarry,	500 00
Westcott place,	2,250 00
Allen place,	500 00
Charmbury place,	450 00
Loomis place,	415 00
Hawley & Brown place,	675 00
Newell farm,	2,800 00
	$69,729 99

College Buildings (Estimated Value).

Animal husbandry building,	$10,000 00
Chemical laboratory,	8,000 00
Clark hall,	67,500 00
Cold-storage laboratory,	12,000 00
Dairy barn and storage,	30,000 00
Dining hall,	35,000 00
Drill hall and gun shed,	10,000 00
Durfee range and glass houses, old,	10,000 00
Durfee range and glass houses, new,	15,000 00
Entomology building,	80,000 00
Farmhouse,	2,500 00
French hall,	17,000 00
Horse barn,	5,000 00
Horticultural barn,	2,500 00
Horticultural tool shed,	2,000 00
Machinery barn,	4,000 00
Mathematical building,	6,000 00
North dormitory,	25,000 00
Physics laboratory,	5,500 00
Poultry feed house,	1,400 00
Poultry brooder house,	1,000 00
Poultry laying houses,	1,300 00
Poultry colony houses,	470 00
Power plant,	13,000 00
President's house,	12,000 00
Quarantine barn,	200 00
Small plant house, with vegetable cellar and cold grapery,	4,700 00
South dormitory,	35,000 00
Stone chapel,	30,000 00
Three houses on Stockbridge Road,	5,000 00
Veterinary laboratory and stable,	23,500 00
Waiting station,	500 00
Wilder hall,	37,500 00
Young stock barn,	6,500 00
	$519,070 00

College Equipment (Estimated Value).

Agricultural division: —	
Academic,	$3,901 80
Dairy school,	1,723 82
Farm,	26,687 05
Agricultural education,	711 95
Botanical department,	7,816 52
Chemical laboratory,	7,100 00
College supplies,	205 40
Dean's office,	108 50
Dining hall,	3,341 57
Entomological laboratory,	6,495 32
Extension department,	1,775 05
Fire apparatus,	950 10
Floriculture,	6,336 25
Forestry,	306 35
General horticulture,	9,448 65
General maintenance,	65,663 16
Landscape gardening,	4,462 61
Language and literature,	189 01
Library,	63,227 85
Market gardening,	893 59
Military,	1,207 22
Pomology,	2,130 28
Physical education,	2,142 33
Physics and mathematics,	5,443 94
President's office,	1,013 20
Registrar's office,	261 51
Textbooks,	307 45
Treasurer's office,	901 50
Trophy room,	1,273 85
Veterinary laboratory,	7,685 40
Water mains,	7,850 00
Zoölogical laboratory,	8,915 28
Zoölogical museum,	6,179 93
	$256,656 44

Experiment Station Buildings (Estimated Value).

Agricultural laboratory and glass houses,	$15,000 00
Agricultural barns,	5,000 00
Agricultural glass house,	500 00
Agricultural farmhouse,	1,500 00
Plant and animal chemistry laboratory,	30,000 00
Plant and animal chemistry barns,	2,500 00
Plant and animal chemistry dairy,	2,000 00
Six poultry houses,	600 00
Entomological laboratory and glass house,	850 00
	$57,950 00

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	$6,033 05
Botanical laboratory,	4,722 55
Chemical laboratory,	17,707 85
Director's office,	3,716 50
Entomological laboratory,	22,799 98
Horticultural laboratory,	1,120 00
Meteorology laboratory,	1,304 80
Poultry department,	409 85
Treasurer's office,	433 50
Veterinary laboratory,	80 00
	$58,328 08

Inventory Summary.

Land,	$69,729 99
College buildings,	519,070 00
College equipment,	256,656 44
Experiment station buildings,	57,950 00
Experiment station equipment,	58,328 08
	$961,734 51

STUDENTS' TRUST FUND ACCOUNTS.

	Disbursements for Year ending Nov. 30, 1911.	Receipts for Year ending Nov. 30, 1911.	Balance on Hand Nov. 30, 1911.	Balance brought forward Dec. 1, 1910.
Athletics,	$5,697 71	$6,664 45	$3,536 65	$2,569 91
Dining hall,	37,436 23	42,191 68	—1,690 80	—6,446 25
Louisa Baker estate,	213 14	-	-	213 14
Keys,	23 00	24 50	30 50	29 00
College signal,	1,917 03	2,054 11	550 16	413 08
Student deposits,	4,481 93	4,897 98	554 55	138 50
Creamery house,	240 90	235 50	35 81	41 20
Trophy room,	506 66	839 00	608 57	276 23
Harlow farm,	262 11	125 00	—164 63	—27 52
Text books,	5,931 25	5,208 70	382 04	1,104 59
Kellogg farm,	169 93	137 50	35 69	68 12
Y. M. C. A.,	12 35	-	-	12 35
Musical association,	70 82	40 00	-	30 82
1912 index,	1,274 57	1,274 83	23 77	23 51
Public speaking council,	9 96	9 96	-	-
Dramatic association,	200 00	200 00	-	-
Uniforms,	3,652 23	2,160 15	239 62	1,731 10
1913 index,	151 56	2,447 74	93 18	-
	$62,251 38	$66,308 10	$6,090 54	$6,651 56
Balance on hand Dec. 1, 1910,	-	178 39	—1,855 43	—6,473 77
Balance on hand Nov. 30, 1911,	4,235 11	-	-	-
	$66,486 49	$66,486 49	$4,235 11	$178 39

Detailed Statement of Dining Hall.

	Liabilities.	Resources.
Dec. 1, 1910, overdraft,	$6,446 25	-
Nov. 30, 1911, provisions purchased,	37,436 23	-
Nov. 30, 1911, outstanding bills,	1,643 66	-
Nov. 30, 1911, total collections,	-	$42,191 68
Nov. 30, 1911, total collections outstanding,	-	1,962 31
Nov. 30, 1911, inventory,	-	1,600 50
Balance,	228 35	-
	$45,754 49	$45,754 49

The average cost of board per week for the fiscal year was $3.86.

Endowment Fund.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
		$10,613 32

[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Beneficiary Funds.

Burnham Emergency Fund.

		Market Value Dec. 1, 1911.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $910,		$1,820 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $1,020,		2,040 00	2,000 00	100 00
One bond United Fruit Company 5s,		-	-	50 00
On June 1, 1911: — The United Fruit Company's bond matured: we received,	$1,000 00			
On Aug. 2, 1911: — We purchased the Newell land for pasture and made a partial payment of,	800 00			200 00
The balance was paid by the State. Unexpended balance Dec. 1, 1910,		-	-	400 90
		$3,860 00	$4,000 00	$830 90
Disbursements for fiscal year ending Nov. 30, 1911,		-	-	230 35
Cash on hand Dec. 1, 1911,		-	-	$600 55

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s, at $940,	$4,700 00	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $940,	4,700 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $106,	212 00	200 00	10 50
Amherst Savings Bank, deposit,	167 77	167 77	6 68
	$9,779 77	$10,367 77	$417 18
Transferred to College library account,	-	-	417 18

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

	Market Value Dec. 1, 1911.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $910,	$1,820 00	$2,000 00	$80 00
Two bonds Lake Shore & Michigan Southern Railroad Company 4s, at $940,	1,880 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	940 00	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	5 72
One bond Metropolitan Street Railway, Kansas City Company 5s, at,	980 00	1,000 00	50 00
	$5,763 39	$6,143 39	$255 72
Unexpended balance Dec. 1, 1910,	-	-	986 39
	-	-	$1,242 11
One Kansas City Metropolitan Street Railway Bond, purchased Jan. 10, 1911,	-	-	994 72
Cash on hand Dec. 1, 1911,	-	-	$247 39

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$940 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	10 84
	$1,211 64	$1,271 64	$50 84
Unexpended balance Dec. 1, 1910,	-	-	57 63
	-	-	$108 47
Disbursements for scholarships for fiscal year ending Nov. 30, 1911,	-	-	90 00
Cash on hand Dec. 1, 1911,	-	-	$18 47

Hills Fund.

Northampton Institution for Savings, deposit,		$1,180 00	$1,180 00	$44 66
One bond American Telephone and Telegraph Company 4s,		910 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 4s,		940 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 3½s,		820 00	1,000 00	35 00
Two bonds Metropolitan Street Railway of Kansas City 5s, at $980,		1,960 00	2,000 00	100 00
Three bonds Pacific Telephone and Telegraph Company 5s, at $995,		2,985 00	3,000 00	150 00
One bond Western Electric Company 5s,		1,020 00	1,000 00	50 00
Boston & Albany Railroad stocks, at $221,		801 12	362 00	31 68
Amherst Savings Bank, deposit,		72 75	72 75	2 88
		$10,688 87	$10,614 75	$494 22
Unexpended balance Dec. 1, 1910,		-	-	618 46
		-	-	$1,112 68
On Jan. 10, 1911: —				
One bond of the Metropolitan Street Railway of Kansas City was purchased for	$994 72			
Disbursements by floriculture and botanical departments for fiscal year ending Nov. 30, 1911,	288 51			1,283 23
Overdraft Dec. 1, 1911,		-	-	$170 55

Mary Robinson Fund.

	Market Value Dec. 1, 1911.	Par Value.	Income.
Northampton Institution for Savings, deposit,	$820 00	$820 00	$31 04
Boston & Albany Railroad stock, at $221,	82 88	38 00	3 32
	$902 88	$858 00	$34 36
Unexpended balance Dec. 1, 1910,	–	–	55 53
Cash on hand Dec. 1, 1911,	–	–	$89 89

Grinnell Prize Fund.

	Market Value Dec. 1, 1911.	Par Value.	Income.
Ten shares New York Central & Hudson River Railroad stock,	$1,060 00	$1,000 00	$52 50
Unexpended balance Dec. 1, 1910,	–	–	193 24
	–	–	$245 74
Disbursement for prizes,	–	–	50 00
Cash on hand Dec. 1, 1911,	–	–	$195 74

Gassett Scholarship Fund.

	Market Value Dec. 1, 1911.	Par Value.	Income.
One bond New York Central & Hudson River Railroad debenture 4s,	$940 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	11 64	11 64	44
	$951 64	$1,011 64	$40 44
Unexpended balance Dec. 1, 1910,	–	–	36 37
	–	–	$76 81
Disbursements for scholarships for fiscal year ending Nov. 30, 1911,	–	–	66 30
Cash on hand Dec. 1, 1911,	–	–	$10 51

Massachusetts Agricultural College (Investment).

	Market Value Dec. 1, 1911.	Par Value.	Income.
One share New York Central & Hudson River Railroad stock,	$106 00	$100 00	$5 25
Unexpended balance Dec. 1, 1910,	–	–	50 20
Cash on hand Dec. 1, 1911,	–	–	$55 45

Danforth Keyes Bangs Fund.

	Market Value Dec. 1, 1911.	Par Value.	Income.
Two bonds Pacific Telephone and Telegraph Company 5s, at $995,	$1,990 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $990,	1,980 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $910,	1,820 00	2,000 00	80 00
Interest from student loans,	–	–	6 28
	$5,790 00	$6,000 00	$286 28
Unexpended balance Dec. 1, 1910,	–	–	345 29
Cash on hand Dec. 1, 1911,	–	–	$631 57

John C. Cutter Fund.

	Market Value Dec. 1, 1911.	Par Value.	Income.
One bond Pacific Telephone and Telegraph Company 5s,	$995 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1910,	-	-	28 33
Cash on hand Dec. 1, 1911,	-	-	$78 33

Summary of Balances on Hand of the Income from Funds held in Trust by the Massachusetts Agricultural College.

Burnham emergency fund,	$600 55
Endowed labor fund,	247 39
Whiting Street scholarship fund,	18 47
Mary Robinson fund,	89 89
Grinnell prize fund,	195 74
Gassett scholarship fund,	10 51
Massachusetts Agricultural College investment,	55 45
Danforth Keyes Bangs fund,	531 57
John C. Cutter fund,	78 33
	$1,827 90
Hills fund overdraft,	170 55
	$1,657 35

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1911. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

Amherst, Dec. 12, 1911.

History of Special Funds.

Burnham emergency fund: —

A bequest from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college have voted that the fund be kept intact, and that the income from it be used for the college for such purposes as they believe to be for its best interest, $5,000 00

Library fund: —

The library of the college at the present time contains about 30,000 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887 Elizur Smith of Lee, Mass., gave $1,215. These were the largest bequests, and amount now to . . 10,000 00

Endowed labor fund: —	
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students,	$5,000 00
Whiting Street scholarship: —	
Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship,	1,000 00
Hills fund: —	
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden,	10,000 00
Mary Robinson fund: —	
Gift of Miss Mary Robinson of Medfield, in 1874 for scholarship,	1,000 00
Grinnell prize fund: —	
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York,	1,000 00
Gassett scholarship fund: —	
Gift of Henry Gassett of Boston, the income to be used for scholarship,	1,000 00
Massachusetts Agricultural College investment fund: —	
Investment made by vote of trustees, in 1893; to purchase one share New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate,	100 00
Danforth Keyes Bangs fund: —	
Gift of Louisa A. Baker of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college,	6,000 00
John C. Cutter fund: —	
Gift of Dr. John C. Cutter of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene,	1,000 00
	$41,100 00

Prizes.

Sophomore prize in botany, given by Prof. A. V. Osmun of the department of botany, to that member of the sophomore class who presents the best herbarium in the regular course (this prize was first offered in 1908 with the hope that it might stimulate a greater interest on the part of the students in this line of work), —	$5 00
Special prize, given by the Western Alumni Association to that member of the sophomore class who during his first two years has shown the greatest improvement in scholarship, character and example, ...	25 00
	$30 00

FRED C. KENNEY,
Treasurer.

THE M. A. C. BULLETIN

AMHERST, MASS.

Vol. IV. No. 4. For May, 1912.

Published Six Times a Year by the College.
Jan., Feb., Mar., May, Sept., Oct.

ENTERED AS SECOND-CLASS MAIL MATTER AT THE POST OFFICE, AMHERST, MASS.

Public Document No. 31

CATALOGUE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

1911-1912.

FORTY-NINTH ANNUAL REPORT.

PART II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1912.

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. — *Acts of Congress, July 2, 1862.*

Massachusetts Agricultural College,

AMHERST.

Catalogue, 1911-1912.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 Post Office Square.
1912.

Approved by
The State Board of Publication.

The Massachusetts Agricultural College.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue.

Calendar.

1912–13.

Regular Courses.

1912.

January 1, Monday, 1 P.M., . . .	Winter recess ends; chapel.
January 29, Monday, ...	Semester examinations begin.
February 5, Monday, 1 P.M., . .	Second semester begins; chapel.
February 22, Thursday, . . .	Half holiday, Washington's Birthday.
March 29, Friday, 6 P.M., . . .	Spring recess begins.
April 8, Monday, 1 P.M., . . .	Spring recess ends.
April 19, Friday, ...	Half holiday, Patriot's Day.
May 30, Thursday, ...	Holiday, Memorial Day.
June 3, Monday, ...	Senior examinations begin.
June 10, Monday, ...	Non-senior examinations begin.
June 15–19, Saturday–Wednesday, .	Commencement.
June 19–22, Wednesday–Saturday, .	Entrance examinations.
September 4–7, Wednesday–Saturday,	Entrance examinations.
September 11, Wednesday, 1.30 P.M., .	First semester begins; chapel.
November 27–December 2, Wednesday, 1 P.M.–Monday, 1.10 P.M., chapel.	
December 20, Friday, 6 P.M., . .	Winter recess begins.

1913.

January 6, Monday, 1.10 P.M., . .	Winter recess ends; chapel.
January 24, Friday, ...	Semester examinations begin.
February 3, Monday, 1.10 P.M., . .	Second semester begins; chapel.
March 28, Friday, 6 P.M., . . .	Spring recess begins.
April 7, Monday, 1.10 P.M., . . .	Spring recess ends.
May 30, Friday, ...	Holiday, Memorial Day.
May 31, Saturday, ...	Senior examinations begin.
June 7, Saturday, ...	Non-senior examinations begin.
June 14–18, Saturday–Wednesday, .	Commencement.
June 18–21, Wednesday–Saturday, .	Entrance examinations.

Massachusetts Agricultural College.

History. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanic arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of the various buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the federal station, and subsequently the whole was incorporated with the college.

Courses. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-years course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science and doctor of philosophy. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and farmers' week. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, railway and trolley specials, lecture courses, demonstrations, etc.

Purpose of the College. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural colleges and high schools, for scientific experts in chemistry, entomology and botany, and for business operations having connection with practical agriculture.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, physics and zoölogy, are an essential preparation. Still other students find the course a desirable education, without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which major courses are offered.

Location and Equipment. — The agricultural college is located in the town of Amherst. The grounds comprise more than 500 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college. It was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about two-fifths of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to the committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, extension work and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

THE CORPORATION.

MEMBERS OF THE CORPORATION.

	TERM EXPIRES
DAVIS R. DEWEY of Cambridge,	1912
M. FAYETTE DICKINSON of Brookline,	1912
WILLIAM H. BOWKER of Concord,	1913
GEORGE H. ELLIS of West Newton,	1913
CHARLES E. WARD of Buckland,	1914
ELMER D. HOWE of Marlborough,	1914
NATHANIEL I. BOWDITCH of Framingham,	1915
WILLIAM WHEELER of Concord,	1915
ARTHUR G. POLLARD of Lowell,	1916
CHARLES A. GLEASON of New Braintree,	1916
FRANK GERRETT of Greenfield,	1917
HAROLD L. FROST of Arlington,	1917
CHARLES H. PRESTON of Danvers,	1918
FRANK A. HOSMER of Amherst,	1918

MEMBERS EX OFFICIO.

His Excellency Governor EUGENE N. FOSS, *President of the Corporation.*
KENYON L. BUTTERFIELD, *President of the College.*
DAVID SNEDDEN, *State Commissioner of Education.*
J. LEWIS ELLSWORTH, *Secretary of the State Board of Agriculture.*

OFFICERS OF THE CORPORATION.

His Excellency Governor EUGENE N. FOSS of Boston, *President.*
CHARLES A. GLEASON of New Braintree, *Vice-President.*
J. LEWIS ELLSWORTH of Worcester, *Secretary.*
FRED C. KENNEY of Amherst, *Treasurer.*
CHARLES A. GLEASON of New Braintree, *Auditor.*

STANDING COMMITTEES OF THE CORPORATION.[1]

Committee on Finance.

CHARLES A. GLEASON, *Chairman.*
GEORGE H. ELLIS.
NATHANIEL I. BOWDITCH.
ARTHUR G. POLLARD.
CHARLES E. WARD.
FRANK A. HOSMER.

[1] The president of the college is *ex officio* member and secretary of standing committees.

Committee on Course of Study and Faculty.

WILLIAM WHEELER, *Chairman.*
WILLIAM H. BOWKER.
M. FAYETTE DICKINSON.
DAVID SNEDDEN.
ELMER D. HOWE.
DAVIS R. DEWEY.
FRANK A. HOSMER.

Committee on Farm.

NATHANIEL I. BOWDITCH, *Chairman.*
FRANK GERRETT.
CHARLES A. GLEASON.
GEORGE H. ELLIS.

Committee on Horticulture.

J. LEWIS ELLSWORTH, *Chairman.*
DAVIS R. DEWEY.
ELMER D. HOWE.
HAROLD L. FROST.

Committee on Experiment Department.[1]

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
ARTHUR G. POLLARD.
CHARLES E. WARD.
HAROLD L. FROST.

Committee on Buildings and Arrangement of Grounds.

WILLIAM H. BOWKER, *Chairman.*
WILLIAM WHEELER.
FRANK GERRETT.
M. FAYETTE DICKINSON.
CHARLES H. PRESTON.

Examining Committee of Overseers.

JOHN BURSLEY of West Barnstable.
FRANK P. NEWKIRK of Easthampton.
WILLIAM E. PATRICK of Warren.
JOHN J. ERWIN of Wayland.
R. HENRY RACE of North Egremont.

[1] The director of the experiment station is a member of the committee on experiment department, without vote.

Officers of the Institution.

The Faculty.

[The names of the faculty are arranged in groups according to rank. Within these groups the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held.]

Kenyon L. Butterfield, A.M., LL.D., . . . President's House.
President of the College and Head of Division of Rural Social Science.

George F. Mills, A.M., ... 46 Amity Street.
Dean of the College and Professor of Languages and Literature.

Charles H. Fernald, Ph.D., ... 3 Hallock Street.
Honorary Director of the Graduate School.

William P. Brooks, Ph.D., ... 28 Northampton Road.
Director of the Experiment Station and Lecturer on Soil Fertility.

William D. Hurd, M.Agr., ... 82 Pleasant Street.
Director of the Extension Service.

Frank A. Waugh, M.Sc., . . . Massachusetts Agricultural College.
Head of Division of Horticulture and Professor of Landscape Gardening.

James A. Foord, M.Sc., ... Nutting Avenue.
Head of Division of Agriculture and Professor of Farm Administration.

Robert J. Sprague, Ph.D., ... North Amherst.
Head of Division of the Humanities and Professor of Economics and Sociology.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Goessman Professor of Chemistry.

Charles Wellington, Ph.D., ... 34 Amity Street.
Professor of Chemistry.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Professor of Veterinary Science, Chairman of Division of Science.

George E. Stone, Ph.D., ... Mount Pleasant.
Professor of Botany.

Philip B. Hasbrouck, B.Sc., ... 130 Pleasant Street.
Professor of Physics and Registrar of the College.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Professor of Mathematics and Civil Engineering.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Professor of Entomology and Acting Director of the Graduate School.

George C. Martin, C.E., Captain 18th U. S. Infantry,
35 North Prospect Street.
Professor of Military Science and Tactics.

Edward A. White, B.S., ... Mount Pleasant.
Professor of Floriculture.

William R. Hart, A.M., ... 97 Pleasant Street.
Professor of Agricultural Education.

Fred C. Sears, M.Sc., ... Mount Pleasant.
Professor of Pomology.

Fred C. Kenney, ... Mount Pleasant.
Treasurer of the College.

Robert W. Neal, A.M., ... 7 Woodside Avenue.
Associate Professor of English.

Joseph S. Chamberlain, Ph.D., ... 16 North Prospect Street.
Associate Professor of Organic and Agricultural Chemistry.

William P. B. Lockwood, B.Sc.Agr., . . . 5 East Pleasant Street.
Associate Professor of Dairying.

Elmer K. Eyerly, A.M., ... Amity Street.
Associate Professor of Rural Sociology.

Frederick F. Moon, A.B., M.F., ... 6 Allen Street.
Associate Professor of Forestry.

John A. McLean, A.B., B.Sc.Agr., ... Prospect House.
Associate Professor of Animal Husbandry.

John C. Graham, B.Sc., ... North Amherst.
Associate Professor of Poultry Husbandry.

Guy C. Crampton, Ph.D., ... 86 Pleasant Street.
Associate Professor of Entomology.

S. Francis Howard,[1] M.Sc., ... 10 Allen Street.
Assistant Professor of Chemistry.

A. Vincent Osmun, M.Sc., ... North Amherst.
Assistant Professor of Botany.

Sidney B. Haskell, B.Sc., ... 5 Fearing Street.
Assistant Professor of Agronomy.

Clarence E. Gordon, Ph.D., ... Nutting Avenue.
Assistant Professor of Zoölogy and Geology.

Edgar L. Ashley, A.M., ... Prospect House.
Assistant Professor of German.

Anderson A. Mackimmie, A.B., ... Nutting Avenue.
Assistant Professor of French.

Alexander E. Cance, Ph.D., ... 9 Fearing Street.
Assistant Professor of Agricultural Economics.

Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Assistant Professor of Beekeeping.

Edward M. Lewis, A.M., ... 29 Amity Street.
Assistant Professor of English and Assistant Dean of the College.

Charles A. Peters, Ph.D., ... 6 High Street.
Assistant Professor of Inorganic and Soil Chemistry.

Curry S. Hicks, B.Sc., ... 8 Allen Street.
Assistant Professor of Physical Education and Hygiene.

Frederick L. Yeaw, B.Sc., ... 25 North Prospect Street.
Assistant Professor of Market Gardening.

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[1] On leave of absence.

George S. Gage, Ph.D., ... 42 Lincoln Avenue.
Assistant Professor of Animal Pathology.

George N. Holcomb, A.B., S.T.B., ... Bolton.
Lecturer in History.

Frank W. Rane, M.F., ... Boston.
Lecturer in Forestry.

C. Robert Duncan, B.Sc., ... 31 North Prospect Street.
Instructor in Mathematics.

Charles R. Green, B.Agr., ... Mount Pleasant.
Librarian.

Alvah J. Norman, M.Sc., ... 7 Phillips Street.
Extension Instructor in Pomology.

George F. E. Story, B.Sc., ... 10 Allen Street.
Extension Instructor in Dairying.

Arthur K. Harrison, ... 8 Allen Street.
Instructor in Landscape Gardening.

Chester A. Butman, B.Sc., ... Prospect House.
Instructor in Physics.

Willard A. Wattles, A.M., ... Mount Pleasant.
Instructor in English.

William L. Harmount, A.B., ... Nutting Avenue.
Instructor in French.

Elvin L. Quaife, B.Sc.Agr., ... 9 Fearing Street.
Instructor in Animal Husbandry.

William L. Machmer, A.M., ... Kendrick Place.
Instructor in Mathematics.

Arthur N. Julian, B.A., ... 50 Pleasant Street.
Instructor in German.

Howard DeF. Widger, B.A., ... 13 Spring Street.
Instructor in English and Public Speaking.

Willard A. Turner, Ph.B., ... 31 Amity Street.
Assistant in Chemistry.

Helena Goessmann, Ph.M., ... 44 Amity Street.
Assistant in English.

Samuel R. Parsons, B.Sc., ... 9 Fearing Street.
Assistant in Mathematics and in Military Science.

Frederick A. McLaughlin, B.Sc., ... 120 Pleasant Street.
Assistant in Botany.

Herbert J. Baker, B.Sc., ... —— ——
Assistant in Agronomy.

Harold S. Adams, B.A., ... 32 North Prospect Street.
Assistant in Chemistry.

Graduate Assistants.

Leonard S. McLaine, B.Sc., ... 84 Pleasant Street.
Assistant in Zoölogy.

Marcus T. Smulyan, B.Sc., ... Nutting Avenue.
Assistant in Botany.

William S. Regan, B.Sc., ... 84 Pleasant Street.
Assistant in Entomology.

Raymond G. Smith, B.Sc., ... 5½ East Pleasant Street.
Assistant in Botany.

Other College Officers.

Edwin H. Forristall, M.Sc., . . . Massachusetts Agricultural College.
Farm Superintendent.

Ralph J. Watts, B.Sc., ... Nutting Avenue.
Secretary to the President.

Newton Wallace, ... 6 Phillips Street.
Electrician.

P. C. Schroyer, ... 120 Pleasant Street.
Assistant Engineer.

Clarence A. Jewett, ... 112 Pleasant Street.
Superintendent of Buildings.

James Whiting, ... Hallock Street.
Foreman, Department of Floriculture.

William Chesley, ... Draper Hall.
Steward, Dining Hall.

Miss Mary E. Caldwell, ... Draper Hall.
Bookkeeper.

Miss Henrietta Webster, ... Draper Hall.
Clerk, Treasurer's Office.

Miss Dorothy Mudge, ... North Amherst.
Clerk, Treasurer's Office.

Miss Stella H. Webb, ... 9 Phillips Street.
Correspondence Clerk, President's Office.

Miss Lillian M. Gelinas, ... Draper Hall.
Clerk, President's Office.

Miss Alice Gilbert, ... Draper Hall.
Stenographer, Division of Agriculture.

Miss Luliona N. Barker, ... 9 Phillips Street.
Clerk, Division of Agriculture.

Miss Georgia A. King, ... 9 Phillips Street.
Clerk to the Dean and Registrar.

Miss Helen V. Gaskell, ... 105 Main Street.
Stenographer, Division of Floriculture.

Miss Lina Fisher, ... —— ——
Stenographer, Department of Chemistry.

Miss Gladys E. Russell, ... —— ——
Stenographer, Division of Horticulture.

Officers of Short Courses and Extension Service.

William D. Hurd, M.Agr., ... 82 Pleasant Street.
Director.

Earnest D. Waid, B.Agr., ... 17 Fearing Street.
Assistant Director.

Charles H. White, B.Sc., ... North Uxbridge.
Field Agent.

Alvah J. Norman, B.Sc., ... 7 Phillips Street.
Horticulture.

George F. E. Story B.Sc., ... 10 Allen Street.
Dairying and Animal Husbandry.

Miss Mabel R. Case, ... Draper Hall.
Clerk to the Director.

Officers of the Experiment Station.

William P. Brooks, Ph.D., ... 28 Northampton Road.
Director.
Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Vice-Director.
Fred C. Kenney, ... Mount Pleasant.
Treasurer.
Charles R. Green, B.Agr., ... Mount Pleasant.
Librarian.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Chemist.
Edward B. Holland, M.Sc., ... 28 North Prospect Street.
Associate Chemist, in charge of Research Division.
Fred W. Morse, Ph.D., ... 44 Pleasant Street.
Research Chemist.
Henri D. Haskins, B.Sc., ... Amherst House.
In charge of Fertilizer Division.
Philip H. Smith, ... 102 Main Street.
In charge of Feed and Dairy Division.
Lewell S. Walker, B.Sc., ... 19 Phillips Street.
Assistant.
James C. Reed, B.Sc., ... Nutting Avenue.
Assistant.
Rudolf W. Ruprecht, B.Sc., ... 31 Amity Street.
Assistant.
George R. Pierce, ... North Amherst.
Assistant.
Carelton P. Jones, ... —— ——
Assistant.
Joseph P. Howard, ... North Amherst.
Collector.
Harry J. Allen, ... Amherst.
Assistant.
James R. Alcock, ... North Amherst.
Assistant in Animal Nutrition.

Department of Agriculture.

William P. Brooks, Ph.D., ... 28 Northampton Road.
Agriculturist.
H. J. Franklin, Ph.D., ... Wareham.
In charge of Cranberry Investigation.
Edwin F. Gaskill, B.Sc., ... North Amherst.
Assistant Agriculturist.

Department of Horticulture.

Frank A. Waugh, M.Sc., . . . Massachusetts Agricultural College.
Horticulturist.
Fred C. Sears, M.Sc., ... Mount Pleasant.
Pomologist.
Jacob K. Shaw, Ph.D., ... 1 Allen Street.
Assistant Horticulturist.

Department of Botany and Vegetable Pathology.

George E. Stone, Ph.D., ... Mount Pleasant.
Botanist and Vegetable Pathologist.
George H. Chapman, M.Sc., ... 13 Fearing Street.
Assistant Botanist.
Edward A. Larrabee, B.Sc., ... Clark Hall.
Assistant Botanist.

Department of Entomology.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Entomologist.
Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Apiarist.
Arthur I. Bourne, B.A., ... 66 North Pleasant Street.
Assistant in Entomology.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.

Department of Meteorology.

John E. Ostrander, A.M., C.E., ... 35 North Prospect Street.
Meteorologist.
Royal N. Hallowell, ... Massachusetts Agricultural College.
Observer.

Other Officers of the Experiment Station.

Herbert J. Baker, ... Massachusetts Agricultural College.
Secretary to the Director.
Mrs. Lucia G. Church, ... 4 Hallock Street.
Stenographer, Director's Office.

Miss F. Ethel Felton, ... 9 Phillips Street.
Stenographer, Department of Plant and Animal Chemistry.

Miss Bridie O'Donnell, ... Hadley.
Stenographer, Department of Entomology.

Miss Alice M. Howard, ... North Amherst.
Stenographer, Department of Plant and Animal Chemistry.

Miss Jessie V. Crocker, ... Sunderland.
Stenographer, Department of Botany.

Committees of the Faculty.[1]

1911–12.

Catalogue and Other Publications.

Associate Professor Neal.
Associate Professor Eyerly.
Assistant Professor Cance.

Commencement.

Professor Paige.
Professor Wellington.
Captain Martin.
Professor White.
Mr. Kenney.
Mr. Duncan.

Course of Study.

Professor Hart.
Professor Waugh.
Professor Foord.
Professor Sprague.
Professor Ostrander.
Associate Professor Chamberlain.

Discipline (Advisory).

Professor Mills.
Professor Hasbrouck.
Captain Martin.
Assistant Professor Gordon.
Assistant Professor Mackimmie.
Assistant Professor Lewis.

Employment.

Professor Sears.
Mr. Kenney.
Assistant Professor Haskell.

Entrance Examinations and Admission.

Professor Hasbrouck.
Assistant Professor Osmun.
Assistant Professor Ashley.
Assistant Professor Peters.
Mr. Machmer.
Mr. Wattles.

[1] The president of the college is ex officio member of these standing committees.

Graduate School.

Professor Fernald.
Professor Lindsey.
Professor Paige.
Professor Stone.
Professor Sears.
Assistant Professor Gordon.

Library.

Professor Stone.
Professor Brooks.
Professor Wellington.
Assistant Professor Cance.

Physical Education and Athletics.

Professor Paige.
Assistant Professor Lewis.
Assistant Professor Hicks.

Schedule.

Professor Ostrander.
Associate Professor Neal.
Associate Professor Lockwood.

Scholarship.

Assistant Professor Gordon.
Professor Mills.
Professor Hasbrouck.
Assistant Professor Mackimmie.
Assistant Professor Lewis.

Student Life.

Professor Hurd.
Associate Professor Chamberlain.
Associate Professor McLean.
Assistant Professor Haskell.
Assistant Professor Mackimmie.
Assistant Professor Lewis.
Assistant Professor Hicks.

Unclassified Students.

Professor White.
Associate Professor Lockwood.
Assistant Professor Peters.

THE COLLEGE.

ADMISSION.

A. APPLICATION FOR ADMISSION.

Correspondence about admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege on or before June 1 of the year in which examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. MODES OF ADMISSION.

Students are admitted to the freshman class either upon *certificate* or upon *examination*. No *diploma* from a secondary school will be considered.

CERTIFICATES. — The entrance requirements may be met by certification in any of the following ways: —

1. By presenting certificate from a school approved for such privilege by this college.

2. By presenting certificate from any school approved by the college entrance examination boards.

3. By presenting the customary credentials from the Board of Regents of the State of New York for any of the subjects of the entrance requirements.

Certificates must present not less than seven of the necessary fourteen credits in all. Those subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.[1]

Places of Examination. — Examinations for admission to the college are held as follows: —

In June of each year: in Amherst, in the building of the Department of Mathematics, Massachusetts Agricultural College; in Boston, in the College of Liberal Arts of Boston University, Boylston Street, corner of Exeter; in Worcester, in Horticultural Hall.

In September, examinations will be held in Amherst only.

Schedule for Entrance Examinations, June 21–24, 1912. — The examinations in June will follow this schedule: —

First Day.

1 P.M.	Registration.[2]
1.15–5 P.M.	Latin (A and B).

Second Day.

8 A.M.	Plane geometry.
10 A.M.	Chemistry.
11.30 A.M.	United States history and civics.
2 P.M.	Algebra.
3.30 P.M.	Physics.
4.30 P.M.	Elective English.

Third Day.

8 A.M.	Required English.
11 A.M.	Solid geometry, agriculture.
2 P.M.	History, required and elective.
5 P.M.	Botany.

Fourth Day.

8 A.M.	French, German, required and elective.
1 P.M.	Greek, and all one-half credit electives, except those already noted.

[1] *Entrance with Condition in English.* — Under the rule permitting entrance conditions of not more than two units of the preparatory subjects applicants may be admitted, upon examination, with a condition in English, provided that they show, upon examination, satisfactory preparation in work entitling them to a ranking of 60 or higher.

The purpose of this provision is to avoid the possible injustice of excluding, without further trial, applicants who appear to be deficient in preparation in only one subject.

Attention is called to the standing rule of the uniform entrance requirement bodies concerning English as an admission subject: namely, that applicants whose work is seriously lacking in correct spelling, punctuation, grammar or other elementary essentials of good usage will be rejected.

Students so admitted, must, to remove the condition, pass an examination covering the regular 3-units requirement.

[2] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

Schedule for Entrance Examinations in September. — In September, 1912, the examinations will be given September 11–14, inclusive, and will follow the order indicated for June, beginning September 11 at 1 P.M.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-years course in a high school or its equivalent, and are stated in terms of units. The term unit means the equivalent of four or five recitations a week for a school year. Neither more nor less credit will be given in any subject than is indicated in the table below. Fourteen units must be offered for admission, of which nine are required and five are elective.[1]

(*a*) The following nine units are required: —

Language.

English,	3
French or German,	2

History and Civics.[2]

United States history and civics,	½
History (elective),	1
(*a*) Ancient history.	
(*b*) Medieval and modern history.	
(*c*) English history.	
(*d*) General history.	

Mathematics.

Algebra, through progressions,	1½
Plane geometry,	1

(*b*) In addition to the requirements under (*a*), five units must be offered from the following-named elective subjects. Not more than four of those subjects in which the credit sought is one-half unit will be accepted.

Language.

English in addition to requirements,	1
French in addition to requirements,	2 or 1[3]
German in addition to requirements,	2 or 1[3]

[1] After September, 1913, the entrance credits will be divided as follows: 8½ from group A, 5½ from group B.

[2] Hereafter one unit in history will be required. In group (*a*) of the requirement for entrance United States history and civics will be put on the same basis with the other history requirement.

[3] If but one elective unit be offered, it must be in the same language as that offered to meet the two-year language requirement.

Greek,	2 or 3
Latin,	2 or 3

Latin A, including Cæsar and Cicero or prose composition, 2; Latin B, including Virgil and prose composition, 1.

History.

In addition to requirements,	1, 2, or 3

Mathematics, and Other Sciences.

Solid geometry,	½
Trigonometry,	½
Chemistry,	1
Physiography,	½
Physiology,	½
Agriculture,[1]	½ or 1
Botany,[1]	½ or 1
Geology,[1]	½
Physics,[1]	1
Zoölogy,[1]	½
Commercial geography,[2]	½
Drawing,[2]	½
Manual training,[2]	½ or 1

PRESENTATION OF NOTE-BOOKS.—The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 1).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificate should not present note-books; but their certificate must state that note-books have been satisfactorily completed.

D. Statement of Preparation required for Admission.[3]

In some cases the requirements of the College Entrance Examination Board are here mentioned. A pamphlet containing detailed explanation of these requirements can be had of the Board for 10 cents. Address sub-station 84, New York City.

Agriculture. — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade. The examination in agriculture will be given in September only.

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[1] Note-book required as part of preparation will be credited as part of the examination.

[2] Certification necessary in these subjects; no examinations given.

[3] In alphabetical order by subjects.

Botany. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Stevens's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit; and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

Chemistry. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements, some of the experiments being quantitative. The keeping of a note-book is required.

Commercial Geography. — Preparation should be given in a course equivalent to that laid down in Adams's "Commercial Geography," Trotter's "Geography of Commerce," or a similar work.

Drawing. — Applicants may offer either freehand or mechanical drawing, or both. They must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable them to draw correctly a simple geometric model from memory; or, if they present mechanical drawing, they must have considerable working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented see "Manual Training."

English. — Preparation in English should develop in the candidate (1) ability to express himself well and correctly in his mother tongue, and (2) ability to penetrate through language to the meaning that underlies it.

All candidates for admission — whether by examination or by certification — are urged to secure a thorough training in composition, in which at least part of the subjects written on shall be derived from personal observation, experience and thought. They are urged to cultivate especially, in all their writing, the habit of correctness in spelling, grammar, punctuation, sentence structure and paragraph building. This habit will be of much greater help to them in their work in the college than will mere knowledge of the prescribed books.

In the examination, direct questions may be put, including questions upon grammar. Several compositions, each about one hundred and fifty words long, will be required, including papers to test the candidate's ability to think and write clearly, either on matters involving personal experience or on topics involving knowledge of the books. All candidates received as members of the freshman class are expected to be able — as a result of their study of the books prescribed "For Study and Practice" — to paraphrase or interpret, with some insight, unfamiliar verse or prose of medium difficulty, in which the meaning does not depend on anything outside the passage itself; and, as part of every examination, at least one passage is given for such interpretation.

The list of books for 1912 is made up from the list recommended by the Conference on Uniform Entrance Requirements in English. The examination will be based upon these; but an applicant who has prepared upon other books of the longer list will be examined thereon if he notify the Department of English of his wish before the first day of June preceding the examinations.

For 1912: —

(*a*) For reading and composition practice: Shakspere's "As You Like It" and "Julius Cæsar;" Franklin's "Autobiography;" Goldsmith's "The Deserted Village;" Dickens's "A Tale of Two Cities;" George Eliot's "Silas Marner;" Irving's "Sketch Book;" Scott's "The Lady of the Lake;" Byron's "Mazeppa" and "The Prisoner of Chillon;" and Macaulay's "Lays of Ancient Rome."

(*b*) For thorough study and practice: Shakspere's "Macbeth;" Milton's "Comus," "L'Allegro" and "Il Penseroso," or Tennyson's "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Burke's "Speech on Conciliation with America," or Washington's "Farewell Address" and Webster's "First Bunker Hill Oration;" Macaulay's "Life of Johnson," or Carlyle's "Essay on Burns."

For 1913, 1914, 1915: —

English Grammar and Composition. — Command of correct and clear English (spoken or written) requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, paragraphs, and the different kinds of whole composition, including letter writing, should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise narration, description and easy exposition and argument based upon simple outlines. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

Literature. — Ability to read with accuracy, intelligence and appreciation is sought through study of books included in two lists, headed respectively "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud, and encouraged to commit to memory some of the more notable passages, both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads, and with their place in literary history.

(*a*) Reading: The aim of this course is to foster in the student the habit of intelligent reading, and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from which at least ten units (each unit being set off by semicolons) are to be selected, two from each group: —

I. The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of books XI., XIII., XIV., XV., XVII., XXI.; Virgil's "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any unit of this group a unit from any other group may be substituted.

II. Shakspere's "Merchant of Venice;" "Midsummer Night's Dream;" "As You Like It;" "Twelfth Night;" "Henry the Fifth;" "Julius Cæsar."

III. Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" either Scott's "Ivanhoe" or "Quentin Durward;" Hawthorne's "House of the Seven Gables;" either Dickens's "David Copperfield" or "A Tale of Two Cities;" Thackeray's "Henry Esmond;" Mrs. Gaskell's "Cranford;" George Eliot's "Silas Marner;" Stevenson's "Treasure Island."

IV. Bunyan's "Pilgrim's Progress," Part I.; "The Sir Roger de Coverley Papers" in "The Spectator;" Franklin's "Autobiography" (condensed); Irving's "Sketch Book," Macaulay's "Essays on Lord Clive" and "Warren Hastings;" Thackeray's "English Humourists;" selections from Lincoln, including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address and the letter to Horace Greeley, along with a brief memoir or estimate; Parkman's "Oregon Trail;" either Thoreau's "Walden," or Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge;" "A Liberal Education" and "A Piece of Chalk;" Stevenson's "Inland Voyage" and "Travels with a Donkey."

V. Palgrave's "Golden Treasury" (first series), books II. and III., with especial attention to Dryden, Collins, Gray, Cowper and Burns; Gray's "Elegy in a Country Churchyard" and Goldsmith's "Deserted Village;" Coleridge's "Ancient Mariner" and Lowell's "Vision of Sir Launfal;" Scott's "Lady of the Lake;" Byron's "Childe Harold," Canto IV., and "Prisoner of Chillon;" Palgrave's "Golden Treasury" (first series), book IV., with especial attention to Wordsworth, Keats and Shelley; Poe's "Raven," Longfellow's "Courtship of Miles Standish," and Whittier's "Snow Bound;" Macaulay's "Lays of Ancient Rome" and Arnold's "Sohrab and Rustum;" Tennyson's "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home

Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City."

(*b*) Study: This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. For this close reading are provided a play, a group of poems, an oration and an essay, as follows: —

Shakspere's "Macbeth;" Milton's "L'Allegro," "Il Penseroso" and "Comus;" either Burke's "Speech on Conciliation with America," or both Washington's "Farewell Address" and Webster's "First Bunker Hill Oration;" either Macaulay's "Life of Johnson," or Carlyle's "Essay on Burns."

Examination.[1] — However accurate in subject-matter, no paper will be deemed satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which may be taken as a preliminary, and the other as a final.

The first part of the examination will be based upon ten units chosen, in accordance with the plan described earlier, from the lists headed reading; and it may include also questions upon grammar and the simpler principles of rhetoric, and short compositions upon topics drawn from the student's general knowledge or experience. On the books prescribed for reading, the form of the examination will usually be the writing of short paragraphs on several topics which the candidate may choose out of a considerable number. These topics will involve such knowledge and appreciation of plot, character-development and other qualities of style and treatment as may be fairly expected of boys and girls. In grammar and rhetoric, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors.

The second part of the examination will include composition and those books comprised in the list headed study. The test in composition will consist of one essay or more, developing a theme through several paragraphs; the subjects will be drawn from the

[1] Read in connection with this statement the first three paragraphs under "English," pp. 29, 30.

books prescribed for study, from the candidate's other studies and from his personal knowledge and experiences quite apart from reading. For this purpose the examiner will provide several subjects from which the candidate may make his own selections. The test on the books prescribed for study will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their other works, and the periods of literary history to which they belong.

English, Elective. — To secure a fourth entrance credit in English, the applicant should do (*a*) the full equivalent of three years' work (required English), and also (*b*) the full equivalent of a fourth year's work. Applicants not certified with a fourth entrance credit will be examined. In order, however, that examination questions may be prepared, the applicant for examination should notify the Department of English by the first of June preceding the examinations, stating which English subject or subjects he wishes to present.

Subjects accepted. — The applicant may offer (*a*) any one of the subjects stated hereunder, or (*b*) any two of these subjects in combination.

(*a*) History of American literature.

(*b*) History of English literature (or lives of the great authors).

(*c*) Classics *other than those read to meet the three-credit requirement, the applicant to present a complete list of his readings for all four years.* The reading for the fourth credit should be of the same detailed, careful kind as is given the books prescribed for "Reading and Practice" in the official list of entrance requirement readings.

(*d*) Advanced composition.

(*e*) History of the English language.

(*f*) Advanced high school grammar.

Advanced Standing in College. — Whether advanced standing shall be given applicants entering with a fourth credit in English will be determined by consideration of each case individually. Much weight is given to the ability of the student to express himself correctly and clearly, to think clearly, and to grasp the meaning of printed language. A special examination will be given in the opening week of college, notice of which will be posted on the English bulletin board, for freshmen who wish to apply for advanced standing.

Presentation of Note-books and Themes. — Applicants for examination, either for fourth-unit credit or for advanced standing, are advised to present the note-books, themes, etc., prepared by them in the preparatory school, as an aid toward determining their proficiency.

GREEK. — Greek will receive credit as an elective requirement upon either examination or certification, as follows: —

1. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

2. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

HISTORY.[1] — Of the one and one-half required units the one-half unit must be offered in United States history and civics, and the one required unit must be offered in either ancient history, medieval and modern history, English history or general history. Either one or two elective units in any one of the historical subjects here named may be offered, provided that such units may not be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on an outline map.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

LATIN. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

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[1] Hereafter one unit in history will be required, United States history and civics being placed upon the same basis with the other history requirement.

1. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

2. Three credit units will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from either books I. to VI. of Virgil's "Æneid," or six orations of Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," books I. to IV.

Manual Training. — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

Mathematics. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the *n*th term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

PHYSICS. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work should consist of both class-room work and laboratory practice. The work covered in the class room should be equal to that outlined in Hall & Bergen's "Text-book of Physics;" the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

PHYSIOLOGY. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body: Briefer Course."

ZOÖLOGY, PHYSIOGRAPHY, GEOLOGY. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis's "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present a note-book, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

E. Admission to Advanced Standing.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. Other Information about Entrance.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)
2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.
3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. No candidate deficient in both algebra and plane geometry will be admitted.
4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination, in the week following the Thanksgiving recess. (2) Second entrance condition examination, in the sixteenth week of the first semester.
5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.
6. Examinations in part of the subjects required for entrance may be taken one year before entering college.

7. For information concerning expenses, scholarships, etc., see "General Information."

8. For information concerning admission to short courses see "Short Courses."

9. All requests for information concerning admission of unclassified students should be addressed to Prof. E. A. White, chairman of committee on unclassified students.

G. Unclassified Students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-years high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

9. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

10. No unclassified student shall be allowed to participate in any intercollegiate contests.

Courses of Instruction.

A. TABLE OF UNDERGRADUATE SUBJECTS.

[The figures indicate the number of credit hours a week. For details, see the descriptions of courses.]

Freshman Year.

First Semester.

[All work required.]

Chemistry,	3
Algebra,	3
Solid geometry,[1]	2
English,	4
Public speaking (at option of instructor),	1
French or German,[2]	4
Drill,	1
Hygiene,	1
College life (attendance without credit).	
	18 or 19

Second Semester.

[All work required.]

Animal husbandry,	2
Chemistry,	3
Trigonometry,	3
Algebra,	2
English,	4
Public speaking (if not taken in semester 1),	1
French or German,	4
Drill,	1
Physical education,	1
	20 or 21

Sophomore Year.

First Semester.

[All work required.]

Agronomy,	3
Physics,	5
Zoölogy,	3
English,	2
French or German,	3
Tactics,	1
Drill,	1
	18

[1] To be taken in course when not offered for entrance.

[2] Students may continue in college the language that they present for admission, or they may take the other; but they must continue whichever language they so elect until the end of the first semester of the sophomore year. Eleven college credits are required in this language.

Second Semester.

[All courses under "Required," with any two of those under "Elective."]

[Required.]

Elementary horticulture,	2
Botany,	4
English,	2
Agricultural industry,	3
Drill,	1
Tactics,	1
Physical education,	1
	14

[Elective.]

French or German, Animal husbandry, Geology, Physics, Chemistry, Surveying,	Each 3 hours. Any two,	6
		20

Junior and Senior Years.

[Effective to June, 1912, only.]

In the junior and in the senior year, work must be taken each semester amounting to not fewer than seventeen nor more than twenty credits.

[Required.]

The following-named subjects are required after the sophomore year, as indicated: —

Military science, two credits each semester of junior year,	4
Physical education, one credit (second semester),	1
Political science (Course 1, Economics),	3
English,	3

[Elective.]

Unless otherwise stated, elective courses to the end of the college year of 1911–12 are open to both juniors and seniors. Elections are subject to such provisions as either the faculty or the instructors in the courses may declare.

MAJORS.

Beginning with September, 1912, a plan of major courses will become operative. For statement, see Addendum.

Starred Courses.

Courses the number of which is marked with a star are announced provisionally only.

B. UNDERGRADUATE COURSES.

[All courses given in the first semester bear odd numbers; all given in the second semester bear even numbers. Studies are pursued in courses, "course" implying the study given a subject within one semester, without regard to the total number of hours or to the number of credits. The special mention of certain courses as prerequisite to other courses does not imply that no courses but those so mentioned are "preliminary or preparatory" within the meaning of paragraph 10, page 10 of the Rules.]

DIVISION OF AGRICULTURE.

Professor Foord.

AGRONOMY.

Assistant Professor Haskell, Dr. Brooks, Mr. Baker.

Required Course.

1. Soils and Fertilizers. — A study of the formation, classification and physical and chemical properties of soils. This is followed by study of methods of soil improvement and of maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments. Prerequisites, Chemistry 1 and 2. Sophomores; 3 lecture hours. Credit, 3.

Assistant Professor Haskell.

Elective Courses.

3. Field and Forage Crops. — History, classification, cultivation and harvesting, commercial grading and valuation. The crops studied are the cereal grains, grasses, legumes, forage crops, and those "money crops" of importance in New England. The laboratory work includes the testing of the purity and vitality of the seeds of the different field crops, valuation and judging thereof, and study of the varieties suited to New England conditions. Prerequisites, Agronomy 1 and Botany 2; 2 lectures and 1 laboratory period. Credit, 3. Assistant Professor Haskell.

4. Advanced Field Crops. — This course takes up the question of breeding and improvement of the crops studied in Agronomy 3; study of seed stock as offered in the market, testing of germination, purity and estimation of valuation; and the methods of production, harvesting and curing. Prerequisites, Agronomy 3 and Botany 2. Juniors and seniors; 1 laboratory period and 2 lecture periods weekly. Credit, 3. Assistant Professor Haskell.

5. Advanced Soils. — A field, laboratory and lecture course on soils; their nature, composition, physical qualities, improvement. Field work, as far as the season allows, consists of detailed soil surveys in different parts of the Connecticut valley; this followed by laboratory work on the physical properties of the soil collected, on the effect of fertilizers on the soil, and on the mixing of fertilizers. Prerequisites, Agronomy 1 and Chemistry 2. Juniors and seniors; 1 lecture period and 1 four-hour laboratory period weekly. Credit, 3.

Assistant Professor Haskell.

6. Drainage and Irrigation. — A field and lecture course on soil improvement, by drainage and irrigation. As a thesis each man is required to take an area of wet or swampy land and to present plans and estimates for its reclamation. Prerequisites, Agronomy 1 and Mathematics 8. Juniors and seniors; 1 four-hour laboratory period and 1 lecture period weekly. Credit, 3.

Assistant Professor Haskell.

8. Manures and Fertilizers. — An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Each of the important manures and fertilizers will be discussed, its origin and its chemical and physical characteristics being considered. Each material taken up will be studied in relation to its capacity to supply plant food and to its effects upon soil texture, moisture, temperature and flora. Considerable attention will be devoted to consideration of the experimental work which has been done, and which is now in progress, in manures and fertilizers. For seniors only. Prerequisite, Agronomy 1; 3 lectures a week, with occasional seminars. Credit, 3. Dr. Brooks.

ANIMAL HUSBANDRY.

Associate Professor McLean, Mr. Quaife.

Required Courses.

2. Elementary Judging. — A study of the different market classes and grades of horses, cattle, sheep and swine. The purpose of this course is to familiarize beginners with the different classes of stock, and to give them a grounding in live-stock judging. Text-book, Craig's "Live Stock Judging." Freshmen; 2 judging laboratories each week. Credit, 2.

Associate Professor McLean and Mr. Quaife.

Elective Courses.

3. Breeds and Types of Live Stock.[1] — A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Prerequisite, Animal Husbandry 2. Text-book, Plumb's "Breeds and Types of Farm Animals." Sophomores; 1 lecture and 2 laboratories. Credit, 3.
Associate Professor McLean and Mr. Quaife.

5. Principles of Breeding. — Prerequisite, Zoölogy 1. Text-book, Davenport's "Principles of Breeding." Juniors; 3 lectures. Credit, 3. Associate Professor McLean.

6. Live-stock Management. — The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, breaking to drive, driving, harnessing, casting, and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work. Prerequisite, Animal Husbandry 4. Juniors; 1 laboratory. Credit, 1.
Mr. Quaife.

8. Advanced Stock Judging. — This course is designed to equip Animal Husbandry students in the judging of classes of different types of live stock, to strengthen them in the selection of superior sires, and equip them for stock judging at fairs. Visits will be made to the best herds of the various breeds of stock in the State. Judging teams to represent the college will be largely selected from this class. Prerequisite, Animal Husbandry 4. Juniors; 2 laboratory periods. Credit, 2.
Associate Professor McLean.

9. Feeding and Management. — A study of the principles of animal nutrition; of the composition and qualities of feeding materials; of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production; a similar study of beef animals and beef production. Prerequisite, Animal Husbandry 4. Text-book, Henry's "Feeds and Feeding." Three lectures. Credit, 3. Associate Professor McLean.

[1] Formerly Course 4; will be given in fall semester in 1912–13, elective to qualified sophomores.

10. Feeding and Management. — A continuation of Course 9, dealing in a similar manner with horses, sheep and swine. Prerequisite, Course 9. Seniors; 3 lectures a week. Credit, 3.
Associate Professor McLean..

11. Herd and Stud-book Study. — An advanced course of the study of the breeds of live stock, familiarizing the student with the most productive sires and dams of the various breeds, and the successful lines and methods of breeding. Prerequisites, Animal Husbandry 5 and 8. Seniors; 2 hours a week. Credit, 2.
Associate Professor McLean.

DAIRYING.

Associate Professor Lockwood, Mr. Story.

Elective Courses.

1. Milk and its Composition. — The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; methods in economic milk production; methods for testing herds and developing them to higher efficiency; the study of analysis of milk products by use of the Babcock test for fat, test for acidity and adulteration, and ordinary preservatives; moisture tests for butter; problems. Must be preceded or accompanied by Animal Husbandry 5; 2 lecture hours and 1 laboratory period. Credit, 3.
Associate Professor Lockwood.

2. Buttermaking. — A study of hand and factory separators, separator instruction and cream separation; handling milk and cream for buttermaking on the farm and in the factory; preparation of home-made and commercial starters, and ripening cream; churning; recording work; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof; practical mechanics as applied to the creamery. Prerequisite, Course 1; 2 laboratory periods and 1 lecture hour. Credit, 3. Associate Professor Lockwood.

3. Dairy Bacteriology. — A study of bacteriology relative to market milk and dairy work. Prerequisite, Courses 1 and 2; 2 laboratory periods and 1 lecture hour.
Associate Professor Lockwood.

4. Market Milk and Milk Products. — A study of market milk conditions, extent and development of the business; supply

and delivery; food value of milk and its use as food; milk and its relation to the public health; methods for the proper handling and preparing of milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection. The manufacture of milk products other than butter, including cheese; condensed milk; cottage cheese, casein, milk powder, ice cream, etc. Prerequisites, Courses 1, 2 and 3; 1 laboratory period and 2 lecture hours. Credit, 3. Associate Professor LOCKWOOD.

5. DAIRYING. — A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work, principles of creaming, separators, elementary butter making, proper method of handling milk and cream, and the relation of market milk to the public health. One lecture, 1 two-hour laboratory period. Credit, 2.

Associate Professor LOCKWOOD.

FARM ADMINISTRATION.

Professor FOORD.

Elective Courses.

3. FARM BUILDINGS AND MACHINERY. — A study of the material equipment of the farm aside from the land; farm buildings, their location, plan and arrangement; water supply; fencing problems; farm power; farm machinery; wagons. Prerequisite, Agronomy 1, Animal Husbandry 2 and Mathematics 5; 2 laboratory periods and 1 lecture hour. Credit, 3. Professor FOORD.

4. FARM MANAGEMENT. — The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts. Prerequisites, Agronomy 1 and 3 and Animal Husbandry 2; 2 lecture or recitation hours and 1 seminar period. Credit, 3. Professor FOORD.

POULTRY HUSBANDRY.

Associate Professor Graham.

Elective Courses.

1. Elements of Poultry Culture. — This course consists of a comprehensive study of poultry-house construction, poultry-house equipment, winter egg production, breeds and types of poultry. Two lectures. Credit, 2. Associate Professor Graham.

2. Elements of Poultry Culture. — This is a continuation of Course 1, treating the subjects of incubation, brooding, care of growing stock, market poultry, including capons, roasters and broilers, and diseases of poultry. Two lectures. Credit, 2.
Associate Professor Graham.

3. Poultry Practice Work. — This is a practical laboratory course in poultry carpentry, caponizing, killing and picking, dressing and packing poultry, also sorting and preparing eggs for market. Must be preceded by or accompanied by Course 1. One laboratory period. Credit, 1. Associate Professor Graham.

4. Incubation and Brooding. — In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg, and the care of sitting hens. This course must be preceded or accompanied by Course 2. One to 3 credits. Time to be arranged.
Associate Professor Graham.

5. Pen Management. — This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls, and profit and loss. Prerequisite, Course 1. One credit. Time to be arranged. Associate Professor Graham.

6. Poultry Management. — In this course a detailed study of large poultry farms and equipment, such as bone cutters, feed cutters, cramming machines, etc., will be carried on. It includes laying out and planning poultry buildings of all kinds, the mating of fowls and the preparing of birds for exhibition. Poultry diseases and investigation work carried on by experiment stations is prominent in this course. A few good poultry plants will be visited

by the class for practical demonstrations. Prerequisites, Courses 1, 2, 3 and 4. Two lectures, 1 laboratory period. Credit, 3.

Associate Professor GRAHAM.

7. ADVANCED POULTRY JUDGING. — This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text. Prerequisites, Courses 1, 2, 3, 4 and 5. One lecture and 2 laboratory periods. Credit, 3.

Associate Professor GRAHAM.

9. MARKET POULTRY AND POULTRY PRODUCTS. — This course includes the study of market classifications of poultry, eggs and feathers; the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept, showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course. Prerequisites, Courses 1, 2 and 3. One lecture or conference period and laboratory work. Laboratory periods to be arranged. Credit, 3.

Associate Professor GRAHAM.

DIVISION OF HORTICULTURE.

Professor Waugh.

[The general subject of horticulture divides naturally into the subjects of pomology, floriculture, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore here grouped under the general designation of horticulture.]

Required Courses (General).

2. Nursery Practice. — This course treats of the fundamental operations of horticulture — propagation, pruning, cultivation — as related to the physiology of the plant. Lectures and practicums; Bailey's "Nursery Book" as text in propagation. Sophomores; 2 hours. Credit, 2. Mr. Norman.

Elective Courses (General).

3. Plant Materials. — This course aims to make the students familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them. Prerequisite, Horticulture 2; 2 lecture periods and 1 laboratory period. Credit, 3. Professor White.

4. Plant Materials. — A continuation of Course 3, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions. Prerequisite, Horticulture 3; 2 lecture periods and 1 laboratory period. Credit, 3. Professor White.

6. Plant Breeding. — This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops. Seniors and graduates; open only to students well prepared in agricultural or horticultural subjects; 2 lecture periods and 1 two-hour laboratory period. [Not given in 1912–13.] Credit, 3.

FLORICULTURE.

Professor WHITE.

Elective Courses.

1. GREENHOUSE MANAGEMENT. — This course is designed to familiarize students with methods followed in the management of greenhouse crops. The students are instructed in the practical operation of glazing concrete, bench construction, bulb culture, greenhouse watering, fumigating and ventilating, in the care of furnaces, and in the methods of propagation of greenhouse plants by seeds, cuttings, budding and grafting. This is designed as a laboratory course, and students electing it will be expected to arrange their hours according to the needs of the work. Prerequisite, Horticulture 2. Juniors; 7 hours a week. Credit, 4.

Professor WHITE.

2. GREENHOUSE DESIGN AND CONSTRUCTION. — A continuation of Course 1, including also a study of the location, arrangement and construction of greenhouses; the drawing of plans for commercial and private ranges, to show foundations and details in construction of superstructure; arrangement of heating pipes; estimates of comparative cost of different methods of construction; drafting specifications. Juniors; prerequisite, Floriculture 1; 7 hours. Credit, 4. Professor WHITE.

3. FALL GREENHOUSE CROPS. — A study of important fall and winter crops and their care, — chrysanthemums, carnations, violets, roses, palms, and the like; the importation, purchase and growth of bulbous material; the preparation of material for forcing; design making; house and church decorating. Lectures, text-books and laboratory exercises. Prerequisites, Floriculture 1 and 2. Seniors; 5 hours. Credit, 3. Professor WHITE.

4. SPRING GREENHOUSE CROPS. — The culture of individual crops in their relation to spring work in a florist establishment. A critical study of methods of propagating bedding plants, the nature and use of these plants, practice in planting them and in the spring care of herbaceous perennials and wholesale and retail marketing of spring plants. Lectures, text-books and practical exercises. Seniors; prerequisites, Floriculture 1, 2 and 3; 5 hours. Credit, 3.

Professor WHITE.

FORESTRY.

Associate Professor Moon, Mr. Rane.

Elective Courses.

1, 2. Dendrology and Silviculture. — These two subjects run parallel throughout the year. Under dendrology, the habits and needs of trees are studied, their distribution, soil and moisture requirements, growth, etc. Under silviculture are taken up the life history of trees and stands; tree characteristics, how modified; the concept of a forest and its subdivisions; methods of reproduction, both natural and artificial, with both theoretical and practical work in thinnings and nursery practice. Course 1 prerequisite to Course 2. Juniors; 3 lectures weekly, with 4 additional hours of optional field work. Credit, 3. Associate Professor Moon.

3, 4. Advanced Forestry. — Forestry 3 consists of an advanced course in forestry, in which forest economics, policy and law, forest mensuration, forest management and lumbering are taken up. Prerequisites, Forestry 1 and 2. Three lectures. Credit, 3.
Associate Professor Moon.

*5, *6. Silvics and Silviculture. — Courses consisting entirely in field work, running parallel with Forestry 3 and 4. Factors of site, silvical habits of trees, forest description and type mapping, reproduction, nursery practice, including the laying out of seed beds, forest mensuration and practical work in the various methods of making thinnings and reproduction cuttings. First given, 1912–13. Four hours. Credit, 2.
Associate Professor Moon.

LANDSCAPE GARDENING.

Professor Waugh, Mr. Harrison.

Elective Courses.

1. Elements of Landscape Gardening. — Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Students should have preparation in surveying, mathematics, plant materials and drawing. Must be followed by Course 2. Juniors; 6 hours a week. Credit, 3. Mr. Harrison.

2. Elements of Landscape Gardening. — As stated under Course 1. Prerequisite, Course 1. Mr. Harrison.

3. General Design. — Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens and parks and private grounds; written reports of individual problems. Seniors; prerequisite, Landscape Gardening 1 and 2, and either plant materials (Horticulture 3 and 4) or advanced mathematics; must be followed by Course 4; 6 hours. Credit, 3. Professor Waugh.

4. General Design. — As stated under Course 3. Prerequisite, Course 3. Professor Waugh.

5. Theory of Landscape Art. — The general theory and applications of landscape study, including a brief history of the art. Seniors and graduates; 2 hours. Credit, 2. Professor Waugh.

6. Architecture. — The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing; 2 hours. Credit, 2. (Alternating with Course 10.) Mr. Harrison.

7. Civic Art. — The principles and applications of modern civic art, including city design, city improvement, village improvement and rural improvement. Prerequisites, Courses 1, 2 and 3; must be followed by Course 8; 6 hours. Credit, 3. Professor Waugh.

8. Civic Art. — As stated under Course 7. Prerequisite, Course 7. Professor Waugh.

10. Construction and Maintenance. — Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc. Two hours. Credit, 2. (Alternating with Course 6 and not to be given in 1912–13.) Mr. Harrison.

MARKET GARDENING.

Assistant Professor Yeaw.

Elective Courses.

2. Elements of Market Gardening. — A course designed for an introduction to market gardening as a business. The work consists primarily of actual field experience in handling vegetable crops from seed to maturity. This is supplemented with lectures and text-book, in which a study of methods, soils, fertilization, tillage and management is made. Juniors; 5 hours. Credit, 3.
Assistant Professor Yeaw.

3. Advanced Market Gardening. — A continuation of the work begun in Market Gardening 2, taking up problems of seed growing, selection of varieties, crop management, harvesting, storage and marketing. A study is made of the greenhouse vegetable industry, and considerable time devoted to growing the special forced crops. Some time is given to a systematic study of vegetable description, classification and nomenclature. Collateral reading is required. Seniors; prerequisite, Market Gardening 2; 5 hours. Credit, 3. Assistant Professor Yeaw.

POMOLOGY.

Professor Sears, Mr. Norman, Mr. Rees.

Elective Courses.

1. Practical Pomology. — *General.* — A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of stock, pruning, spraying, etc. Text and reference books; field and laboratory exercises. Prerequisite, Horticulture 2. Juniors; 5 hours. Credit, 3. Professor Sears.

2. Practical Pomology. — *Special.* — The special application of the general principles discussed in Course 1 to the culture of the principal kinds of fruits, such as apples, pears, peaches, plums, cherries and quinces; grape culture and the culture of small fruits, such as blackberries, raspberries, currants, gooseberries and strawberries. Text-books, lectures and reference books; field and laboratory exercises. Prerequisites, Horticulture 2 and Pomology 1. Juniors; 5 hours. Credit, 3. Professor Sears.

3. Systematic Pomology. — A study of the varieties of the different fruits and of nomenclature, with critical descriptions;

special reference being given to relationships and classification. Text-books, laboratory and field exercises. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 5 hours. Credit, 3.

Professor SEARS.

4. COMMERCIAL POMOLOGY. — The storing and marketing of fruits; includes a discussion of storage houses, the handling and storing of fruits, fruit packages, methods of grading and packing, etc. Text and reference books; laboratory exercises. Seniors; prerequisites, Horticulture 2, Pomology 1, 2 and 3; 5 hours. Credit, 3.

Professor SEARS.

6. SPRAYING. — A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small fruit plantations. Prerequisites, Horticulture 2, Pomology 1 and 2. Seniors; 3 hours (1 lecture period and 1 laboratory period). Credit, 2.

Professor SEARS.

DRAWING.

MR. HARRISON.

Elective Courses.

1. FREEHAND DRAWING. — Lettering; sketching from type models, leaves, fruits, vegetables, flowers and trees, insects and small animals; laying flat and graded washes in water colors; water-color rendering of fruits, vegetables, leaves, flowers and trees; topographical lettering and conventional signs in ink; conventional coloring; mapping in ink and in water colors. Juniors; 6 hours. Credit, 3. Mr. HARRISON.

2. MECHANICAL DRAWING. — Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Juniors; 6 hours. Credit, 3. Mr. HARRISON.

DIVISION OF SCIENCE.

Professor PAIGE.

BOTANY.

Professor STONE, Assistant Professor OSMUN, Mr. MCLAUGHLIN.

[The object of the courses in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. Undergraduate work extending through five semesters is offered. Considerable latitude is allowed students in the senior year in their electives; and, besides the courses here outlined, students often take up the study of histology or of systematic botany, the microscopic examination of pure and adulterated human and cattle foods, spices and drugs, etc. Students sufficiently prepared are occasionally permitted to undertake special physiological and pathological investigations. A botanical conference is held monthly wherein new problems in botanical science are considered by graduate students and the seniors who elect botany.]

Required Courses.

2. HISTOLOGY, PHYSIOLOGY, MORPHOLOGY AND CLASSIFICATION OF PLANTS. — This course is divided into two parts: Part I. extends to the first week in May; Part II. occupies the remainder of the semester. Part I.: Devoted to study of the minute structure and the function of stems, leaves, roots and seeds, and of the chemical composition of plant constituents. The laboratory work consists largely of microscopic study of plant structures, with some time devoted to chemical tests for plant constituents. The lectures aim to amplify and interpret the laboratory work, and to explain the inter-relation of structure and function. Part II.: The laboratory periods are employed in the study of morphology and plant analysis. Lectures are given in morphology, ecology, evolution and taxonomy. Each student is required to collect and prepare an herbarium of 75 species of native plants. Gray's "New Manual of Botany" is used in determining and naming plants. Though only one lecture period is scheduled for this course, it is understood that laboratory hours may be used for lectures at the discretion of the instructor. Sophomores; 3 two-hour laboratory periods and 1 lecture hour. Credit, 4. Assistant Professor OSMUN.

Elective Courses.[1]

3. CRYPTOGAMIC BOTANY. — Systematic study of typical forms of the lower plants (bacteria, algæ, fungi, lichens, mosses and ferns); instruction in laboratory technique and methods, and the making of herbaria of lichens, mosses and ferns. Laboratory work and lectures; field excursions for the purpose of observing environmental habits and collecting material for laboratory study; collateral reading. This course is intended for those students who wish to specialize in biology; its purpose is to afford more thorough scientific training than is offered in Course 5, and students electing this course will attend the lectures in Course 5. Juniors; 3 two-hour laboratory periods and 1 lecture hour. Credit, 4.

Assistant Professor OSMUN.

4. CRYPTOGAMIC BOTANY. — This is a continuation of Course 3. Prerequisite, Course 3. Juniors; 1 two-hour laboratory period and 1 lecture hour. Credit, 2. Assistant Professor OSMUN.

5. PLANT PATHOLOGY. — This course comprises a study of the common diseases of crops and consideration of the methods for their prevention and control, and is intended especially for students in horticulture and agriculture. Laboratory work and lectures. The work in pathology is preceded by a brief study of the lower cryptogams. Juniors; 1 two-hour laboratory and 1 one-hour lecture period. Credit, 2.

Professor STONE and Assistant Professor OSMUN.

7. PLANT PATHOLOGY. — This course includes a study of the diseases of one or more crops and the methods of controlling them. Laboratory work and lectures, together with extensive reading of experiment station literature. The course is intended for those who wish to become more familiar with the diseases of one or more groups of economic plants. Seniors; those students continuing in botany must take Course 8; 3 three-hour laboratory periods and 1 lecture period. Credit, 5. Professor STONE.

8. PLANT PATHOLOGY. — As stated in Course 7. Prerequisite, Course 7. Professor STONE.

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[1] Students electing any of the junior work may take botany in their senior year, and those specializing in chemistry may take plant physiology in their senior year without having had the junior work in botany.

9. Economic Fungi. — This course comprises the study of economic fungi from a taxonomic point of view, and is intended for those who wish a more comprehensive knowledge of the phylogenetic relationships of fungi. Laboratory work and lectures. Tubeuf & Smith's "Diseases of Plants" is used as a guide, with special monographs on fungi and with the more important experiment station literature treating of the life history of fungi. Seniors; must be followed by Course 10; 2 or 3 three-hour laboratory periods and 1 one-hour lecture period. Credit, 4 or 5.
Professor Stone.

10. Economic Fungi. — As stated in Course 9. Prerequisite, Course 9. Professor Stone.

11. Plant Physiology. — This course is largely experimental, and is especially adapted to the needs of students who are taking chemistry. Laboratory work and lectures; various handbooks on plant physiology. Seniors; must be followed by Course 12; 3 three-hour laboratory periods and 1 one-hour lecture period. Credit, 5.
Professor Stone and Mr. McLaughlin.

12. Plant Physiology. — As stated in Course 11. Prerequisite, Course 11. Professor Stone and Mr. McLaughlin.

13. Physiology and Pathology of Shade Trees. — This course includes a comprehensive study of the diseases, structure and functions of trees and shrubs, and of every agency which in any way affects shade trees. Laboratory work and lectures; extensive reference reading. Designed for those students who intend to take charge of parks or large estates, or to become tree wardens, city foresters, landscape gardeners or professional advisers and caretakers. Seniors; must be followed by Course 14; 2 three-hour laboratory periods and 1 one-hour lecture period. Credit, 4.
Professor Stone.

14. Physiology and Pathology of Shade Trees. — As stated in Course 13. Prerequisite, Course 13. Professor Stone.

GENERAL AND AGRICULTURAL CHEMISTRY.

Professor J. B. Lindsey, Professor Charles Wellington, Associate Professor Joseph S. Chamberlain, Assistant Professor Charles A. Peters. Assistants, William A. Turner, Harold S. Adams.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and who intend following chemistry as a vocation are prepared for positions as instructors in high schools and colleges, in the agricultural experiment stations, the United States Department of Agriculture, as well as in the fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take graduate work leading especially to the degree of M.Sc., and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.[1]]

Required Courses.

1. General Chemistry. — *The Non-metals.* — An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements. Students presenting chemistry for entrance are given slightly different laboratory work. Kahlen-

[1] Changes have been made in the numbering and names of certain courses heretofore given as shown in the following table:

Former Number and Name (Catalogue, 1910–11, with Supplement).	New Number and Name.
Course 3. — General chemistry.	*Course 3.* — Qualitative analysis.
Courses 9 and 10. — Quantitative analysis.	*Course 9.* — Quantitative analysis. Includes former 9 and 10.
Courses 17 and 18. — Chemical practice in agriculture.	*Courses 10 and 11.* — Agricultural chemical analysis.
Not given previously.	*Course 12.* — Special work in agricultural analysis.
Not given previously.	*Course 14.* — Special work in physiological and organic agricultural chemistry.
Not given previously.	*Course 15.* — Physical chemistry.
Not given previously.	*Course 16.* — Special work in physical chemistry.
Not given previously.	*Course 18.* — History of chemistry.

berg's "Outlines of Chemistry" is used as a text. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.
Assistant Professor PETERS and Mr. ADAMS.

2. GENERAL CHEMISTRY. — *The Metals.* — A continuation of Course 1. A study of the common metals used in the arts. The laboratory work takes the synthetic form, and the student prepares fewer substances in larger quantities. Sulfur and arsenic insecticides and superphosphates are made in addition to preparations outlined in Blanchard's "Synthetic Inorganic Chemistry." Freshmen; lectures, 2 hours; laboratory, 2 hours. Prerequisite, Course 1. Credit, 3. Assistant Professor PETERS and Mr. ADAMS.

Elective Courses.

3. QUALITATIVE ANALYSIS. — *Basic.* — A course in the systematic analysis of metallic salts. Many of the processes used in exact analysis are studied here. Special attention is given to the treatment of colloidal solutions and to the application of the law of mass action. Designed for *sophomores* and should be taken by all intending to study chemistry further. Text, Gooch and Browning's "Outlines of Qualitative Analysis," with Treadwell-Hall's "Qualitative Analysis" for reference. Prerequisite, Course 2. First offered in 1912–13. Lecture, 1 hour; laboratory, 4 hours. Credit, 3. Assistant Professor PETERS and Mr. TURNER.

4. QUALITATIVE ANALYSIS. — *Acidic.* — A continuation of Course 3. Assistant Professor PETERS and Mr. TURNER.

5. ORGANIC CHEMISTRY. — This course, with Course 6, continues through the junior year. The two courses are designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry

and agricultural analysis, and thus for future work in agricultural chemical investigation. Prerequisites, Courses 1, 2, 3 and 4. Juniors; those electing Course 5 are expected to elect Course 6. Lectures, 3 hours; laboratory, 4 hours. Credit, 5.

Associate Professor CHAMBERLAIN.

6. As stated under Course 5.

Associate Professor CHAMBERLAIN.

7. AGRICULTURAL CHEMISTRY. — This course and Course 8 are designed as an alternative for Courses 5 and 6. They are especially intended for those who, having completed Courses 1 and 2, do not care to continue the study of chemistry for itself, but are planning to enter practical agricultural work and desire a further knowledge of chemistry as it is related directly to agriculture and agricultural problems. The work is planned in two parts, viz.: *Course 7, Inorganic Agricultural Chemistry,* the study of the general composition, properties and reactions of soils and fertilizers, and in addition to this the study of some of the more important fungicides and insecticides, and the common materials of construction, such as tile, brick, cements, paints, oils, etc. *Course 8, Organic Agricultural Chemistry,* the study of the composition, physiological processes, uses and nutritive value of plants, and the composition and general processes of nutrition and growth of animals. Also, the study of products related to plants and animals, such as milk, butter, sugar, maple syrup, denatured alcohol, wood pulp, paper, etc. The treatment of the subject in both of these courses is entirely general, avoiding all complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the chemical aspect of agricultural processes and products. Prerequisites, Courses 1 and 2. Juniors; those electing Course 7 are expected to elect Course 8. Lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor CHAMBERLAIN.

8. As stated under Course 7.

Associate Professor CHAMBERLAIN.

9. QUANTITATIVE ANALYSIS. — Instruction in this course includes the gravimetric and volumetric determinations of the commoner metals and non-metals in minerals, ores and industrial products. After closely following detailed methods of analysis, if time permits the student is directed in the discrimination between

various methods as to their accuracy and adaptability for special purposes. Talbot's "Quantitative Chemical Analysis" is used as a text. Prerequisite, Courses 1, 2, 3 and 4. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON and Mr. TURNER.

10. AGRICULTURAL CHEMICAL ANALYSIS. — In this course and Course 11 the methods previously studied, and other approved methods which appear from time to time, are applied to the examination of agricultural materials. The analysis of fertilizers, insecticides, fungicides and soils is followed by that of cattle foods, dairy products, sugars, starches and allied substances. Prerequisite, Course 9. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5. Professor WELLINGTON and Mr. TURNER.

11. AGRICULTURAL CHEMICAL ANALYSIS. — As stated under Course 10. Prerequisite, Course 10. Seniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON and Mr. TURNER.

13. PHYSIOLOGICAL CHEMISTRY. — This course is intended to be supplementary to Courses 5 and 6 and Courses 7 and 8. To those who expect to take up scientific work, and who have had Courses 5 and 6, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 5 and 6 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment station work, especially those connected with investigations in animal nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems which were treated generally in Courses 7 and 8. Prerequisites, Courses 5 and 6 or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor CHAMBERLAIN.

[*12, *14, *16. GENERAL STATEMENT. — Each student electing either of these courses will be required to take up and follow out some special line of work, the object being to acquaint him with methods of original inquiry.

A single concrete example may be found in a comparative study of the different methods for the determination of the several forms of nitrogen. A thesis may not be required, but frequent consultation of the literature bearing on the subject will be necessary. These courses are valuable for all chemists, and particularly so for those intending to take up experiment station work. A student may choose any one but not two of these separate courses.]

*12. Special Work in Agricultural Chemical Analysis. — Topics for laboratory study will be assigned to each student. Prerequisite, Course 11. First offered in 1912–13. Seniors; laboratory, 10 hours. Credit, 5.

Professor Wellington and Assistant.

*14. Special Work in Physiological and Organic Agricultural Chemistry. — In this course, as in Courses 12 and 16, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, etc. Prerequisite, Course 13. First offered in 1912–13. Seniors; laboratory, 10 hours. Credit, 5.

Associate Professor Chamberlain.

*16. Special Work in Physical Chemistry. — Special topics of agricultural importance assigned to each student. Prerequisite, Course 15. First offered in 1912–13. Seniors; laboratory, 10 hours. Credit, 5.

15. Physical Chemistry. — A résumé of general chemistry from the viewpoint of modern physical chemistry. Prerequisites, Courses 1, 2, 3, 4, 9 and 10. First offered in 1912–13. Seniors; lectures, 2 hours; laboratory 2 hours. Credit, 3.

18. History of Chemistry. — This will consist of an exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at some length. More particular attention will be

given to the questions of plant and animal industry. Chemists are strongly advised to take this course. First offered in 1912–13. Seniors; lectures, 2 hours. Credit, 2.

Professor WELLINGTON.

ENTOMOLOGY.

Professor FERNALD, Associate Professor CRAMPTON, Assistant Professor GATES, Mr. REGAN, ———.

Elective Courses.

1. GENERAL AND ECONOMIC ENTOMOLOGY. — Course 1 comprises a general introduction to the study of insects, including studies on their structure as applied to their identification; the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collections, and methods for their control. The most important insecticides and their preparation and application are also treated. Juniors; 3 lecture periods. Students electing Course 1 must also take Course 2. Credit, 3.

Professor FERNALD.

2. GENERAL AND ECONOMIC ENTOMOLOGY. — A continuation of Course 1, with laboratory and field work on methods of collecting, preserving and studying insects and their work. Juniors; 2 laboratory or field periods. Credit, 3. Professor FERNALD.

3. ADVANCED ENTOMOLOGY. — This course is subdivided, the time spent on the various subdivisions differing somewhat according to the particular needs of those taking it, and is to a large degree given in the form of individual instruction.

A. Morphology. — Careful studies of the structure of insects belonging to each of the larger and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. Histology. — Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. Insecticides and Apparatus. — Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects; tests for detecting adulterations; and a study of other methods of insect control, together with laboratory work.

D. Coccidology. — Laboratory work on methods of preserving, mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. Bibliography. — Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. Special Studies. — In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's "Manual for the Study of Insects" is used in the laboratory work. Seniors; prerequisite, Entomology 2; students electing 3 must also take 4; 1 one-hour lecture period and 3 two-hour laboratory or field periods. Credit, 4.

Professor FERNALD, Associate Professor CRAMPTON,
MR. REGAN and ——————

4. ADVANCED ENTOMOLOGY. — As stated in Course 3. Prerequisite, Course 3.

5. FOREST INSECTS. — A study of insects injurious to forest trees and of methods for their control, with laboratory and field work on these insects, and a study of what has been published about them. Seniors; prerequisites, Entomology 1 and 2. One lecture and 2 two-hour laboratory or field exercises. Credit, 3.

Professor FERNALD.

8. BEEKEEPING. — This course comprises a general consideration of the biology of the honey bee and of practical beekeeping. Some topics covered are: phylogeny, life history, general behavior and instincts, structure, products, relations of bees to plants and the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental to the industry, are considered. So far as possible the work is made individual in constructing materials and apparatus.

Juniors; Seniors may elect. Courses 1 and 2 form a desirable preparation; 2 lectures; 1 two-hour laboratory period. Credit, 3.

Assistant Professor GATES.

*10. ADVANCED BEEKEEPING. — A course in advanced beekeeping will probably be offered in 1912–13.

MATHEMATICS AND CIVIL ENGINEERING.

Professor OSTRANDER, Mr. DUNCAN, Mr. MACHMER, Mr. PARSONS.

Required Courses.

1. HIGHER ALGEBRA. — A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra." Freshmen; 3 hours a week. Credit, 3.

Mr. MACHMER and Mr. PARSONS.

2. HIGHER ALGEBRA. — As stated under Course 1.

Mr. MACHMER.

3. SOLID GEOMETRY. — Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Freshmen; required unless accepted for admission; 2 hours a week. Credit, 2.

Mr. DUNCAN.

4. PLANE TRIGONOMETRY (in Charge of Department of Physics). — The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry." Required unless accepted for admission. Freshmen; 3 hours. Credit, 3.

Professor HASBROUCK and Captain MARTIN.

Elective Courses.

6.[1] Plane Surveying. — The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures. Sophomores; 6 hours a week. Credit, 3.

Mr. Duncan and Mr. Parsons.

7. Analytic Geometry. — A discussion of the geometry of the line, the circle, of conic sections and of the higher plane curves. Fine and Thompson's "Coördinate Geometry." Prerequisites, Mathematics 1, 2, 3 and 4; 3 hours a week. Credit, 3.

Professor Ostrander.

8.[1] Differential and Integral Calculus. — A first course in the subject, with some of the more important applications. Nichol's "Differential and Integral Calculus." Prerequisites, Mathematics 1, 2, 3, 4 and 7; 5 hours. Credit, 5.

Professor Ostrander.

10.[1] Advanced Surveying. — Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. [Not given in 1912–13.] Text-book and lectures; 6 hours. Credit, 5. Professor Ostrander.

11. Hydraulics and Sanitary Engineering. — Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. [Not given in 1912–13.] Text-book and lectures; 3 hours. Credit, 3.

Professor Ostrander.

12.[1] Elementary Structures. — An elementary course in roof and bridge stresses. Text-book and lectures; 4 hours. Not given in 1911–12. Credit, 3. Professor Ostrander.

13.[1] Materials of Construction, Foundations and Masonry Construction. — Text-book and lectures; 5 hours. Not given in 1911–12. Credit, 5. Professor Ostrander.

15. Applied Mechanics. — A course in applied mechanics, based on the calculus, with problems. Text-books and lectures. Prerequisites, Mathematics 7, 10; 3 hours. Credit, 3.

Professor Ostrander.

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[1] Courses here numbered 6, 8, 10, 12, 13 and 14 were numbered 8, 10, 12, 13 and 17 respectively in the previous catalog.

14.[1] DESCRIPTIVE GEOMETRY. — An elementary course; given only in 1911–12; 5 hours. Credit, 3. Professor OSTRANDER.

PHYSICS.

Professor HASBROUCK, Captain MARTIN, Mr. BUTMAN.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Courses.

1. GENERAL PHYSICS. — General physics covers mechanics of solids, mechanics of fluids, wave motion and heat. These topics are chosen for the required work because they are regarded as the most fundamental of all, and there is no part of the work in physics more necessary for the student who plans to take up practical farming. Course given by text-book and lectures. Sophomores; 4 hours' class-room work and 1 laboratory period. Credit, 5.
Professor HASBROUCK and Mr. BUTMAN.

Elective Courses.

2. GENERAL PHYSICS. — Electricity and light. Text-book, lectures, recitations and laboratory work. Sophomores; 2 hours of class-room work and 1 laboratory period. Credit, 3.
Mr. BUTMAN.

3. OPTICAL INSTRUMENTS AND LIGHT. — Three-hour lecture course open to juniors and seniors; 3 hours. Credit, 3.
Mr. BUTMAN.

4. ELECTRICITY AND HEAT. — Three-hour lecture and laboratory course open to juniors and seniors; 3 hours. Credit, 3.
Mr. BUTMAN.

[Mathematics 4 (trigonometry) is, for convenience of grouping, listed under Mathematics, although in charge of the Department of Physics.]

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[1] Courses here numbered 6, 8, 10, 12, 13 and 14 were numbered 8, 10, 12, 13, 14 and 17 respectively in the previous catalog.

VETERINARY SCIENCE.

Professor Paige, Assistant Professor Gage.

[The courses in veterinary science have been arranged to meet the needs of students who purpose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

1. Introductory Bacteriology. — The object of this course is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and with the relation of these organisms to such processes as decomposition, fermentation and digestion, and to the production of disease. Toxic substances resulting from the growth of organisms, and the antitoxins used to counteract their action, are considered. Lectures, recitations and laboratory work. Seniors; 3 two-hour laboratory exercises. Credit, 3. Professor Paige and Assistant Professor Gage.

2. Bacteriology. — A continuation of Course 1, taking up more advanced problems.
Professor Paige and Assistant Professor Gage.

3. Veterinary Science. — A course treating of veterinary hygiene, comparative anatomy and general pathology; veterinary materia medica and therapeutics; the theory and practice of veterinary medicine; general, special and operative surgery; and veterinary bacteriology and parasitology. Lectures, clinics, demonstrations and laboratory exercises. Must be followed by Course 4. Seniors; 5 hours. Credit, 5. Professor Paige.

4. Veterinary Science. — As stated under Course 3.
Professor Paige.

ZOÖLOGY AND GEOLOGY.

Assistant Professor Gordon, Mr. McLaine.

Zoölogy.

Required Courses.

1. Elementary Zoölogy. — This course in a general way constitutes the zoölogical part of an introductory course in biology. Laboratory dissection and lectures; laboratory text, Drew's "Invertebrate Zoölogy." Sophomores; 2 two-hour laboratory periods and 1 lecture hour. Credit, 3. Assistant Professor Gordon.

Elective Courses.

3. Invertebrate Zoölogy. — This course does not include the insects. Economic zoölogy. Text-books, Parker & Haswell's "Textbook of Zoölogy," Vol. I., and Drew's "Invertebrate Zoölogy." Prerequisite, Course 1 or its equivalent. Must be followed by Course 4. Juniors; 2 two-hour laboratory periods and 1 lecture hour. Credit, 3. Assistant Professor Gordon.

4. Vertebrate Zoölogy. — Text-book, Parker & Haswell's "Textbook of Zoölogy," Vol. II. Prerequisite, Course 3. Juniors; 2 two-hour laboratory periods and 1 lecture hour. Credit, 3.
Assistant Professor Gordon.

5. Animal Parasites. — A survey of this special field of zoölogy. Laboratory and lecture work, with outside reading. Laboratory technique. Seniors; not open to fewer than 3 students. Prerequisites, Courses 1, 3 and 4. Three two-hour periods, 2 one-hour periods. Credit, 5. Assistant Professor Gordon.

6. Animal Parasites. — A continuation of Course 5. Two two-hour periods, 1 one-hour period. Credit, 3.

Graduate Courses. — See "Graduate School."
Assistant Professor Gordon.

Geology.

Elective Courses.

2. General Geology. — Rock-forming minerals; rock types; dynamical, structural and surface geology. Lectures, map and field work. Sophomores; 1 two-hour laboratory period and 2 lecture periods. Credit, 3. Assistant Professor Gordon.

DIVISION OF THE HUMANITIES.

Professor SPRAGUE.

ECONOMICS AND SOCIOLOGY.

Professor SPRAGUE.

Required Course.

1. POLITICAL ECONOMY. — An introductory course. A study of the nature and scope of economics; the evolution and organization of the present economic system, the principles of production, exchange and consumption. This course will take up such topics as value, rentals, population, labor and its problems, capital, interest and profits, systems and factors of production, tariffs and commerce. Students will be called upon to analyze industrial plants in actual operation. Text-books, lectures and general discussions; a required course, but it may be taken in either junior or senior year; 3 hours. Credit, 3. Professor SPRAGUE.

Elective Courses.

2. INDUSTRIAL PROBLEMS. — A course in the most important industrial problems of the day, covering the methods of organizations of labor and capital, systems of industrial remuneration, means of securing industrial peace, legal status of labor unions and their activities, protective legislation for workmen and employers, the problems of immigration, the sweated industries, prison labor, child labor and industrial education. Text-book, with collateral readings, lectures and discussions; 3 hours. Credit, 3.
Professor SPRAGUE.

3. SOCIAL INSTITUTIONS AND SOCIAL PROBLEMS. — This course is devoted to the study of the social institutions, such as the family, the church, State and property; and to such current social problems as divorces, race suicide, crime and prison reform, poverty and its relief, social effects of low wages, child labor, overwork, immigration and congestion of population. The later weeks of the semester will be given to a short introduction to sociological theory. The correctional and charitable institutions of Massachusetts will be studied in considerable detail. Readings, lectures, papers; 3 hours. Credit, 3. Professor SPRAGUE.

4. Modern Social Reform Movements. — The history of property and its vital issues in modern times. The socialistic systems, anarchy and communism. Systems of workingmen's insurance in Europe and America, and other methods of relief from the chances of life. Educational reforms, in process, to meet the demands of a new age, and legislative remedies for the evils of social change and maladjustment. The crisis of Christianity under modern capitalized industrialism. These topics indicate the nature of the subjects studied. This course follows Economics 3. Three hours. Credit, 3. Professor Sprague.

5. Public Finance, Money and Banking. — This course follows Economics 1. It will take up taxation and the various systems for collecting public revenue in Europe and America, with the problems involved; the history of money and the systems of banking and finance now in operation; the causes and problems of economic crises and depressions; the currency problems of the United States. Readings, lectures and discussions; 3 hours. Credit, 3.
Professor Sprague.

6. Economic History. — This course will be divided between the economic history of Europe and that of America. An outline history will be followed with special study of selected epochal periods and important topics. Three hours. Credit, 3.
Professor Sprague.

8. Anthropology; the History of Human Civilization. — The evolutionary origin and history of man; characteristics of primitive men, departure from the animal status, and the beginnings of civilization; development of industries, arts and sciences; the growth of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern conditions, will constitute the subject matter of the course. Three hours. Credit, 3.
Professor Sprague.

HISTORY AND GOVERNMENT.

Associate Professor Eyerly, Mr. Holcomb.

Elective Courses.

1. Elements of Political Science. — Nature and scope of political science; origin and evolution of the State; systems of government in the principal European States; organization and work-

ing of the national and of the State governments of the United States; relation of government to political parties and to public opinion; the functions of government as related to labor and commerce. Three hours. Credit, 3.

Associate Professor Eyerly.

2. Local Political Institutions. — A comparative study of the organization, functions and achievements of country and city groups, especially as these are concerned with such matters as taxation, finance, licenses, franchises, public ownership, highways, transportation and communication, water supply, fire protection, public lighting, markets, food inspection, garbage and sewage disposal, infectious diseases, housing conditions, police force, parks and playgrounds, libraries, schools, care of dependents. Three hours. Credit, 3. Associate Professor Eyerly.

3. The History of New England. — In this course, New England is regarded as a unit. Although the history of agriculture and rural life is treated with special fulness, ample attention is given to political, religious and ethical history. It is hoped that the student will not only be led to an intelligent understanding of present economic conditions, but will also be imbued with a progressive loyalty to the highest ideals of the New England of the past. Lectures and required reading; 3 hours. Credit, 3.

Mr. Holcomb.

5. The History of Ideals. — This course treats history from the idealistic rather than from the economic, point of view. It attempts to define the great ideals which have impelled some of the most important social, political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. Lectures and reading; 3 hours. Credit, 3. Mr. Holcomb.

LANGUAGES AND LITERATURE.

Professor MILLS.

LANGUAGES AND LITERATURE: ENGLISH, JOURNALISM AND PUBLIC SPEAKING.

Associate Professor NEAL, Assistant Professor LEWIS, Mr. WATTLES, Mr. WIDGER, Miss GOESSMANN.

Required Courses.

1, 2. FRESHMAN ENGLISH. — Composition; introduction to literature. Recitations, laboratory practice and lectures; theme writing; conferences. Text-book and laboratory manual, Neal's "Thought Building in Composition." Freshmen; 4 hours. Credit, 4.

Associate Professor NEAL, Mr. WATTLES, Mr. WIDGER and Miss GOESSMANN.

3. SOPHOMORE ENGLISH.[1] — Composition; literature. Prerequisite, Course 2; sophomores; 2 hours. Credit, 2.

Assistant Professor LEWIS and Mr. WATTLES.

4. SOPHOMORE ENGLISH.[1] — As stated under Course 3. Prerequisite, Course 3. Mr. WATTLES and Miss GOESSMANN.

Elective Courses in English Language and Journalism.

7. EXPOSITORY WRITING.[2] — The principles of exposition, with exercises in composition. Subjects will be largely found in current events and contemporary thought, and treated editorially. A foundation course in more advanced composition, primarily for juniors but open to seniors. [Not offered in 1912–13.] Two hours, with a third hour at the option of the instructor. Credit, 2. ——————

8. EXPOSITORY WRITING.[2] — The principles of exposition with especial reference to technical writing, including the writing of bulletins; some attention also to the more popular exposition of scientific facts. Primarily for juniors but open to seniors. [Not offered in 1912–13.] Two hours, with a third hour at the option of the instructor. Credit, 2. ——————

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[1] The rule that "students whose work in Courses 1, 2, and 3 reaches a standard satisfactory to the Department may be excused from not more than half of the sophomore work in English," has been repealed by faculty vote.

[2] These courses are to be substituted for the courses previously given under the same numbers as Composition Training Courses.

9, 10. Rural Journalism. — The courses in journalism aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant merely the application of journalistic principles in getting and suitably presenting material adapted to the non-urban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. Professional ideals are regarded as being practically involved in all parts of the work undertaken. Members of the classes have this year been supplying, under the head "The Bay State Ruralist," a feature page for the "Springfield Sunday Union." Members of all classes turn in copy regularly for publication or other disposition, as the instructor may determine, and must have free time for covering stories. Students wishing to proceed beyond elementary study are urged to consult with the instructor before making their election of subjects for the junior-senior years, in order that the most helpful program of work may be arranged.

9*A*. *Introduction to Journalism.* — The foundation conceptions and aims of journalism; practice in the simple forms of journalistic writing. Prerequisite to all other work in journalism, and valuable also to students preparing for practical farming, agricultural or general science, rural education, etc., as a vocation. [Heretofore given as 9*B*.] Two hours, with a third hour at option of the instructor. Credit, 2. Associate Professor Neal.

9*B*. *Journalistic Practice.* — The gathering and preparation of material for publication. The class may be organized as a staff. Prerequisite, 9*A* or its equivalent. [Heretofore given as 9*A*, Agricultural Journalism. Omitted in 1911–12.] Two hours, with a third hour at the option of the instructor. Credit, 2.

Associate Professor Neal.

9*C*. *Advanced Journalistic Practice.* — Informal; students will be assigned work as editorial assistants or writers, or otherwise employed in some form of journalistic activity. Study of particular forms of journalistic writing, of special subjects and their journalistic presentation, of particular kinds of periodical, or of

current topics, may be directed, and the presentation of a thesis may be required. Hours to be arranged. Two hours. Credit, 1.
Associate Professor NEAL.

10*A*. *Reporting.* — News-gathering and news-writing. This includes the gathering and presentation of industrial and agricultural information, campus news or other stories, as may be directed. Courses 9*A* and 10*A* are the foundation courses in journalism. Students admitted to 10*A* who have not had 9*A* will be required to do extra work. Two hours, with a third hour at the option of the instructor. Credit, 2. Associate Professor NEAL.

10*B*. *Journalistic Practice.* — As stated under 9*B*.

10*C*. *Advanced Journalistic Practice.* — As stated under 9*C*.

17. ADVANCED COMPOSITION AND LITERATURE. — The reading and study of writings that are typical of literary style or form, especially in description and narration, and the writing of exercises involving problems of the same general cost as those illustrated by the readings. A good deal of fiction will probably be read, of which more or less will be found in the novels and short stories of our own day. On this study will be based the work in composition. Primarily for seniors but open to juniors. [Not given in 1911–12.] Two hours, with a third hour at the option of the instructor. Credit, 2. Associate Professor NEAL.

Elective Courses in Literature.

9, 10. CULTURAL READING. — The substitution of other work for these courses is probable. Associate Professor NEAL.

13. ENGLISH WRITERS AND THOUGHT. — Studies, laboratory problems, readings, and reports in some period of English literature. In 1911–12, Chaucer to the sixteenth century. Three hours. Credit, 3. Associate Professor NEAL.

14. ENGLISH WRITERS AND THOUGHT. — As in Course 13. In 1911–12, the sixteenth century to Shakspere. Three hours. Credit, 3. Associate Professor NEAL.

15. ENGLISH LANGUAGE AND LITERATURE. — The origin, history and development of the English language; essayists and novelists of the nineteenth century. Continuous with Course 16. Three hours. Credit, 3. Assistant Professor LEWIS.

16. English Language and Literature. — Continuous with Course 15. The elements of literary criticism; nineteenth century poets. Three hours. Credit, 3. Assistant Professor Lewis.

18. Advanced Literature. — This course varies from year to year. It will usually provide opportunity either for intensive study of great writers or for study of the historical development or the structure and characteristics of literary types; in 1911–12, Tennyson. Three hours. Credit, 3. Associate Professor Neal.

Required Courses (Public Speaking).

1. Freshman Public Speaking. — Freshman public speaking is required in either the first or the second semester, at the option of the instructor. Voice exercises; practice in the delivery of declamations and interpretive readings. Freshmen; 1 hour. Credit, 1.
Mr. Widger.

2. Freshman Public Speaking. — As stated under Course 1. Required of all freshmen who are not assigned to take Course 1.
Mr. Widger.

Elective Courses.

*8. Oratory.[1] — Speeches on assigned topics; prescribed reading; the preparation and delivery of an oration, supplemented by a study of the principles of oratorical composition and delivery. It is especially recommended for those who desire to enter the Flint contest. Prerequisite, Course 3; 1 hour. Credit, 1.
Mr. Widger.

9. Debating. — Considerable time is given to the study of argumentation and brief-drawing. The class is divided into teams for the platform discussion of leading questions of the day. This course is designed to develop readiness in extempore speaking. It is recommended for those who desire to enter the intercollegiate debates. Prerequisite, Course 3; 2 hours. Credit, 2.
Mr. Widger.

10. Dramatic Reading.[1] — Exercises for voice and gesture; a study of the elements of vocal expression and action; expressional reading of selections in prose and poetry; presentation of scenes from plays. Prerequisite, Course 3; 1 hour. Credit, 1.
Mr. Widger.

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[1] It is expected that Courses 8 and 10 will be combined into a 2-hour course as Occasional Oratory.

LANGUAGES AND LITERATURE: GERMAN.

Assistant Professor Ashley, Mr. Julian.

Required Courses.

1. Elementary German. — Grammar and composition; the reading of short stories, poems, plays, etc. Especial attention is given to oral questioning and answering in German, and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Mr. Julian.

2. Elementary German. — As stated under Course 1. Prerequisite, Course 1. Mr. Julian.

3. Intermediate German. — Rapid reading of selected works from Schiller, Goethe, Lessing and others; review of grammar and dictation in German; outside readings. Required of freshmen who present German for entrance and do not take French. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4.
Assistant Professor Ashley.

3A. Intermediate German. — Rapid reading of prose works, such as Sudermann's "Frau Sorge," and dramas, such as "Wilhelm Tell" and "Die Journalisten." Required of sophomores who took Courses 1 and 2 as freshmen. Mr. Julian.

4. Intermediate German. — As stated under Course 3. Prerequisite, Course 3. Assistant Professor Ashley.

4A. Intermediate German. — As stated under Course 3A. Open to students who have completed German 3A; 3 hours. Credit, 3. Mr. Julian.

5. Advanced German. — Literary study of the classicists, — Schiller's "Wallenstein," Lessing's "Nathan der Weise," Goethe's "Iphigenia," etc.; collateral readings in German and class-room reports. Conducted in German. Prerequisite, Course 4. Sophomores; required of those who took German 3 and 4 as freshmen; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Ashley.

Elective Courses.

6. Advanced German. — As stated under Course 5. Sophomores; open upon arrangement to other students. Prerequisite, Course 5; 3 hours. Credit, 3. Assistant Professor Ashley.

7. Modern German. — Reading of articles from the best modern German periodicals, such as "Ueber Land und Meer;" conversation and composition work based on text. "Ferien in Deutschland," prepared by instructor; 3 hours. Credit, 3.
Assistant Professor Ashley.

8. Modern German. — As stated under Course 7.
Assistant Professor Ashley.

9. Scientific German. — Reading of modern magazine articles and works in German of a scientific nature. Different work assigned according to needs of individual students. Open to juniors who have completed Course 4A or more advanced work. Three hours. Credit, 3. Assistant Professor Ashley.

10. Scientific German. — As stated under Course 9.
Assistant Professor Ashley.

11. German Literature. — Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust," and one modern typical drama. Prerequisite, Course 6 or 10.
Assistant Professor Ashley.

12. German Literature. — As stated under Course 11.
Assistant Professor Ashley.

LANGUAGES AND LITERATURE: FRENCH.

Assistant Professor Mackimmie, Mr. Harmount.

Required Courses.

1. Elementary French. — A beginning course. Thieme and Effinger's "French Grammar;" reader; graduated texts. Required of freshmen presenting German for entrance who do not continue that language and have not studied French; open upon arrangement to other students. Freshmen; 4 hours. Credit, 4.
Mr. Harmount.

2. Elementary French. — As stated under Course 1. Prerequisite, Course 1. Mr. Harmount.

3. Intermediate French (third year). — Training for rapid reading; the reading of a number of standard novels and plays; composition; reports on collateral reading from periodicals and scientific texts in the library. Required of freshmen who present two years of French for entrance and do not take German, and of sophomores who take Courses 1 and 2 as freshmen; open upon arrangement to other students; 4 hours. Credit, 4.
Assistant Professor Mackimmie, Mr. Harmount.

4. Intermediate French. — As stated under Course 3, but not required of sophomores who take Courses 1 and 2 as freshmen. Prerequisite, Course 3. Assistant Professor Mackimmie.

5. Advanced French (fourth year). — A reading course; representative masterpieces of the nineteenth century; collateral reading and written reports. Required of sophomores who take Courses 3 and 4 as freshmen; open upon arrangement to other students. Prerequisite, Course 4; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

Elective Courses.

6. Advanced French (fourth year). — A general view of the history of French literature. Several plays of the great classical dramatists will be read. Prerequisite, Course 5. Sophomores; open upon arrangement to other students; 3 hours. Credit, 3.
Assistant Professor Mackimmie.

7, 8. Scientific French. — This course is intended to continue and enlarge the scientific readings begun in the freshman and sophomore years. It will consist of the reading of a scientific reader, outside readings and reports, and the careful reading of some recent work or series of articles in the subject in which the student is taking his major. Prerequisite, the required French or its equivalent. Intended principally for juniors. Three hours. Credit, 3. Mr. Harmount.

9, 10. French Literature from 1852. — The outline is intended as a suggestion. The exact subject-matter of the course will be determined when the men are enrolled. The object of this course is to give an introduction to the movements of French literature in the past fifty years. In the drama readings from Augier, A. Dumas, fils, Delavigne; in the novel from Flaubert, the de Goncourts, Zola; in criticism from Taine, Renan and Sainte Beuve; for the literary history of the period Lanson's Histoire de la litterature française. Prerequisite, the required French. Juniors or seniors; 3 hours. Credit, 3.

Assistant Professor Mackimmie.

LANGUAGES AND LITERATURE: SPANISH.

Assistant Professor Mackimmie.

Elective Courses.

1. Elementary Spanish. — Grammar, with special drill in pronunciation; reading from a simple reader. Seniors; open upon arrangement to other students; 4 hours. Credit, 4.

Assistant Professor Mackimmie.

2. Modern Spanish Authors. — Reading from modern Spanish novel and drama. Prerequisite, Course 1. Seniors; open upon arrangement to other students; 4 hours. Credit, 4.

Assistant Professor Mackimmie.

LANGUAGES AND LITERATURE: MUSIC.

Assistant Professor Ashley.

Elective Courses.

1. History and Interpretation of Music. — History of music among the ancients; medieval religious and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school — Bach, Händel, Haydn, Gluck and Mozart. One hour. Credit, 1. Assistant Professor Ashley.

2. History and Interpretation of Music. — A continuation of Course 1. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers. One hour. Credit, 1. Assistant Professor Ashley.

DIVISION OF RURAL SOCIAL SCIENCE.

President Butterfield.

AGRICULTURAL ECONOMICS.

Assistant Professor Cance.

Required Courses.

2. Agricultural Industry and Resources. — A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions. Sophomores; 3 hours. Credit, 3. Assistant Professor Cance.

Elective Courses.

4. Elements of Agricultural Economics. — This course is designed to follow the required work in the elements of economics. It will consider the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; determination of price; speculation; problems of land tenure and land values; taxation of land values; farmers' organizations; the farmer and legislation; the maintenance of the social, political and economic status of the farmer; and the relation of the farmer to the State. Lectures, text, readings, topics and field work; 3 hours. Credit, 3. Assistant Professor Cance.

5. Historical and Comparative Agriculture. — A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on present conditions and the history of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, to show that the agriculture of any country is a distinct individual problem, and to ascertain the causes now working to effect agri-

cultural changes. Lectures, readings and library work. Seniors and juniors; open to other students upon arrangement; prerequisite, Course 4 or equivalent; 3 hours. Credit, 3.

Assistant Professor CANCE.

[6. CO-OPERATION IN AGRICULTURE. — The course contemplates a somewhat comprehensive view of the history, principles and business relations of agricultural organization for profit. (1) A survey of the development and progress, the methods and economic results, of the farmers' organizations and great co-operative movements in the past; (2) the phases of business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, as illustrated by the most advanced and prosperous business organizations and exchanges, with particular reference to the marketing of perishable products. Lectures, text, assigned reading and practical exercises; 2 hours. [Not given in 1912–13.] Credit, 2. Assistant Professor CANCE.]

7. PROBLEMS IN AGRICULTURAL ECONOMICS. — An advanced course for students desirous of studying more intensively some of the problems immediately affecting the welfare of the farmer and society. Some of the problems that may be studied are: land problems, — land tenure; size of farms; causes affecting land values; private property in land; taxation of farm values; special problems, — cost of producing farm products; farm labor in New England; immigration; shifting of the rural population. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest. Seniors and juniors; open upon arrangement to other students; enrollment subject to approval of instructor; 2 or 3 hours a week. Credit, 2 or 3. Assistant Professor CANCE.

8. THE AGRICULTURAL MARKET. — This course contemplates a fundamental study of the forces and conditions which determine the prices of farm products, and the mechanism, methods and problems concerned with transporting, storing and distributing them. Such topics as supply and demand, course of prices, transportation by freight, express and trolley, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market, direct sales and the like will be taken up. The

characteristics and possibilities of the New England market will be given special attention. Lectures, readings, assigned studies and field work. [Not offered in 1913–14.] Juniors and seniors; 2 or 3 hours a week. Credit, 2 or 3. Assistant Professor CANCE.

9. SEMINAR. — Research in agricultural economics and history: New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged. Credit, 1. Assistant Professor CANCE.

10. SEMINAR. — As stated in Course 9.
Assistant Professor CANCE.

AGRICULTURAL EDUCATION.

Professor HART, Associate Professor MORTON.

Elective Courses.

1. MEANING OF EDUCATION (PSYCHOLOGY). — A study of the development, structure and function of the nervous system with reference to the sense organs; relation of mind to the nervous system; growth and nature of mental processes; the activities of the mind in the process of learning. Text-book, lectures, discussion, and collateral readings and reports; 3 hours. Credit, 3.
Professor HART.

2. VOCATIONAL EDUCATION (HISTORY AND PHILOSOPHY). — A survey of educational, religious and social movements with reference to their vocational aspects; the growth of educational institutions as influenced by science and industry. Lectures, collateral readings, reports, and a thesis on some phase of industrial education; 3 hours. Credit, 3. Professor HART.

3. RURAL SCHOOL PROBLEMS. — A study of mental growth; the theory and practice of teaching; school organization and methods of instruction; the place and function of agriculture in the course of study. Primarily for those who have had Course 1 or 2; 2 hours. Credit, 2. Professor HART.

4. RURAL SCHOOL PROBLEMS. — Designed primarily for those who intend to teach; may be taken in connection with Course 3. The work consists of the selection and review of such parts of the courses in agriculture, horticulture and the biological and physical

sciences as are adapted to the work of the public schools; planning, and practical work in school gardens; decoration of school grounds; equipment and conduct of playgrounds. One lecture period, 2 two-hour laboratory periods. Credit, 3.

Professor HART, Associate Professor MORTON.

5. SEMINAR IN EDUCATION. — For students who have had courses 1, 2 and 3, or an equivalent. Topics that may be taken up for rather exhaustive study are: rural school supervision, and rural school surveys, etc. Seniors and graduate students; 2 hours. Credit, 2. Professor HART.

6. SEMINAR IN EDUCATION. — As stated under Course 5.

Professor HART.

RURAL SOCIOLOGY.

Associate Professor EYERLY, President BUTTERFIELD, Professor HART, Mr. HOLCOMB.

Elective Courses.

2. THE RURAL COMMUNITY. — A broad survey of the field of rural sociology, including such topics as the movements of the rural population, the social conditions and life of rural people, the influence of rural life, the description of the various social institutions of the rural community, an analysis of the fundamental problems of rural life, and the means of developing and redirecting the life of the rural community. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3.

President BUTTERFIELD and Associate Professor EYERLY.

3. THE LITERATURE OF RURAL LIFE. — A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities; 3 hours. Credit, 3.

Mr. HOLCOMB.

4. RURAL LAW. — The work of this course will cover such points as land titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures, and class discussions; 1 hour. Credit, 1. Professor HART.

5. THE SOCIAL CONDITIONS OF THE RURAL PEOPLE. — Composition of the rural population; vital statistics; nature, extent and causes of diseases and accidents; health agencies of control; extent and causes of delinquency and dependency; conditions of temperance, of sexual morality and family integrity; child labor; woman's work and position; relation of employer to employee; standard of living; size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics; 3 hours. Credit, 3. Associate Professor EYERLY.

6. SOCIOLOGICAL ASPECTS OF CO-OPERATION AMONG FARMERS. — An historical sketch of the origin, extent and success of co-operation among farmers in the various European countries and in the United States; personal qualities and social conditions necessary to successful co-operative endeavor; the various forms of co-operative organization viewed in their industrial, intellectual and moral aspects; the influence of co-operation on the farmer's individualism, conservatism, self-help, thrift, contentment and on agrarian legislation, scientific agriculture and farm labor; the relation of co-operation to neighborhood life, to community pride and loyalty, to further associated effort, to class stability, solidarity and status; the demand of co-operation for a new type of leadership; the relation of co-operation to socialism and the competitive system; 3 hours. Credit, 3. [Given in 1912–13; not given in 1913–14.]

Associate Professor EYERLY.

7. RURAL INSTITUTIONS. — A study of the organized agencies by which rural communities carry on their various forms of associated life; particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment. Special attention given to the rural family and the rural church; 3 hours. Credit, 3.

Associate Professor EYERLY.

8. THE STATE AND THE FARMER. — A general survey of political organizations and movements among farmers in foreign countries and their influence in shaping agrarian legislation; the character, extent and results of foreign State aid to the farming class; political movements among farmers in the United States; "Granger" legislation; relation of the Department of Agriculture, State boards of agriculture, agricultural colleges and experiment stations, postal

system, railway commissions, highway commissions, public health agencies, etc., to rural welfare; 3 hours. Credit, 3.

Associate Professor EYERLY.

9. THE SOCIAL PSYCHOLOGY OF RURAL LIFE. — Characteristics of the rural mind; character of hereditary and environmental influences; nature and effects of face to face groups; psychological effects of isolation, relative security and freedom from strain; relation of contact with nature, of control over immediate environment, of family co-operation and of neighborhood life to self-control, self-expression, sympathy, service and leadership; nature and effects of fashion, conventionality and custom; character of discussion and public opinion, and their relation to class feeling and organization; relation of individualism, conservatism and homogeneity to crowd phenomena and progressive democracy; 3 hours. Credit, 3. Associate Professor EYERLY.

10. FARMERS' ORGANIZATIONS. — The history, purposes and achievements of the grange, the farmers' union, farmers' clubs, village improvement associations, boys' clubs, etc.; the nature, scope, methods and history of local, State and national associations formed about some farm product or special farm interest, *e.g.*, dairying, horticulture, stock breeding, forestry; their influence on "better farming, better business, better living;" their influence in forming a class consciousness and in shaping legislation; need of federation; 3 hours. Credit, 3. Associate Professor EYERLY.

11. SOCIOLOGICAL ASPECTS OF CURRENT AGRICULTURAL QUESTIONS. — Government conservation policy, roads, railways, trolleys, telephones, postal service, credit facilities, taxation, pure food laws, tenancy and ownership, intensive versus extensive farming, agricultural labor; 3 hours. Credit, 3.

Associate Professor EYERLY.

13. SEMINAR.

Associate Professor EYERLY.

GENERAL DEPARTMENTS.

MILITARY SCIENCE AND TACTICS.

Captain Martin, Mr. Parsons.

[The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-years course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical (drill) courses in Military Science are given up to the Christmas recess and from the close of the spring recess to the end of the semester each year; the corresponding courses in Physical Education occupy the intervening time.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

A dark blue uniform, old army pattern, costing about $15, is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $15 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

Required Courses.

1. FRESHMAN DRILL. — Practical instruction in infantry drill regulations through the school of the battalion in close and extended order; advance and rear guards; outposts; marches; ceremonies; guard duty. Upon the conduct and proficiency of this year depends the appointment of corporals for the ensuing year. Freshmen; first semester until Christmas recess; 3 hours. Credit, 1.
Captain MARTIN, Mr. PARSONS.

2. FRESHMAN DRILL. — As stated under Course 1. Freshmen; second semester after spring recess; 3 hours. Credit, 1.
Captain MARTIN, Mr. PARSONS.

3. SOPHOMORE DRILL. — Practical instruction as before; pointing, aiming and sighting drills; litter drills, and first aid to the injured by detachment; target practice, in gallery and on the range. Corporals are appointed from this class. On their conduct and proficiency depends the appointment of sergeants in the next class. Sophomores; first semester until Christmas recess; 3 hours. Credit, 1. Captain MARTIN, Mr. PARSONS.

4. SOPHOMORE DRILL. — As stated under Course 3. Sophomores; second semester after spring recess; 3 hours. Credit, 1.
Captain MARTIN, Mr. PARSONS.

5. SOPHOMORE TACTICS. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the company, "Manual of Guard Duty," "Small Arms Firing Regulations." Sophomores; 1 hour. Credit, 1. Captain MARTIN.

6. SOPHOMORE TACTICS. — As stated under Course 5. Sophomores; 1 hour. Credit, 1. Captain MARTIN.

7. JUNIOR DRILL. — Practical instruction as before, target practice, in gallery and on the range. Sergeants are appointed from this class. On their conduct and proficiency depends their selection as officers for the ensuing year. When necessary, officers will also be appointed from this class. Juniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain MARTIN, Mr. PARSONS.

8. JUNIOR DRILL. — As stated under Course 7. Juniors; second semester after spring recess; 3 hours. Credit, 1.
Captain MARTIN.

9. JUNIOR TACTICS. — Theoretical instruction in "Infantry Drill Regulations," to include the school of the battalion; advance and rear guards; outposts; marches and ceremonies; "Manual of Field Service Regulations;" preparation of reports, returns, muster-rolls, enlistment and discharge papers, rosters, requisitions, etc.; army regulations; lectures on military science. Juniors; 1 hour. Credit, 1. Captain MARTIN.

10. JUNIOR TACTICS. — As stated under Course 9. Juniors; 1 hour. Credit, 1. Captain MARTIN.

Elective Courses.

11. SENIOR DRILL. — Practical instruction as before; conduct of drills of lower classes. Officers will as a rule be selected from this class. Cadets electing Courses 11 and 12 must make the election for the year, and not later than the first Monday in June of their junior year. No cadet electing this course will after the commencement drill be permitted to change his election without the consent of the dean of the faculty and of the commandant. Seniors; first semester until Christmas recess; 3 hours. Credit, 1.
Captain MARTIN.

12. SENIOR DRILL. — As stated under Course 11. Seniors; second semester after spring recess; 3 hours. Credit, 1.
Captain MARTIN.

PHYSICAL EDUCATION AND HYGIENE.

Assistant Professor HICKS.

HYGIENE.

Required Courses.

1. HYGIENE. — Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation. Freshmen; 1 hour. Credit, 1. Assistant Professor HICKS.

PHYSICAL EDUCATION.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in Military Science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. Elementary Gymnastics. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 2. Freshmen; 3 hours. Credit (given only for Course 2), 1.

Assistant Professor Hicks.

2. Elementary Gymnastics. — As stated under Course 1.

Assistant Professor Hicks.

3. Graded Gymnastics. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 4. Sophomores; 3 hours. Credit (given only for Course 2), 1.

Assistant Professor Hicks.

4. Graded Gymnastics. — As stated under Course 3.

Assistant Professor Hicks.

5. Heavy Gymnastics. — Drills, games and athletics; from January 1 to April 1, in connection with Course 6. Juniors; 3 hours. Credit (given only for Course 2), 1.

Assistant Professor Hicks.

6. Heavy Gymnastics. — As stated under Course 5.

Assistant Professor Hicks.

Elective Courses.

7. Training Course. — Leadership class and squad work; supervision of indoor and outdoor athletic contests and games; boxing and wrestling. Seniors; 3 hours. Credit, 1.

Assistant Professor Reynolds.

8. Training Course. — As stated under Course 7.

Assistant Professor Reynolds.

The Graduate School.

The Graduate School.

Kenyon L. Butterfield, A.M., LL.D., President of the College.

Henry T. Fernald, Ph.D., Acting Director of the Graduate School and Professor of Entomology.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years. Demands for these courses have now greatly increased, and in recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station agriculturists, bacteriologists, botanists, chemists, entomologists, horticulturists and zoölogists; and for numerous other positions requiring a great degree of skill and scientific knowledge.

Admission.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.

2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the professor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for admission to the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, — together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

Nature and Methods of Graduate Work.

Persons taking graduate work will find this quite different in its nature from undergraduate courses. A broad knowledge of two (or three) subjects is required, and the professors in charge of these may adopt any methods which may seem desirable to secure this to the student. Lectures, laboratory and field work in various forms are utilized; but whatever the method chosen, the aim is to train the students in methods of original investigation and experiment, inductive reasoning and the ability to carry on independent research. In addition to the lectures, a large amount of outside reading is required, the object being to give a broad knowledge of all aspects of the subjects chosen, in addition to the complete knowledge of those portions involved in or directly related to the original investigation which is to result in the thesis. Originality and ability to lead in scientific research after completing graduate work, and the establishment of a broad and thorough foundation upon which these qualities must be based, are the objects aimed at; and any methods which promise to give these results may be made use of (varying according to the nature and personal equation of each student), the supervision being largely individual rather than collective.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as the major and the other as the minor. These subjects may not be selected in the same department.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major, the others as minors. No two of these subjects may be taken in the same department.

Advanced students who are not candidates for degrees may, with the approval of the faculty of the school, take more than one subject in the same department.

A statement of the subjects chosen must in each case be submitted to the director of the school for approval by the necessary committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

A description of the equipment of the various departments is given under "General Information."

Theses.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject, must show that its writer possesses the ability to carry on original research, and must be an actual contribution to knowledge.

Two copies of each thesis in its final form, ready for the printer, must be submitted to the director of the school before the candidate for the degree may take the required oral examination. One of the said copies, to contain all drawings, is to be retained as an official copy by the said director, and the other by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis. When printed, three copies of each thesis must be deposited with the director of the graduate school and three copies with the department in which the work was carried out.

All theses become the property of the department in which they are prepared.

Final Examinations.

For the degree of master of science, a final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degree of doctor of philosophy, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

Degrees conferred.

The degree of master of science is conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.

2. The devotion of twenty hours each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.

3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.

4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The degree of doctor of philosophy is conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.

2. The devotion of twenty hours each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.

3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary.

4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The fee for the degree of master of science is $10, and for the degree of doctor of philosophy, $25.

Courses for Degree of Master of Science.

Available either as major or minor subjects for the degree of master of science: —

Agriculture.
Botany.
Chemistry.
Entomology.
Horticulture.
Mathematics and physics.
Veterinary science.

Available as a minor subject for the degree of master of science: —

Zoölogy.

Courses for the Degree of Doctor of Philosophy.

Available for a major subject for the degree of doctor of philosophy: —

Botany.
Chemistry.
Entomology.
Horticulture.

Available for a minor subject for the degree of doctor of philosophy: —

Agriculture.
Botany.
Chemistry.
Entomology.
Horticulture.
Zoölogy.

General Outline of Courses for the Doctorate.

(a) *Major Courses.*

Botany. — The following subjects in botany may be studied: —

(*a*) Vegetable physiology.
(*b*) Vegetable pathology.
(*c*) Mycology.
(*d*) Ecology.
(*e*) Taxonomy.
(*f*) Phylogeny.
(*g*) History of botany.
(*h*) History and theory of evolution.

These subjects are pursued, to a greater or less extent, as the previous training of the student and the nature of the original problem undertaken may determine. The object of the course is to give the student a technical training in botany, to develop the spirit of research and to lay a broad foundation in the subject. (As a supplement to this course the student will do well to take, in addition to his prescribed minor work, a brief course in the history of philosophy and psychology.) Extensive reading of botanical literature, both general and specific, is required in certain subjects, and occasional lectures are given. A botanical conference is held monthly, in which various new problems of botanical science are considered by graduate students and the seniors who elect botany. A thesis dealing with some economic problem in plant physiology or pathology, or in both, and containing a distinct contribution to knowledge, is required.

Chemistry. — The department of chemistry is prepared to offer advanced courses in the following subjects: —

(*a*) Inorganic chemistry.
(*b*) General organic chemistry.
(*c*) Physiological chemistry.
(*d*) Qualitative and quantitative analysis.
(*e*) Analyses of fertilizers, cattle feeds, dairy products, soils, insecticides, sugars, and of any other materials of an agricultural nature.

Instruction may also be obtained in special problems relating to the chemistry of soils, plants and animals. Students are taught how to conduct original investigations. Further information may be secured by consulting the chemical staff of the department.

ENTOMOLOGY. — I. For the degree of doctor of philosophy as a major: Some knowledge of all the divisions of this subject is essential for the professional entomologist, though a large part of his time will be devoted only to certain portions. To insure some familiarity with all these divisions, lectures, laboratory work, field training or required reading are given in each of the following topics: —

(*a*) *Morphology.* — Embryology; life history and transformations; histology; phylogeny and the relation of insects to other arthropods; hermaphroditism; hybrids; parthenogenesis; pedogenesis, heterogeny; chemistry of colors of insects; luminosity; deformities of insects; variation; duration of life.

(*b*) *Ecology.* — Dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migration; geological history of insects; insects as disseminators of disease; enemies of insects, vegetable and animal, including parasites.

(*c*) *Economic Entomology.* — General principles; insecticides; apparatus; special cases; photographs of insects and their work; methods of drawing for illustrations; field work on insects and study of life histories; legislation concerning insects.

(*d*) *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.

(*e*) *Seminar.* — A monthly meeting of graduates, at which reports on current literature are presented and various entomological topics of importance are discussed.

(*f*) *Required Readings.* — The best articles on the various topics named above and on the different orders of insects, to cover from fifteen thousand to twenty thousand pages of English, French and German, the candidate to be examined at the close of his course on this with his other work.

(*g*) *Thesis.* — A thesis, illustrated with drawings, consisting of the results of original investigation upon one or several topics, and constituting a distinct contribution to knowledge, must be completed before the final examinations are taken.

II. For the degree of doctor of philosophy as a minor, and for the degree of master of science either as a major or minor: Such portions of the course outlined above as seem most appropriate to their other subjects are given to students taking entomology as a minor.

HORTICULTURE. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, original investigation and the development of individual initiative in dealing with new questions. Each candidate must select some special field of horticultural study, and devote himself to it continuously. He will be required to attend lectures, conferences and seminars dealing with horticulture in its broader aspects, and to do advanced work in the following subjects: —

(*a*) Systematic pomology.
(*b*) Pomological practice.
(*c*) Commercial pomology.
(*d*) Systematic, practical and commercial olericulture.
(*e*) Greenhouse plants and problems.
(*f*) Floriculture.
(*g*) Landscape gardening.
(*h*) Plant breeding and general evolution.
(*i*) Questions of physiology connected with propagation and pruning.

Other requirements and opportunities are (1) periodical seminars, with special lectures by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits, always with definite purpose, to orchards, gardens, greenhouses, estates and libraries outside the college grounds; and (4) the preparation and publication of a thesis which shall set forth the results of the candidate's major study, and be an original and positive contribution to horticultural knowledge.

It is probable that the work in horticultural subjects will soon be considerably developed and modified.

(*b*) *Minor Courses.*

ZOÖLOGY. — Courses in zoölogy are available as a minor for the degrees of master of science and doctor of philosophy. The nature of the work varies according to circumstances, and may be intensive in a special field, or of a somewhat more general character; depending on the student's previous acquaintance with general zoölogical science.

The time devoted to zoölogy as a minor for either of the above-named degrees may vary from twelve to sixteen hours per week, pursued for a year and a half.

THE SHORT COURSES

AND

THE EXTENSION SERVICE.

The Short Courses and the Extension Service.

Under the usual definition of extension activities, Short Courses are not strictly extension work. They are rather a part of the academic work of the institution. For the sake of administrative efficiency it has seemed best to place them in charge of the Director of the Extension Service, in so far as organization and direction are necessary. An effort is made through these courses to bring to the college, for a few weeks or a few days, as many people as can possibly be reached in this way. In the main, the instruction in the Short Courses is given by the regular teaching force of the college, the same laboratories and equipment being used for this work as in the regular college work.

The Extension Service proper comprises various methods for the dissemination of agricultural information to the people of the Commonwealth who are interested in agriculture and country life, but who cannot come to the college for even a short time. The object of the Extension Service is to make the college as useful to the people of the Commonwealth as is possible.

A. THE SHORT COURSES.

Organization and Description.

The work is organized thus: —

Short Courses given at the College.

1. Winter School.
   - (*a*) Ten Weeks' Winter Course.
   - (*b*) Poultry Course.
   - (*c*) Farmers' Week.
   - (*d*) Beekeepers' Course.
   - (*e*) Packing School.
2. Summer School.
   - (*a*) The Summer School (General Course).[1]
   - (*b*) Conference for Rural Leaders.

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[1] Omitted in 1912.

ENROLLMENT, 1910–11.

Ten Weeks' Winter Course,	113
Special Poultry Course,	74
Farmers' Week,	830
Beekeepers' Course,	16
Summer School,	153
Conference of Rural Social Workers,	247
Total,	1,433

Short Courses at the College (Winter School; Summer School).

EXPENSES IN THE SHORT COURSES. — The expenses of attending either of the short courses will be about as follows: —

Registration fee,	$5
Furnished rooms with private families, per week,	$1–$3
Board at college dining hall, per week,	$4
Board with private families, per week,	$4–$5

Students in either of the dairy courses must provide themselves with two white wash suits and a white cap for use in the practical dairy work; the cost in Amherst is about $1.25 for suit and cap.

REQUIREMENTS FOR ADMISSION TO SHORT COURSES. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic before entering. Practical experience in farm, garden, orchard or greenhouse work will be an advantage. The courses are open to both men and women. Students must be at least eighteen years of age, and must furnish satisfactory evidence of good moral character.

Application for admission should be made as early as possible. Students should report to the professor in charge on Monday, Jan. 6, 1913, in order to begin work promptly on the morning of Jan. 7, 1913.

COURSES IN THE TEN WEEKS' WINTER SCHOOL (JAN. 2 TO MARCH 8, 1912). — The following courses were given: —

1. Soil Fertility. Director HURD and Assistant Director WAID. Three exercises a week for ten weeks.
2. Field Crops. Assistant Professor HASKELL. Three exercises each week for ten weeks.
3. Breeds and Breeding. Associate Professor MCLEAN and Mr. QUAIFE. Three exercises weekly, with appointed hours for stock judging.
4. Feeding and Management. Associate Professor MCLEAN and Mr. QUAIFE. Two exercises weekly.

5. Dairying. Associate Professor LOCKWOOD, Mr. STORY and assistants. Three one-hour and two two-hour periods.
6. Dairy Bacteriology. Associate Professor LOCKWOOD. Two exercises each week.
7. Animal Diseases and Stable Sanitation. Dr. PAIGE. Two exercises each week.
8. Poultry Course. Associate Professor GRAHAM. Lectures with one or two demonstration periods per week.
9. Fruit Growing. Professor SEARS. Five exercises each week for ten weeks.
10. Market Gardening. Assistant Professor YEAW. Three lectures and one afternoon practicum each week for ten weeks.
11. Landscape Gardening. Professor WAUGH and Mr. HARRISON. Twenty exercises.
12. Floriculture. Professor WHITE. Five exercises each week.
13. Forestry. Associate Professor MOON. One lecture a week for ten weeks.
14. Botany. Assistant Professor OSMUN and Mr. McLAUGHLIN. Three exercises each week.
15. Entomology. Professor FERNALD and assistants. Three exercises each week.
16. The Development of the Community. Two periods a week for ten weeks.
17. Farm Buildings and Machinery. Professor FOORD. One exercise a week for ten weeks.
18. Farm Accounts. Professor FOORD. One exercise each week.
19. Mechanics. Professor LOCKWOOD and Mr. WALLACE. One exercise of two hours each week.
20. Meat, Meat Production and Marketing on the Farm. Mr. HINKLEY, of Armour & Co.
21. Rural Sanitary Science. Assistant Professor GAGE. Two one-hour exercises per week.

THE ONE WEEK POULTRY COURSE (WINTER SCHOOL, MARCH 4 TO 8, 1912). — In order to give a large number of poultry men, who cannot come to the college for a longer time, practical instruction in modern methods of breeding, feeding, poultry-house construction, operation of incubators and brooders, selecting and judging poultry for utility and for show, marketing poultry products, etc., a convention was held on the dates given above. The week was filled with practical talks and demonstrations. Some of the leading professional and practical men in this country were engaged to supplement the work of the regular faculty. No charges aside from cost of room and board were made for this course.

FARMERS' WEEK (WINTER SCHOOL, MARCH 11 TO 15, 1912). — In order to reach those who cannot come to the college for a longer time, this very practical course, four days in length, is given. The regular college equipment is used, and the work of the regular faculty will be supplemented by lectures and demonstrations given by eminent men.

The work is divided into three sections: (1) General agriculture, to include farm management, farm crops, dairying, animal breeding and feeding, veterinary science and bacteriology; (2) Horticulture, to include fruit growing, market gardening, floriculture and forestry; (3) Farmers' wives' section, including lectures and demonstrations in home economics, cookery and problems of home making.

Features of the week will be the evening lectures by specialists along agricultural lines, the conference pertaining to problems of rural betterment aside from practical agricultural topics, a corn and grain show, and others.

The Massachusetts Dairymen's Association, M. A. C. Agricultural Improvement Association and other organizations hold their annual meetings at the college this week.

BEEKEEPERS' COURSE (WINTER SCHOOL, MAY 29 TO JUNE 12, 1912). — The college has recently come into possession of a number of swarms of bees which, with the other equipment to be added, will afford a fine opportunity for those interested to get some practical information on this subject. The course will be under the direction of Dr. Burton N. Gates. The following courses will be given: —

1. Practical Phases of Beekeeping. Assistant Prof. BURTON N. GATES.
2. Crops for Honey Bees. Dr. WILLIAM P. BROOKS.
3. Relation of Bees to the Pollination of Plants. Prof. GEORGE E. STONE.
4. Origin and Evolution of the Honey Bee. Prof. HENRY T. FERNALD.
5. Bees and Beekeepers' Supplies. Dr. JAMES B. PAIGE.

PACKING SCHOOL (WINTER SCHOOL, FEB. 12 TO 24, 1912). — The greatest need in New England fruit growing is acknowledged to be proper grading and packing of the fine fruit that is already being grown. To give all who desire it the best of instruction in this subject, a two weeks' course in packing was arranged between the dates given above. The work consisted of grading and packing apples in boxes and barrels. Special lectures and demonstrations were arranged for those who attended, on the subjects of planting, fertilizing, pruning, spraying and the management of orchards.

THE SUMMER SCHOOL (GENERAL COURSE). — The very successful summer school of agriculture and country life which has been held by the college for the last five years will be omitted in 1912. In 1913 it will be resumed, with the addition of new courses, more instructors and covering a broader scope of work.

A bulletin giving the courses, instructors and other information will be issued in March, 1913.

Conference for Rural Leaders (Summer School, June 28 to July 3, 1912). — The Conference for Rural Leaders which has been held as a closing feature of the summer school will take place as usual, except at an earlier date (June 28 to July 3 inclusive).

The Federation of Churches of Massachusetts, the State Library Commission, Massachusetts Civic League, the New England Home Economics Association, the County Work of the Y. M. C. A. and the State Board of Education have each decided to co-operate with the college by furnishing teachers and lecturers for their respective sections. The State Grange and the State Board of Health have been asked to co-operate in a similar manner.

Definite class instruction will be given each morning. The afternoons will be given up entirely to special and general conferences, demonstrations of organized play, recreation, etc. The evenings will be given over to music and lectures by the most eminent men, who are making a study of rural sociology, economics and education.

The Rural Social Service exhibits will be more elaborate and extensive than in 1911.

The object of this conference is to acquaint those who are leaders in their respective communities with the work that is going on, not only in Massachusetts but in New England and other parts of the world, and to give them renewed inspiration and enthusiasm for larger and more intelligent efforts.

Teachers, clergymen, grange officers, librarians, county Y. M. C. A. workers, town officers, boards of health, officers of village improvement societies, home makers, school officers, and all others interested in community development, are cordially invited to attend this conference. The expenses for board and room are low. There are no tuition or registration fees.

A complete program will be published next May and can be had by making application for it.

B. THE EXTENSION SERVICE.

Organization and Description.

1. Special Days for Foreigners; Agricultural Organizations, etc.; Polish Farmers' Day.
2. Instruction given away from the College.
    1. Correspondence Courses.
    2. Lecture Courses and Demonstrations.

3. Conferences for Community Development.
4. Extension Schools of Agriculture.
5. Educational Trains (Steam and Trolley).
6. Educational Exhibits, with Lectures and Demonstrations at Fairs.
7. Demonstration Orchards.
8. Dairy Improvement Associations.
9. The M. A. C. Agricultural Improvement Association.
10. Agricultural Surveys.
11. Advisory Work with Individuals, State Institutions, etc.
12. Publications, "Facts for Farmers," etc.
13. Student Extension Work.
14. Faunce Demonstration Work.
15. Boys and Girls' Clubs.
16. Demonstration Plots.
17. Traveling Libraries.
18. Co-operation with Various Organizations already in Existence.
19. District Field Agents.
20. Information by Correspondence, etc.

1. *Special Days for Foreigners, Associations, etc.*

Days are set aside for especial attention to the interests of foreigners, of agricultural organizations, etc.

Agricultural Organizations. — It has been especially pleasing to the college to have organizations such as the Massachusetts Poultry Association, the Massachusetts Fruit Growers' Association, Market Gardeners' and Breeders' Associations, and others of a similar nature meet frequently at the college. Usually, a program of one or two days is provided, largely by the college faculty. These meetings serve the twofold purpose of giving the members of these organizations a chance to inspect the equipment and see the work that is being carried on by the college, and it also gives the college men a chance to find out the needs of the men engaged in the various lines of agriculture. It is to be hoped that organizations like those named above and others will continue to meet at the college even more frequently than in the past.

Polish Farmers' Day. — In order to show the Polish farmer — who forms a large part of the population of this section of the Connecticut valley — what the college has to offer him, a Polish Farmers' Day was held in 1911. This was such a success that a like day was held March 28, 1912. Members of the faculty gave lectures which were interpreted by Mr. Wolski of Holyoke; some of the Polish farmers who have made a success of farming also gave talks. The Y. M. C. A. co-operates with the college in this work, and Dr. Tupper of the Immigration Department and Mr. Rudman, county secretary for Franklin County, addressed the gathering.

Mr. John Romaszkiewisc, president of the Polish American Alliance, also gave an address.

2. *Instruction given away from the College.*

An abstract follows of the instruction that is given away from the college. The abstract divides this instruction into correspondence courses and instruction not included in the correspondence course.

Correspondence Courses. — The correspondence courses are offered by the Massachusetts Agricultural College in response to calls from all sections of the State, from people who desire agricultural information but who, for various reasons, cannot come to the college for it. These courses are designed to meet the needs of farmers, dairymen, stock breeders, fruit growers, market gardeners, floriculturists and teachers, either in elementary schools, high schools, academies or normal schools.

Since agricultural science and practice have changed and are changing so rapidly, it is the purpose to give a summary of the latest information on the subjects treated, yet in such language that any who pursue the study can readily understand the work. Additional courses, covering other subjects, will be added later.

Method of Conducting Correspondence Work. — While a large number of books have been written on various agricultural subjects, very few of them are especially adapted to the correspondence course work. For this reason our courses are conducted principally by especially prepared lessons. The subject-matter of these lessons partakes somewhat of the lectures that are given to the college classes. Whenever possible we recommend one or two books which ought to be purchased and read along with the course. Other books are recommended for collateral reading, which oftentimes can be obtained from the local libraries.

The courses are especially recommended to Y. M. C. A.'s, granges and other farmers' clubs for study. It is to be hoped that grange lecturers, club secretaries or some other interested person will organize study classes. If the size of the class, or the interest which the members take in the subject, is sufficient, we shall be pleased to send a representative of the college to the class from time to time to discuss the work and offer suggestions. A description of the correspondence courses follows: —

1. Soil and Soil Improvement. Director W. D. Hurd. The cost of the course is $1.

2. Manures and Fertilizers. Director W. D. Hurd. The cost of the course is $1.
3. Field Crops. Assistant Prof. Sidney B. Haskell. The cost of the course is $1.
4. Farm Dairying. Prof. W. P. B. Lockwood. The cost of the course is $1.
5. Fruit Growing. Prof. F. C. Sears and Mr. A. J. Norman. The cost of the course is $1.
6. Market Gardening. Assistant Prof. F. L. Yeaw. The cost of the course, including the textbook, is $2.50.
7. Animal Feeding. Mr. G. F. Story. The cost of the course is $1.
8. Floriculture. Prof. E. A. White. Part I. The general culture of plants, including those grown out of doors as well as those grown under glass. Part II. Greenhouse construction and heating. Part III. Carnation culture. Part IV. Rose culture. The cost of each part, not including the textbook, is $1.
9. Farm Accounts. Prof. J. A. Foord. The cost of the course is $1.
10. Agriculture in the Common Schools. Assistant Prof. F. B. Jenks. The cost of the course is $1.
11. Agricultural Education. Prof. W. R. Hart. The cost of the course is $1.
12. Beekeeping. Assistant Prof. B. N. Gates. The cost of the course is $1.
13. Forestry. Associate Prof. F. F. Moon. The cost of the course is $1.
14. Shade Tree Management. Prof. G. E. Stone. The cost of the course is $1.
15. Entomology. Prof. H. T. Fernald. The cost of the course is $1.
16. Poultry. Associate Prof. J. C. Graham. The cost of the course is $1.

Enrollment for Correspondence Courses. — Students may enroll in the correspondence courses any time between September 1 of each year and the following 1st of June. It has been found advisable not to run the courses during the summer, because the farmers as well as the other students are so busy that they cannot spend the necessary amount of time upon the lessons during the summer months. We are better equipped than we were last year to handle the great number of students who desire these courses, and we hope to be able to handle all the students who enroll; nevertheless, it will be well to enroll early so as to be sure of getting in before the enrollment closes.

Enrollment must be made on the card which is furnished by the college. This will entitle the student to a suitable set of covers for the courses, and other privileges.

Expenses of the Correspondence Courses. — In order that none may enroll but those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at the uniform rate of $1 for each course, except in Course 8, where it is necessary to charge $1 for each of the four parts, as each part is really a course in itself. This fee is payable strictly in advance, when the enrollment card is sent. The first lesson of the course will not be sent until the enrollment fee is paid.

This fee is not charged to cover cost of preparing the course, for this, in time of the instructors, is many times what is received, but it is used to defray the expenses of postage and materials which are used in preparation of the lessons, and to insure a higher quality of work from those who enroll.

The cost of the text-book, when one is used, is in addition to this enrollment fee. We strongly urge all students to purchase one or two books to be used in connection with each course, because they can be kept and used for reference purposes after the course is completed. We have made arrangements with the Johnson Book Company, Amherst, Mass., to handle all of these books at reduced rates.

For a catalogue of books and prices address the Johnson Book Company, Amherst, Mass.

Remittances should be made by money order or check.

Lecture and Demonstration Courses away from the College. — The renewed and unprecedented interest in agriculture and rural life makes many more calls on the college for lectures and demonstrations than can be met. These calls come from all sorts of organizations, and the audiences are usually of good size and comprised of interested people, who are eager to get the latest scientific information to use in their work.

Conferences on Community Betterment. — Largely as an outgrowth of inspiration received in our Summer School and Conference, meetings have been held in West Newbury, Sandwich, Walpole, Rowe and Kingston, where subjects of community betterment were discussed. The whole State is alive to this question, and many similar meetings are known to be contemplated for the near future.

Extension Schools of Agriculture. — There has been a call from differents parts of the State for instruction of a more systematic and far-reaching nature than can be given in a single lecture or demonstration. Extension schools, five days in length, have been planned for West Brookfield, Walpole, Shelburne and Kingston. Several other applications for similar schools are already in file.

Educational Trains (Steam and Trolley). — In 1910, co-operating with the State Board of Agriculture, the State Forester and the Boston & Albany and Springfield trolley systems, a steam train (four cars) and a trolley train (five cars) were run through western Massachusetts. Stops of from one and one-half to two hours were made at Westfield, Pittsfield, Cheshire, North Adams, Chester, Springfield, Enfield, New Salem, Athol, Templeton, Barre, Ware, Palmer, East Brookfield, Worcester, Westborough, South Framingham, Milford, Amherst, South Hadley, Russell, Huntington, North Wilbraham, Brimfield, Sturbridge, Charlton, Oxford, Holden and Sterling. Inquiries have already come in asking when more of this kind of work will be carried on.

Educational Exhibits, Lectures and Demonstrations at Fairs. — During the last two years the college has made extensive exhibits at fairs held in Barnstable, Worcester, Clinton, Greenfield, Amherst, Northampton, Topsfield, South Framingham and Amesbury; also at the New England Corn Show, the National Corn Show, Columbus, O., the Massachusetts Corn Show and the New England Industrial Exposition. At each fair five or six short practical talks and demonstrations have been given each day. Fair managers and the general public have been very appreciative of this work.

Demonstration Orchards. — New orchards of from four to six acres each have been planted by the college in the towns of West Newbury, Westhampton, Sturbridge, Medway, Granville, Enfield and North Adams. Renovation plots have been selected in Hardwick, North Adams and North Grafton.

Dairy Improvement Associations. — Two of these have been started during the year, one in the Connecticut valley and one in Norfolk County. Other sections of the State desire the college to organize similar associations, but so far we have been unable to find men to act as official testers.

The M. A. C. Agricultural Improvement Association. — This is an organization of ex-students of this college, banded together for the purpose of improving plants, animals and the conditions of rural life. There are now 110 members. The usefulness of this organization depends almost entirely on the ability of the college to furnish proper supervision for the organization and direction of the work.

Agricultural Surveys. — Through these surveys an attempt is made, by systematic study, to find out the exact conditions of farm management, including dairying, orcharding, poultry raising and other specialties, the income which is derived from these, and the facilities for marketing products. An inquiry into the social, educational, religious and moral life of rural communities is also made. Under the direction of Dr. Alexander E. Cance and two assistants, a fairly comprehensive survey of the town of Belchertown was made during the past summer.

Advisory Work with State Institutions, Individuals, etc. — From letters received from about 28 State institutions, it is evident that co-operation on the part of the college in the handling of the agricultural plants connected with these institutions would be warmly welcomed and is much desired. Some of these institutions have already been visited and help has been given. A large number of individuals have applied to the college for expert advice and help. It is possible to send men to only a small percentage of those who have asked for this personal help.

Extension Service Publications. — Each year, bulletins and circulars descriptive of the various short courses have been published. Each month, "Facts for Farmers" has been issued, and is much sought after. The titles of the pamphlets already published are as follows: "Directions for Selecting Corn for Exhibition," "Fall Spraying for Massachusetts Orchards," "The Possibility of Keeping Bees," "Some Good Books for Farmers and Others interested in the Affairs of the Country," "Pruning of Shade Trees," "Top Grafting Fruit Trees," "Feeding for Milk Production," "Home-mixed Fertilizers," "Summer Spraying," "The Feeding and Care of Chicks hatched artificially," "Home Vegetable Gardening," "Fruit for Exhibitions," "Pig Feeding," "Clean Milk." A list of desirable books on agriculture and rural social science is usually kept on hand for distribution.

Student Extension Work. — About 30 of our college students have been doing volunteer work in the smaller towns near Amherst during the past two years. The communities reached have been Cushman, Sunderland, Leverett, Shutesbury, Pelham, Belchertown, South Amherst, Hadley, South Hadley, North Hadley, Dwight, Granby, Conway, Ashfield, Hatfield, Shelburne Falls, Three Rivers, Cummington and Northampton. The work has consisted chiefly in teaching English to foreigners, coaching school athletic teams, supervising contests, organizing debating societies, giving talks on clean living, conducting religious services, giving musical entertainments, teaching Bible classes, acting as judges at grange fairs, etc.

The Faunce Demonstration Farm. — This farm, located at Sandwich, has been under the direction of a committee from our faculty, of which the Director of the Extension Service is chairman. The farm has demonstrated beyond a doubt that small fruits, vegetables and poultry can be raised at a profit on Cape Cod. Through the work of this farm the whole community has taken on new life. The superintendent of the farm, Mr. A. W. Doolittle, has taught agriculture in the schools of the village, and has given much help to the farmers of Barnstable County by his personal visits to farms.

BOYS' AND GIRLS' CLUBS. — This work has been under the direction of Prof. W. R. Hart and Assistant Prof. F. B. Jenks of the Department of Agricultural Education. The large numbers enrolled, and the interest that has been shown on the part of school superintendents, parents and pupils, will attest to the value of these clubs as a means of turning the attention of the young people in our smaller towns to the possibilities open to them in their home communities.

DEMONSTRATION FIELD PLOTS. — Aside from the work done by the members of the M. A. C. Agricultural Improvement Association, little has been done toward placing demonstration plots in different sections of the State. Co-operating with the Bureau of Plant Industry of the United States Department of Agriculture, four demonstration pasture plots have been placed on farms in the vicinity of Amherst, for a study of some method of improving the typical hill pastures of Massachusetts.

TRAVELING LIBRARIES. — Through the generosity of several of the leading publishers of agricultural books, in donating about 160 of the latest books on various agricultural subjects, the college has been able to place in circulation four traveling libraries. These they loaned to the libraries of small towns for a few weeks at a time, and the books are loaned to those interested in reading them. These libraries are in great demand.

CO-OPERATION WITH EXISTING ORGANIZATIONS. — The aim of those in charge of the Extension Service has, from the start, been to co-operate with existing organizations so far as possible. During the past two years we have co-operated with the State Board of Agriculture, the State Board of Health, the State Dairy Bureau, the State Grange, the Boston Chamber of Commerce, the Springfield Board of Trade, the county work of the Y. M. C. A., several village improvement associations, the Tent Evangelistic Work in western Massachusetts, the Y. M. C. A.'s of Worcester and Springfield, men's clubs in churches, women's clubs, the schools of a number of towns, and other agencies interested in the rural problem.

DISTRICT FIELD AGENTS. — Mr. Charles H. White (M. A. C. 1909) is now devoting part time to the work of field agent in southern Worcester County. Mr. White visits farms, and is ready, on consultation by farmers, to bring to the men the best advice the experts at the college can give. He attends grange meetings, farmers' institutes, and co-operates with all sorts of organizations on the arrangement of programs. He is available for conferences at all times with farmers on questions of farm management.

Through the Short Courses and the Extension Service, an effort is made to render the departments of the Massachusetts Agricultural College as helpful to the people of the Commonwealth as they can be. Correspondence is invited from any who desire such helps as have been spoken of. Letters should be addressed to the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

General Information.

General Information.

A. FINANCIAL AND ADMINISTRATIVE.

Student Expenses.

Tuition. — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $40 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk, stating that the applicant's father is a legal resident of Massachusetts.

Dormitories and Board. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bed rooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1.25 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present the price of board there is about $4 a week. Board is furnished at cost, the price being determined by adding 5 per cent. to the audited rate for the previous three months, and at the end of the period final settlement is made on the basis of actual cost.

Expenses.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts free; other citizens of the United States, $40 a year; foreigners, $120 a year.

	Low.	High.
Room in college dormitories or in private houses,	$39 00	$110 00
Board in college dining hall, $4 a week,	144 00	144 00
Laundry, 50 cents to 85 cents a week,	18 00	30 00
Military uniform, first year,	13 50	13 50
Laboratory fees,	2 00	20 00
Books, stationery and other miscellaneous,	23 50	32 50
	$240 00	$350 00

Other Expenses. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various student organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student furniture in dormitories, either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $250 and $350 per year.

Laboratory Fees.

The following laboratory fees are at present charged. The schedule is subject to modification without previous announcement in the catalogue.

	Per Semester.
Botany: —	
Graduates,	$4 00
Courses 2, 3,	3 00
Course 4,	2 00
Course 5,	1 00
Courses 7, 9, 11, 13,	3 00
Chemistry: —	
Courses 1, 2, 11, 13, 14, each,	3 00
Courses 4, 5, 6, each,	4 00
Courses 9, 10, 15, 17A, B, C or D, 18A, B, C or D,	5 00
Entomology: —	
Graduate,	3 00
Entomology 3,	3 00
Entomology 4,	3 00
Landscape gardening: —	
Landscape gardening 1, 2,	2 50
Landscape gardening 3, 4, 7, 8,	4 00
Landscape gardening 6,	1 00
Drawing 1, 2,	2 50
Zoölogy: —	
Elementary 1,	2 00
Invertebrate 3,	4 00
Vertebrate 4,	4 00

Student Aid.

Self Help. — A number of students find opportunities for earning money without depending upon the college to furnish them with work, and many are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should remember that, owing to the large number of applications for employment, no one man can receive a large amount of work through the college.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and thirty or more students are employed at the dining hall. Applications for student labor should be made directly to the president. Applicants are required to present a certificate, signed by parent or guardian and by one of the selectmen or aldermen of the town or city in which they reside, showing that the applicant needs the assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last year or two the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer.

The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

Student Accounts.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each semester. This rule is strictly adhered to, and no student will be allowed to register in his classes until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each semester at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the semester he is more than one week in arrears in his payment for board.

All money due for student labor shall be applied on account toward any bills that a student may owe to the institution.

B. COLLEGE ACTIVITIES.

General Exercises.

Chapel exercises are held four mornings each week. On Wednesday, instead of chapel an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

Student Activities.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about four years ago. All students become members of the Union by paying a small fee. The Union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study. In the basement of this building there is also a game room for pool and billiards. In the fall and winter months the Union gives a series of entertainments, free to the students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The Young Men's Christian Association is active both socially and religiously. Under its direction voluntary Bible classes are conducted during the winter months. A Catholic Club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A Dramatic Club has been organized, and each year presents a play.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and tennis.

A Rifle Club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Signal," published weekly by the student body, and the "Index," published annually by the members of the junior class.

The Stockbridge Club is an organization of students especially interested in practical agriculture, horticulture and floriculture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Scientific clubs also exist in the departments of French, entomology and landscape gardening.

C. ACADEMIC AND DEPARTMENTAL.

Degrees.

Those who complete a four-years course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10.

Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-years course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

Prizes.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1912 are: —

Agriculture. — The Grinnell prizes (first, second and third), given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture. They are $25, $15 and $10.

Botany. — The Hills prizes (amounting to $35), given by Henry F. Hills of Amherst, will be awarded to members of the senior class as follows: for the best herbarium, $15; for the best collection of Massachusetts trees and shrubs, $10; for the best collection of Massachusetts woods, $10. No collection deemed unworthy of a prize will be considered. In 1912, a prize of $5 is offered to that member of the sophomore class who presents the best herbarium of native flowering plants.

General Improvement. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during the first two years in college, has shown the greatest improvement in scholarship, character and example.

Public Speaking. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declarations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

Military Diplomas.

Military diplomas are given to those men receiving the degree of bachelor of science who by their work in the department of military science have shown themselves worthy of distinction. These diplomas recommend those receiving them for commissions in the United States army or the militia of the several States.

Equipment.

Agronomy. — The work in agronomy is carried on by means of lectures, laboratory work and field work. The laboratories are in the north wing of South College. The seed laboratory is equipped with samples of the different grains and seeds of economic importance in field culture, and with apparatus for the study and testing of these seeds, including microscopes and the apparatus necessary for viability and purity tests. The soil laboratory is well equipped with apparatus for the study of the physical properties of soils, including an electric centrifuge; an electric resistance thermometer for determining soil and other temperatures; evaporimeters and drying ovens; and good balances. For the work in drainage there is available a surveyor's transit, a wye level, drainage levels, rods, steel tapes, surveyor's pins, and a set of drainage tools. The college farm may also be considered a part of the agronomy laboratory.

Animal Husbandry. — The most important part of the equipment for laboratory work in animal husbandry is the new judging pavilion, which will be completed by Jan. 1, 1911. This will give new opportunities for practice work in management of live stock, together with demonstrations in judging. Another very essential part of the equipment for this department is the live stock of the college farm, which includes pure bred and grade Ayrshire, Guernsey, Holstein and Jersey cattle, French coach and Percheron horses, and Berkshire swine. A set of plaster-of-paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different food stuffs available for the use of the New England farmer, are included in the equipment for this work.

Botany. — The department of botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for sophomore and junior work, and one for senior work; and three rooms specially fitted for graduate students. The experiment station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with all necessary conveniences. The basement contains a bacteriological laboratory, a seed and soil room; and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe, and other tools and appliances. In the senior laboratory is a room designed especially for physiological work; this laboratory is well supplied also with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc. The herbarium contains 15,000 species of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and about 12,000 sheets of fungi. The laboratory is equipped with 90 modern compound microscopes and a number of dissecting microscopes, microtomes and a large series of charts. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experiment work and for housing material often needed in the laboratory.

Chemistry. — The department of chemistry occupies an entire building, supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor seats 84 students and that on the third floor 100 students. The laboratories for beginners have 80 working tables, which accommodate 180 students in sections. Each table is supplied with reagents and apparatus for independent work. Well-equipped organic, physiological and quantitative laboratories for advanced students are also provided. The weighing room connected with the quantitative laboratory has 11 balances. The equipment includes a valuable and growing collection of specimens and samples of rocky minerals, soils, raw and manufactured fertilizers, food, milk products, fibers, various other vegetable and animal products, and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

Dairying. — Two large, well-drained, cement-floored rooms in the South College are used for dairy work. These are equipped with a milk heater, separators, coolers and aërators, a pasteurizer, ripening vats, churns, butter workers, a mechanical can washer, a sterilizer, and other small apparatus necessary to a well-equipped dairy or butter factory. A third room is equipped with hand and power Babcock milk-testing machines and other apparatus used for milk and butter testing. These rooms have individual lockers for students. The new sanitary dairy and stable give an opportunity for practical laboratory work in the production and handling of certified milk.

Dining Hall. — Draper Hall, a brick colonial building, equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college.

Drawing. — Two rooms on the second floor of Wilder Hall are occupied by the classes in drawing. They are equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details, and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

Entomology. — *Entomological Laboratories.* — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas, is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped. It will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump, methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room, provided with chemical desks and apparatus, methods for the determination of the impurities and adulterations of insecticides are taught. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building, the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

Farm Administration. — The college farm of 190 acres is under the supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The work in this department includes the production of the common field crops, and the care and raising of the different classes of live stock mentioned under animal husbandry. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied.

Floriculture. — The department of floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a department of floriculture better equipped than this. The legislative appropriation of 1908 has made possible the erection of a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

Forestry. — The aim of the course in forestry is to prepare men for the advanced study in forestry schools, and at the same time, by laying particular stress on local conditions, to enable them to handle the farm wood lot in the same scientific manner as the rest of the farm. The college is well situated for forestry study. There is a good forest nursery on the college grounds; also two typical farm wood lots. In the vicinity are considerable areas of typical New England forest land.

Geology. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has 6 large cases for exhibition purposes.

The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

Heating, Lighting and Power. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop.

Landscape Gardening. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, aboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

Library. — The library — stack room, reading room and office — occupies the entire lower floor of the library-chapel building. It contains nearly 34,000 volumes and a large number of pamphlets, hitherto inaccessible, but which are being put into good working order as fast as possible. Works of a scientific character predominate, but economics, literature and history are well represented and are receiving due attention. The reading room provides a variety of periodical literature, both technical and popular, encyclopedias and general reference books, and a select collection of works for general reading.

The library is now being reclassified and recatalogued, to make the splendid collection of material here gathered together readily accessible and of the greatest working value. Every effort is being made toward developing the library into a vital intellectual center of college life, of equal value to every student, teacher and teaching department. In consequence, only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced.

Lectures are given to regular and short course students to enable them to make the best use of the library. Emphasis is laid upon the proper use of the card catalogue, periodical indexes, bibliographies and guides; also, in general, assigned and class-room work, and essay and debate work.

The library hours are from 7.45 A.M. to 9 P.M. every week day, and from 9 A.M. to 2 P.M. on Sundays, in term time. Shorter hours prevail during vacations.

Market Gardening. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and a laboratory particularly equipped for floriculture and market gardening. A good library of works on vegetable gardening is available.

Mathematics and Civil Engineering. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a Queen plane table, 2 wye levels, a dumpy level, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

Military Science. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

Physical Education. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The room used for exercise and recreation is equipped with modern developing apparatus and two hand-ball courts, and is large enough for basket ball. The apparatus can quickly be removed to clear the floor. An out-door board track enables students to secure track practice through the winter. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a bathroom. The gymnasium is open from 9 A.M. to 10 P.M., and exercise may be taken at such hours as do not conflict with military drill or physical education classes. The regulation costume for class exercise consists of a white track suit and white, rubber-sole shoes.

POMOLOGY. — The department of pomology has 10 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There is also a commercial vineyard and a smaller one; in these are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also extensive nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples and plums in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1909–10, for instance, apples for class use were received from British Columbia, Ontario, Quebec, Nova Scotia, Iowa, Wisconsin, Michigan, Connecticut, New York, Oklahoma, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrous fruit from Florida and Texas.

PHYSICS. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock, systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

Poultry Husbandry. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well drained. At present the buildings consist of an incubator cellar 22 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system) 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house 14 by 180 feet (when completed), which will accommodate 500 layers and furnish facilities for student work in pen management; the 6 old experiment station buildings, each 12 by 18 feet, to be used as breeding houses, and 11 colony brooder houses. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry, carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of Barred Plymouth Rocks, White Plymouth Rocks, White Wyandottes, Columbian Wyandottes, single-comb Rhode Island Reds, Light Brahmas, Buff Orpingtons and single-comb White Leghorns. The aim of the department is to keep good specimens of all the most popular varieties of chickens, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

Public Speaking. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests furnish a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollege contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

resulted in stimulation of the seed. The germinator was then placed in an autoclave and kept at a temperature of about 25° C. The results of the experiments follow: —

TABLE I. — *Showing the Results of the Stimulating Effect of Positive and Negative Electrical Charges on Radish Seeds and Seedlings (Raphanus sativus, L.).*

[Average of two experiments in each of which 60 seeds were used. Moist treated seed charged with 10 small sparks from a Töpler-Holtz machine. Measurements in millimeters, temperature 25° C.]

TREATMENT.	AVERAGE LENGTH OF —		PER CENT. GAINED IN LENGTH OF —	
	Hypocotyl (Centimeters).	Radicle (Centimeters).	Hypocotyl.	Radicle.
Normal,	1.13	1.07	-	-
Negative charge,	1.39	1.24	23.00	15.88
Positive charge,	1.72	1.76	52.21	64.48

It is quite evident that the electrical treatment stimulated the seed very materially, as shown by the growth of the hypocotyls and radicles given in this table. The average increased length of the radicles and hypocotyls of the negatively charged seeds over that of the normal was 23 per cent. for the hypocotyl and 15.88 per cent. for the radicle. The positively charged seeds gave an average increase of 52.21 per cent. for the hypocotyl and 64.48 per cent. for the radicle over that of the normal; showing that the positive charges induced the greater growth. No attention was given to accelerated germination in this experiment.

TABLE II. — *Showing the Results of the Stimulating Effect of Positive and Negative Electrical Charges on Lettuce Seeds and Seedlings (Lactuca sativa, L.).*

[Average of two experiments in each of which 60 seeds were used. Moist treated seed charged with 10 small sparks from a Töpler-Holtz machine. Measurements in millimeters, temperature 25° C.]

TREATMENT.	AVERAGE LENGTH OF —		PER CENT. GAINED IN LENGTH OF —	
	Hypocotyl (Centimeters).	Radicle (Centimeters).	Hypocotyl.	Radicle.
Normal,	0.96	1.52	-	-
Negative charge,	1.08	1.77	12.50	16.40
Positive charge,	1.21	2.18	26.00	43.42

In the experiments shown in Table II. the accelerated growth of the hypocotyl and radicle is somewhat similar to that shown in Table I., namely, the negative charges gave for the hypocotyl 12.5 per cent. increase, for the radicle 16.4 per cent., while the positively charged seeds gave 26 per cent. for the hypocotyl and 43.42 per cent. for the radicle. Here, too, the positively charged seeds gave the largest average increased growth for both hypocotyl and radicle.

The experiments shown in Tables I. and II. are typical of others made along the same line, although we have repeatedly found that it is quite an easy matter to charge the seed too strongly and obtain retardation in growth. Instead of using ten-minute sparks to stimulate the seeds in the electro-germinator we have found by subsequent experiments that it is better to use only two or three, and these should be very slight charges. The stimulating effect of positive and negative charges on germination is similar to that on growth, but there is no evidence to show that the treatment affects the germinating capacity of seeds, and we have stimulated many thousands. The following table gives an average of four experiments with seed germination.

TABLE III. — *Showing Results of the Stimulating Effects of Positive and Negative Electrical Charges on Germination of Lettuce Seed (Lactuca sativa, L.).*

[Average of four experiments, 20 seeds being used in each treatment; otherwise the same experiments as shown in Tables I. and II.]

TREATMENT.	Total Number of Seeds.	NUMBER OF SEEDS GERMINATED IN — 24 Hours.	48 Hours.	72 Hours.
Normal,	80	19	35	64
Negative charge,	80	24	51	64
Positive charge,	80	48	69	72

From the experiments in Table III. it will be observed that germination is accelerated to a considerable degree by electrical stimulation, and that the positive caused greater acceleration than the negative charges, corresponding to the effects produced on the growth of the hypocotyl and radicle. In Fig. 1 is shown a diagrammatic representation of seedlings based upon an aver-

Associate Alumni of the Massachusetts Agricultural College.
Secretary: SIDNEY B. HASKELL, 1904, Amherst, Mass.

Local Alumni Association of the Massachusetts Agricultural College.
Secretary: SIDNEY B. HASKELL, 1904, Amherst, Mass.

Alumni Club of Massachusetts.
Clerk: H. LINWOOD WHITE, 1909, 136 State House, Boston, Mass.

Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: CHARLES L. BROWN, 1894, 870 State Street, Springfield, Mass.

Massachusetts Agricultural College Club of New York.
Secretary: JOHN ASHBURTON CUTTER, 1882, 262 West 77th Street, New York, N. Y.

Massachusetts Agricultural College Club of Washington, D. C.
Secretary: CLARENCE H. GRIFFIN, 1904, Washington, D. C.

Western Alumni Association of the Massachusetts Agricultural College.
Secretary: CHARLES A. TIRRELL, 1906, 4012 Perry Street, Chicago, Ill.

Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: THOMAS F. HUNT, 1905, Berkeley, Cal.

Class Secretaries.

Class of	Secretary.	Secretary's Address.
1871	E. E. Thompson,	5 Jaques Avenue, Worcester, Mass.
1872	S. T. Maynard,	Northborough, Mass.
1873	C. Wellington,	Amherst, Mass.
1874	D. G. Hitchcock,	Warren, Mass.
1875	M. Bunker,	Newton, Mass.
1876	C. Fred Deuel,	Amherst, Mass.
1877	Atherton Clark,	Newton, Mass.
1878	C. O. Lovell,	5 Bromfield Street, Boston, Mass.
1879	R. W. Swan,	41 Pleasant Street, Worcester, Mass.
1880	Alvan Fowler,	413 Post Office Building, Philadelphia, Pa.
1881	J. L. Hills,	55 North Prospect Street, Burlington, Vt.
1882	G. D. Howe,	25 Winter Street, Bangor, Me.
1883	J. B. Lindsey,	Amherst, Mass.
1884	– –	– –
1885	E. W. Allen,	1923 Biltmore Street, Washington, D. C.
1886	Dr. Winfield Ayres,	616 Madison Avenue, New York City.
1887	F. H. Fowler,	Shirley, Mass.
1888	H. C. Bliss,	14 Mechanic Street, Attleborough, Mass.
1889	C. S. Crocker,	2453 Carpenter Street, Philadelphia, Pa.
1890	David Barry,	Amherst, Mass.
1891	H. T. Shores,	117 Elm Street, Northampton, Mass.
1892	H. M. Thomson,	Amherst, Mass.
1893	F. A. Smith,	Turner Hill, Ipswich, Mass.
1894	S. F. Howard,	Amherst, Mass.
1895	E. A. White,	Amherst, Mass.
1896	A. S. Kinney,	South Hadley, Mass.
1897	C. A. Peters,	Amherst, Mass.
1898	– –	– –
1899	D. A. Beaman,	Rio Piedras, Porto Rico.
1900	E. K. Atkins,	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering,	Dover, Mass.
1902	H. L. Knight,	United States Department of Agriculture, Washington, D. C.
1903	G. D. Jones,	North Amherst, Mass.
1904	P. F. Staples,	North Grafton, Mass.
1905	P. F. Williams,	Auburn, Ala.
1906	Richard Wellington,	Geneva, N. Y.
1907	J. N. Summers,	48 Copeland Street, Campello, Mass.
1908	J. A. Hyslop,	Bureau of Entomology, Washington, D. C.
1909	C. S. Putnam,	Walpole, N. H.
1910	F. L. Thomas,	Amherst, Mass.
1911	L. M. Johnson,	Newtown, Conn.

Degrees Conferred and Roll of Students.

Degrees Conferred — 1911.

Doctor of Philosophy.

Shaw, Jacob Kingsley, North Amherst, University of Vermont, B.Sc., Massachusetts Agricultural College, M.Sc., 1908.

Summers, John Nicholas, Campello, Massachusetts Agricultural College, B.Sc., 1907.

Master of Science.

Smith, Philip Henry, Amherst, Massachusetts Agricultural College, B.Sc., 1897.

Whitmarsh, Raymond Dean, Amherst, Massachusetts Agricultural College, B.Sc., 1908.

Bachelor of Science (B.Sc.).

Adams, James Fowler,	Melrose.
Allen, Park West,	Westfield.
Baker, Herbert Jonathan,	Selbyville, Del.
Barrows, Raymond Corbin,	Stafford Springs, Conn.
Bentley, Arnold Gordon,	Hyde Park.
Blaney, Herbert Wardwell,	Swampscott.
Brown, Edgar Morton,	Merrick.
Bursley, Allyn Parker,	West Barnstable.
Conant, Arthur Theodore,	Sunderland.
Damon, Charles Murray,	Haydenville.
Davis, Egbert Norton,	South Framingham.
Davis, Irving Wilder,	Lowell.
Gilgore, Irvin Craig,	Central Square, N. Y.
Hill, Nathaniel Herbert,	Princeton, N. J.
Jenks, Albert Roscoe,	Three Rivers.
Johnson, Leonard Matthews,	Easthampton.
Labouteley, Gaston Edward,	Lynn.
Larrabee, Edward Arthur,	Medford.
Lull, Robert Delano,	Windsor, Vt.
McGraw, Frank Dobson,	Fall River.
McLaughlin, Frederick Adams,	Lee.
Morse, Henry Bowditch,	Salem.
Nagai, Isaburo,	Tokyo, Japan.
Nickerson, George Payne,	Amherst.
Nielsen, Gustaf Arnold,	West Newton.
Ostrolenk, Bernhard,	Gloversville, N. Y.
Parsons, Samuel Raynolds,	North Amherst.

Patch, Roland Harrison, ...	Wenham.
Pauly, Herman Alfred, ...	Plainfield, Vt.
Pickard, Percy William, ...	Hopedale.
Piper, Ralph Waldo, ...	South Acton.
Prouty, Philip Herman, ...	Shrewsbury.
Racicot, Phileas Armand, ...	Lowell.
Robinson, Ralph Cushing, ...	Boston.
Sharpe, Arthur Harris, ...	Saxonville.
Smith, Clarence Albert, ...	Northampton.
Smith, Raymond Goodale, ...	Lynn.
Stevenson, Lomas Oswald, ...	Hackensack, N. J.
Titus, Willard McCready Snow, ...	New Braintree.
Warren, Edward Erving, ...	Leicester.
Whitney, Raymond Lee, ...	Brockton.
Willard, Harold Francis, ...	Leominster.
Winn, Ervin Lawrence, ...	Holden.

Roll of Students.

Senior Class.

Ackerman, Arthur John,	Worcester,	7 South College.
Baker, Horace Mitchell,	Selbyville, Del.,	South College Tower.
Beals, Carlos Loring,	Sunderland,	5 South College.
Beers, Rowland Trowbridge,	Billerica,	8 North College.
Bent, William Richard,	Marlborough,	2 North College.
Bodfish, Edward Hill,	West Barnstable,	Plant House.
Boland, Eric Nichols,	South Boston,	17 South College.
Brett, Alden Chase,[1]	North Abington,	81 Pleasant Street.
Brown, Merle Raymond,	Greenwich Village,	92 Main Street, Amherst.
Burr, Frederick Huntington,	Worthington,	88 Pleasant Street.
Caldwell, Lawrence Sanborn,	Lynnfield Center,	Kappa Sigma House.
Carpenter, Jesse, Jr.,[1]	Attleborough,	Kappa Sigma House.
Castle, Fred Arlo,	Roseburg, Ore.,	13 South College.
Clapp, Raymond Kingsley,	Westhampton,	Theta Chi House.
Curran, Daniel Joseph,	Marlborough,	2 North College.
Deming, Winfred Griswold,	Wethersfield, Conn.,	16 South College.
Dodge, Albert Wesley,[1]	Hamilton,	14 North College.
Fagerstrom, Leon Emanuel,	Worcester,	12 South College.
Fisherdick, Warren Francis,	Amherst,	26 South Pleasant Street.
Fitts, Frank Orus,	North Amherst,	Chemical Laboratory.
Fitzgerald, John Joseph,	Holyoke,	75 Pleasant Street.
Fowler, George Scott,	Wayland,	44 Pleasant Street.
Gallagher, James Andrew,	North Wilmington,	3 North College.
Gaskill, Lewis Warren,	Hopedale,	6 South College.
Gelinas, Louis Edmond,	North Adams,	4 South College.
Gibbs, Robert Morey,	Chester,	Plant House.
Gibson, Lester Earl,	Melrose,	Kappa Sigma House.
Gray, Frank Leonard,	East Boston,	21 Fearing Street.
Hall, Henry Bass,[1]	Northampton,	Paradise Road.
Hall, Horace Whitney,[1]	Newton Center,	P. O. Building, Amherst.
Hallowell, Royal Norton,	Jamaica Plain,	South College Tower.
Hamblin, Stephen Francis,	Marston Mills,	94 Pleasant Street.
Harlow, Joseph Alvin,	Turners Falls,	Kappa Sigma House.
Heald, Jay Morrill,	Watertown,	10 South College.
Hemenway, Thomas,	Nashua, N. H.,	17 South College.
Hickey, Francis Benedict,[1]	Brockton,	C. S. C. House.
Hills, Frank Burrows,[1]	Bernardston,	8 South College.
Holland, Henry Lucine,	Amherst,	28 North Prospect Street.
Hubert, Benjamin Franklin,	White Plains, Ga.,	48 E. Pleasant Street.
Kingsbury, Arthur French,	Medfield,	Theta Chi House.
Lamson, Robert Ward,	Amherst,	51 Pleasant Street.
Lin, Dau Yang,	Shanghai, China,	21 Fearing Street.
Lodge, Charles Albert,	Manchester,	87 Pleasant Street.
Lloyd, Edward Russell,[1]	Boston,	15 North College.
Madison, Francis Spink,	East Greenwich, R. I.,	Veterinary Laboratory.
Martin, James Francis,	Amherst,	19 South East Street.
McGarr, Thomas Anthony,	Worcester,	3 North College.
Merkle, George Edward,	Amherst,	North East Street.
Merrill, Fred Sawyer,	Danvers,	C. S. C. House.
Moreau, Theodore Joseph,	Turners Falls,	10 South College.

[1] Work incomplete.

Mueller, Alfred Frederick,	Jamaica Plain,	4 South College.
Noyes, Harry Alfred,	Marlborough,	79 Pleasant Street.
O'Flynn, George Bernhard,	Worcester,	Kappa Gamma Phi House.
Parker, Ralph Robinson,	Malden,	C. S. C. House.
Pearson, Charles Cornish,	Arlington,	18 South College.
Peckham, Curtis,	New Bedford,	7 North College.
Philbrick, William Edwin,	Taunton,	18 South College.
Pierpont, John Edwards,	Williamsburg,	C. S. C. House.
Pratt, Marshall Cotting,	Holderness, N. H.,	Kappa Sigma House.
Puffer, Stephen Perry,	North Amherst,	8 North College.
Raymond, Arthur Nathaniel,	Leominster,	9 North College.
Reed, Robert Edward,[1]	Abington,	Theta Chi House.
Robinson, Earle Johnson,[1]	Hingham,	8 South College.
Rockwood, Lawrence Peck,	Waterbury, Conn.,	116 Pleasant Street.
Sanctuary, William Crocker,	Amherst,	Mill Valley.
Sellew, Lewis Raymond,	Natick,	Plant House.
Shaw, Ezra Ingram,	Amherst,	East Street.
Southwick, Benjamin Gilbert,	Buckland,	11 North College.
Stack, Herbert James,	Conway,	French Hall.
Terry, Leon,[1]	Springfield,	12 North College.
Torrey, Ray Ethan,	North Leverett,	Clark Hall.
Tower, Daniel Gordon,	Roxbury,	15 South College.
Tupper, George Wilbur,	Roxbury,	C. S. C. House.
Turner, Howard Archibald,	Dorchester,	Plant House.
Wales, Robert Webster,	North Abington,	Kappa Sigma House.
Walker, Herman Chester,	Marlborough,	16 South College.
Warner, Roger Andrew,[1]	Sunderland,	Theta Chi House.
Weaver, William Jack,	Alandar,	15 North College.
Whitney, Charles Everett,	Wakefield,	10 North College.
Wilbur, Emory Sherman,	East Wareham,	79 Pleasant Street.
Wilde, Earle Irving,	Taunton,	2 South College.
Williams, Edward Roger,	Concord,	12 South College.
Williams, Silas,	Fall River,	Theta Chi House.
Wood, Howard Holmes,	Shelburne Falls,	15 South College.
Young, Edwin Burnham,	Dorchester,	11 North College.

Junior Class.

Adams, Winfred Frederic,[1]	East Leverett,	83 Pleasant Street.
Allen, Harry Willis,	Amherst,	South Street, West Pelham.
Anderson, Oscar Gustaf,[1]	East Pepperell,	Entomological Building.
Angier, Harris William,	Westborough,	88 Pleasant Street.
Baird, Harry Albert,[1]	Somerville,	29 Lincoln Avenue.
Baker, Dean Foster,	Fairhaven,	116 Pleasant Street.
Barber, George Ware,[1]	Franklin,	13 North College.
Bevan, Lawrence Algur,[1]	Newtonville,	84 Pleasant Street.
Blake, Ralph Cedric,[1]	Wollaston,	President's House, M. A. C.
Birdsall, Webster Jennings,[1]	Otego, N. Y.,	Kappa Sigma House.
Borden, Ralph James,	Fall River,	7 North College.
Brewer, Charlesworth Herbert,	Mt. Vernon, N. Y.,	C. S. C. House.
Brown, Herbert Augustine,[1]	Saxonville,	Brooks Farm.
Burby, Lawrence Walter,[1]	Chicopee Falls,	88 Pleasant Street.
Bursley, Harold Barrows,	Peabody,	Theta Chi House.
Caldwell, David Story,	South Byfield,	9 North College.
Carver, John Stuart,	Roslindale,	C. S. C. House.
Chun, Woon Young,[1]	Shanghai, China,	90 Pleasant Street.
Clark, Norman Russell,[1]	Worcester,	Theta Chi House.
Cobb, Joseph Boyd,[1]	Chicopee Falls,	5 North College.
Cole, Arlin Tower,	West Chesterfield,	Pease Avenue, care of Mr. Reed.
Cole, Flora Atwood,	Newton,	10 Draper Hall.
Coleman, Isaac[1],	Amherst,	12 North College.

[1] Work incomplete.

Cooper, Everett Hanson,	Wakefield,	14 North College.
Cory, Harold,[1]	Rutherford, N. J.,	15 Beston Street.
Covill, Joseph Warren,[1]	West Roxbury,	7 South College.
Cristman, Clyde Edward,	Dalton,	Pease Avenue, care of Mr. Reed.
Culley, Frank Hamilton,	Marshalltown, Ia.,	77 Pleasant Street.
Curtis, Harold William,	Belchertown,	Entomological Building.
Daniel, Edward Stephen Coen,	Osterville,	15 Fearing Street.
Dayton, James Wilson,	South Norwalk, Conn.,	15 Beston Street.
Dooley, Thomas Patrick,[1]	South Boston,	35 East Pleasant Street.
Drury, Lewis Floyd,	Rutland,	120 Pleasant Street.
Edminster, Albert Franklin,	Brooklyn, N. Y.,	5 South College.
Eisenhaure, John Louis,[1]	North Reading,	Brooks Farm.
Ellis, Benjamin Ward,	Plymouth,	Clark Hall.
Ells, Gordon Waterman,	Haverhill,	116 Pleasant Street.
Fay, Robert Sedgwick,	Monson,	84 Pleasant Street.
Forbush, Wallace Clifford,	Rutland,	79 Pleasant Street.
French, James Dudley,	Hyde Park,	116 Pleasant Street.
Gaskill, Ralph Hicks,	Amherst,	15 Hallock Street.
Godvin, Thomas Joseph,[1]	Jamaica Plain,	75 Pleasant Street.
Gore, Harold Martin,	Wollaston,	11 South College.
Greenleaf, George Freeman,[1]	Brockton,	21 Fearing Street.
Griggs, Frederick David,	Chicopee Falls,	5 North College.
Harris, Burton Adams,	Wethersfield, Conn.,	84 Pleasant Street.
Hasey, Willard Harrison,[1]	Campello,	87 Pleasant Street.
Hatch, Herbert Tilden,	Beverly,	East Experiment Station.
Headle, Herbert Wallace,	Bolton,	Plant House.
Headle, Marshall,	Bolton,	Plant House.
Holden, James Loomis,	Palmer,	5 McClellan Street.
Howe, Glover Elbridge,	Marlborough,	11 South College.
Howe, Ralph Wesley,	East Dover, Vt.,	Wilder Hall.
Huntington, Samuel Percy,	Lynn,	96 Pleasant Street.
Hutchings, Herbert Colby,	South Amherst,	87 Pleasant Street.
Hyland, Harold Wilson,[1]	Weymouth,	Old Insectary.
Jones, Harold Frederick,	Campello,	West Experiment Station.
Jordan, Simon Miller,	Rutherford, N. J.,	9 South College.
Kelley, Albert Joseph,	Roxbury,	35 East Pleasant Street.
Kelley, Bernard Jenkins,[1]	Harwichport,	Brooks Farm.
Kenney, Frederick Alfred,[1]	Charlestown,	Theta Chi House.
Larsen, Nils Paul,	Bridgeport, Conn.,	Clark Hall.
Lesure, John Warren Thomas,	Fitchburg,	94 Pleasant Street.
Little, Willard Stone,	Newburyport,	66 Pleasant Street.
Lowry, Quincy Shaw,[1]	Canton,	6 South College.
Lundgren, Arthur Robert,	Orange,	Theta Chi House.
Lyon, Harold,	Somerville,	13 Phillips Street.
Macone, Joseph Augustine,	Concord,	1 North College.
Mallett, George Alfred,	Bridgeport, Conn.,	13 North College.
Matz, Julius,[1]	Boston,	112 Pleasant Street.
Mayer, John Lawrence,	South Boston,	35 East Pleasant Street.
McDougall, Allister Francis,	Westford,	6 North College.
Moir, William Stuart,	Boston,	Theta Chi House.
Murray, Joseph Wilbur,	Holyoke,	96 Pleasant Street.
Neal, Ralph Thomas,	Mattapan,	Old Insectary.
Nichols, Norman Joseph,	Everett,	Mathematics Building.
O'Brien, James Leo,[1]	Wayland,	19 Hallock Street.
Packard, Clyde Monroe,	Springfield,	Cottage Hospital, Kellogg Avenue.
Pease, Lester Newton,	Meriden, Conn.,	84 Pleasant Street.
Pillsbury, Joseph James,[1]	West Bridgewater,	8 South Prospect Street.
Post, George Atwell,[1]	Richmond Hill, N. Y.,	Theta Chi House.
Roberts, Clarence Dwight,[1]	Edinburgh, Scot.,	Brooks Farm.
Roehrs, Herman Theodore,[1]	New York, N. Y.,	Kappa Sigma House.

[1] Work incomplete.

Rosebrooks, Walter Edwin,	Millbury,	15 Hallock Street.
Samson, Stuart Dodds,	Grand Isle, Vt.,	Kappa Sigma House.
Selden, John Lincoln,[1]	Northampton,	6 Ahwaga Avenue, Northampton.
Serex, Paul, Jr.,	Jamaica Plain,	116 Pleasant Street.
Sheehan, Dennis Anthony,[1]	South Lincoln,	1 North College.
Shute, Carl August,[1]	Hampden,	14 South College.
Streeter, Charles Marsh,	Brimfield,	79 Pleasant Street.
Thayer, Clark Leonard,	Enfield,	West Experiment Station.
Tucker, Waldo Guy,	Lynn,	Mathematics Building.
Tupper, Arthur Somerville,	Roxbury,	C. S. C. House.
Van Zwaluwenburg, Reyer Herman,	Rutherford, N. J.,	East Experiment Station.
Walker, Charles Dexter,	Greenwich Village,	14 South College.
Whitney, Francis Wellington,[1]	Wellesley,	4 North College.
Zabriskie, George 2d,[1]	New York City,	83 Pleasant Street.

Sophomore Class.

Abbott, Leslie Elmer,	Sandwich,	Care of Mr. E. F. Gaskill.
Allen, Carl Murdough,	Holyoke,	87 Pleasant Street.
Allen, Henry Dickinson,[1]	Lynn,	82 Pleasant Street.
Anapolsky, Morris,[1]	Boston,	11 Amity Street.
Anderson, Leslie Oscar,[1]	Concord,	7 Nutting Avenue.
Baker, Warren Sears,[1]	Wollaston,	116 Pleasant Street.
Besser, Sidney Stokes,	Gilbertville,	3 Nutting Avenue.
Black, Harold Cotting,[1]	Falmouth,	3 Pleasant Street,
Bokelund, Chester E.,[1]	Worcester,	66 Pleasant Street.
Bragg, Ralph Stanley,	Milford,	Mt. Pleasant, care of Professor White.
Brewer, Harold William,[1]	Mount Vernon, N. Y.,	C. S. C. House.
Brooks, Arthur Winslow,	Enfield,	Chemical Laboratory.
Brown, Harry Dunlap,	Lowell,	82 Pleasant Street.
Bullard, Alvan Henry,	South Framingham,	5 McClellan Street.
Calvert, Melville Bradford,[1]	New London, Conn.,	56 Pleasant Street.
Campbell, Malcolm David,	Still River,	35 East Pleasant Street.
Christie, Edward Wheeler,	North Adams,	29 Lincoln Avenue.
Churchill, George Clarence,	Worcester,	58 Pleasant Street.
Clark, Ernest Samuel, Jr.,	Tolland,	82 Pleasant Street.
Clay, Harold Johnson,	North Cambridge,	21 Fearing Street.
Clegg, Frank Jackson,	Fall River,	C. S. C. House.
Coe, Alfred Lyne,	Cazenovia, N. Y.,	79 Pleasant Street.
Cole, Herbert Elmer,[1]	Manchaug,	Plant House.
Coleman, David Augustus,	South Framingham,	108 Pleasant Street.
Damon, Samuel Reed,[1]	Kingston, R. I.,	Kappa Sigma House.
Davies, Lloyd Garrison,[1]	Peabody,	75 Pleasant Street.
Davis, Ralph Edward,	Southbury, Conn.,	77 Pleasant Street.
Davis, William Ashmun,	Sunderland,	79 Pleasant Street.
Dearing, Newton Howard,	Brookline,	7 Nutting Avenue.
Demond, Robert Norton,	North Adams,	Care of Mr. E. H. Forristall.
Dexter, Evans King,	Mattapoisett,	31 East Pleasant Street.
Dunbar, Erving Walker,	North Weymouth,	7 Nutting Avenue.
Edgerton, Almon Morley,[1]	West Springfield,	6 Nutting Avenue.
Edwards, Edward Clinton,[1]	Salem,	Nutting Avenue, care of R. J. Watts.
Eldridge, Harold Lockwood,	Wareham,	North College, College Store.
Foster, Stuart Brooks,[1]	West Somerville,	96 Pleasant Street.
Freeborn, Stanley Barron,	Ware,	116 Pleasant Street.
Freedman, Samuel Leavitt,	Roxbury,	101 Pleasant Street.
Frost, Robert Theodore,	New York, N. Y.,	85 Pleasant Street.
Frye, Carl Raymond,	South Hadley Falls,	116 Pleasant Street.
Fuller, George,	Deerfield,	86 Pleasant Street.
Gibson, David Wyman,	Groton,	116 Pleasant Street.
Grebin, Mark Anthony,[1]	North Hadley,	North Hadley.

[1] Work incomplete.

Griffin, William Gerald,	South Hadley Falls,	35 East Pleasant Street.
Hadfield, Harold Frederick,	North Adams,	29 Lincoln Avenue.
Handy, Ralph Ellis,	Cataumet,	10 North College.
Harris, Rodney Wells,	Wethersfield, Conn.,	77 Pleasant Street.
Hayden, William Vassall,[1]	Beverly,	13 South College.
Hazen, Edward Leonard,	Springfield,	Care of Mr. E. H. Forristall.
Heath, Chester Blanchard,	Needham,	4 North College.
Hebard, Emory Blodgett,	Holland,	3 Fearing Street.
Heffron, Frederick,	Sherborn,	108 Pleasant Street.
Hogg, Lawrence Jagger,	Lawrence,	13 Fearing Street.
Howard, Lewis Phillips,	North Easton,	19 Hallock Street.
Hutchinson, John Gouvernour,	Arlington,	8 Allen Street.
Hutchinson, Raymond Ernest,[1]	South Hanson,	35 East Pleasant Street.
Ingham, Earl Morris,	Granby,	86 Pleasant Street.
Jacobs, Loring Humphrey,	Wellesley,	25 Pleasant Street.
Jenney, Herbert Hedge,	South Boston,	6 Nutting Avenue.
Johnson, Rollin Eugene,	Templeton,	120 Pleasant Street.
Jones, Dettmar Wentworth,	Melrose,	66 Pleasant Street.
Kilbourn, Walton Goss,	South Lancaster,	85 Pleasant Street.
Kriebel, Addison Reiff,[1]	Norristown, Pa.,	81 Pleasant Street.
Leach, Benjamin Robert,	Methuen,	13 Phillips Street.
Leete, Richard Fowler,	Mount Kisco, N. Y.,	66 Pleasant Street.
Levine, Henry Walter,	Roxbury,	101 Pleasant Street.
Lincoln, Murray Danforth,	North Raynham,	19 Hallock Street.
Lucas, Hoyt Dennis,	West Springfield,	1 Allen Street.
MacDonald, Daniel Alfred,[1]	Walpole,	67 Pleasant Street.
Major, Joseph,	Rutherford, N. J.,	58 Pleasant Street.
Melloon, Ralph Reid,	Lowell,	Mt. Pleasant, care of Mr. Greene.
Merkle, Frederick Grover,	Amherst,	North East Street.
Morrison, Harold Ivory,	Melrose,	77 Pleasant Street.
Morse, Harold John,[1]	Townsend,	75 Pleasant Street.
Needham, Lester Ward,[1]	Springfield,	Kappa Sigma House.
Nicolet, Tell William,	Fall River,	85 Pleasant Street.
Nicolet, Theodore Arthur,[1]	Fall River,	85 Pleasant Street.
Nissen, Harry,	Boston,	85 Pleasant Street.
Norton, Leslie Howard,	Newport, R. I.,	79 Pleasant Street.
Nute, Raymond Edwin,	Fall River,	9 Fearing Street.
Oertel, John Thomas,[1]	South Hadley Falls,	116 Pleasant Street.
Palmer, John Philip,[1]	Portsmouth, N. H.,	Care of President Butterfield.
Parker, Ervine Franklin,	Poquonock, Conn.,	81 Pleasant Street.
Payne, Roland Alfred,	Wakefield,	North Amherst.
Pellett, John Doubleday,	Worcester,	Theta Chi House.
Peters, Chester Harry,	Brown Station, N. Y.,	116 Pleasant Street.
Petersen, Peverill Oscar,	Concord,	7 Nutting Avenue.
Porter, Bennett Allen,	Amherst,	R. D. 1, No. 25, Amherst.
Powers, Richard Henry,[1]	Malden,	9 South College.
Read, Frederick William,	Boston,	7 Nutting Avenue.
Rees, Harry Launcelot,	Monson,	3 Fearing Street.
Reid, George Alexander,	Worcester,	52 Lincoln Avenue.
Robinson, Herbert Calvin,	Haverhill,	75 Pleasant Street.
Russell, Alden Hesseltine,	Watertown,	7 Nutting Avenue.
Sahr, Gabriel Arthur,[1]	Boston,	60 Pleasant Street.
Sanford, Clarence Higgins,	Allston,	Cottage Hospital, Kellogg Avenue.
Sherman, Joel Powers,	Hyannis,	4 North College.
Shirley, John Newton,	South Duxbury,	30 North Prospect Street.
Simmons, George Walker,[1]	Amsterdam, N. Y.,	35 East Pleasant Street.
Slein, Owen Francis,	New Braintree,	9 Nutting Avenue.
Small, Francis Willard,[1]	North Truro,	35 North Prospect Street.
Smith, Leon Edgar,	Brighton,	85 Pleasant Street.

[1] Work incomplete.

Smith, Leone Ernest,	Leominster,	116 Pleasant Street.
Stevens, Arthur Eben,	Brockton,	79 Pleasant Street.
Strange, Sarah Josephine,	Marshfield,	6 Draper Hall.
Sullivan, Arthur James,	Rochester, N. Y.,	19 Hallock Street.
Tarbell, Munroe Gifford,	Brimfield,	College Store, North College.
Taylor, Arthur Wright,	Feeding Hills,	13 Fearing Street.
Taylor, Leland Hart,	Peabody,	75 Pleasant Street.
Thurston, Arthur Searle,	Everett,	9 Fearing Street.
Tower, Alfred Leigh,	Sheffield,	120 Pleasant Street.
Tsang, Oong Hyuen,	Shanghai, China,	26 Lincoln Avenue.
Upton, Ernest Franklin,	Salem,	Nutting Avenue, care of R. J. Watts.
Walker, Nathaniel Kennard,	Malden,	83 Pleasant Street.
Walker, Raymond Philip,	Taunton,	120 Pleasant Street.
Warner, Raymond Winslow,	Sunderland,	Care of Mr. E. H. Forristall.
Webster, Louis Armstrong,	Blackstone,	82 Pleasant Street.
Weigel, Arthur George,	Lawrence,	13 Hallock Street.
Wells, Nathan Holmes,[1]	Kennebunk, Me.,	Prospect House.
Wheeler, Chester Eaton,	Lowell,	87 Pleasant Street.
Whidden, Burton Clark,	Waltham,	81 Pleasant Street.
Whippen, Charles Warren,	Lynn,	13 Phillips Street.
White, Samuel Alexander,	Boston,	12 Hallock Street.
Williams, George Edward,[1]	Belchertown,	Belchertown.
Wing, John Govan,	Somerville,	116 Pleasant Street.
Wood, Henry Joseph,	Mendon,	82 Pleasant Street.
Wooley, Harold Curtis,[1]	Malden,	Kappa Sigma House.

Freshman Class.

Alden, Charles Harold,	Amherst,	East Pleasant Street.
Allen, Francis Ellwood,	Melrose,	10 Allen Street.
Anderson, Herbert Henry,	Ware,	13 Hallock Street.
Archibald, Herbert Hildreth,	Waltham,	120 Pleasant Street.
Baird, Earle Fairbank,	Waltham,	120 Pleasant Street.
Banister, Seth Warren,	Westford,	30 North Prospect Street.
Barnes, Dwight Fletcher,	Marshfield,	3 Nutting Avenue.
Bartlett, Emory Haynes,	Enfield,	12 Cottage Street.
Bartlett, Edward Russell,	Newburyport,	66 Pleasant Street.
Bartley, Hastings Newcomb,	Sandwich,	77 Pleasant Street.
Beebe, William Carleton,	Evans Mills, N. Y.,	Prospect House.
Beers, Norman Lauer,	Somerville,	21 Fearing Street.
Bemis, Willard Gilbert,	North Brookfield,	12 Cottage Street.
Bennett, John Ingram,	Boston,	77 Pleasant Street.
Bisbee, Eleanor,	Arlington Heights,	Draper Hall.
Bishop, Chester Allen,	Peterboro, N. H.,	79 Pleasant Street.
Bishop, Herbert Walker,[1]	Doylestown, Pa.,	79 Pleasant Street.
Bittinger, Fritz John,	Plymouth,	96 Pleasant Street.
Boyer, Edward E. Hale,	Lynn,	Northampton Road.
Braley, Merton Loring,	Rock,	East Experiment Station.
Bredemeier, Carl,	Buffalo, N. Y.,	86 Pleasant Street.
Bronson, Harold Julius,	Buckland,	Walker Hall.
Brooks, Gardner Milton,	Newton,	9 Allen Street.
Buttrick, John Willard,	Melrose,	31 North Prospect Street.
Cale, Gladstone Hume,	West Springfield,	79 Pleasant Street.
Callard, John Case,	Winthrop,	40 Amity Street.
Cande, Donald Hopkins,	Pittsfield,	83 Pleasant Street.
Chase, Alexander Baxter, Jr.,	West Barnstable,	13 Fearing Street.
Churchill, Chester Albert,	Brockton,	Angus's Cottage.
Clare, Frederick Henry,	Mattapan,	- -
Clark, Arthur Lincoln,	Jamaica Plain,	35 East Pleasant Street.
Clark, Ellis Fred,	Granby, Conn.,	Theta Chi House.
Clark, George Henry,[1]	Sherborn,	3 Nutting Avenue.

[1] Work incomplete.

Clark, Saxon Dickinson,	Springfield,	120 Pleasant Street.
Clough, Maurice Joseph,	Swampscott,	30 North Prospect Street.
Cohen, Samuel Adams,	Roxbury,	101 Pleasant Street.
Dalrymple, Andrew Campbell,	Revere,	3 McClellan Street.
Damon, Leon Blanchard,	Melrose,	31 North Prospect Street.
Darling, Homer Chester,[1]	Mendon,	15 Hallock Street.
Day, George Allen,	Warren,	12 Cottage Street.
Dole, Sumner Alvord,	Bardwell's Ferry,	Walker Hall.
Donnell, George Edwin,	Burlington,	10 Tyler Place.
Doran, William Leonard,	North Dartmouth,	35 East Pleasant Street.
Draper, Earle Sumner,	Milford,	C. S. C. House.
Eaton, Paul Baker,	Wakefield,	83 Pleasant Street.
Estes, Ralph Carey,	Lancaster,	79 Pleasant Street.
Fairbank, Harvey Nathan,	Sudbury,	Care of E. F. Gaskill.
Fales, Gerald,	Worcester,	75 Pleasant Street.
Farrar, Stuart Kittridge,	Springfield,	Kappa Sigma House.
Fisher, Leonard Cyrus,[1]	Norwood,	35 East Pleasant Street.
Fitzgerald, Daniel James,[1]	Worcester,	75 Pleasant Street.
Flebut, Alpha John,	Amherst,	27 McClellan Street.
Fox, Everett Bailey,	Dracut,	East Experiment Station.
Gare, Edward John,	Northampton,	13 Phillips Street.
Gibbs, Robert Burley,	Ballston Spa, N. Y.,	3 Nutting Avenue.
Goodwin, Malcolm Noyes,	Newburyport,	66 Pleasant Street.
Grant, Harold Davidson,	Melrose,	3 McClellan Street.
Griggs, Raymond Bradford,	Chicopee Falls,	84 Pleasant Street.
Hager, Clayton Marden,	Somerville,	9 Nutting Avenue.
Hall, George Morris,	Brookline,	Lincoln Block.
Hall, Roderick Chesley,	Worcester,	29 Pleasant Street.
Harper, James Edward,	New Haven, Conn.,	29 Lincoln Avenue.
Harper, Raymond Wires,	Barre,	Hatch Experiment Barn.
Harvey, Russell Wilton,	Lanesville,	44 Pleasant Street.
Haskell, Willis Henry, Jr.,	Brooklyn, N. Y.,	15 Beston Street.
Haskins, Leroy Everett,	Taunton,	120 Pleasant Street.
Hatfield, William Hollis,	Wellesley,	30 North Prospect Street.
Hathaway, Isaac,	Kingston,	Care of E. F. Gaskill.
Haug, Chester Amos,	New York, N. Y.,	15 Fearing Street.
Hawes, Clayton Prescott,	North Dartmouth,	35 East Pleasant Street.
Heartz, Forrest Oscar,	Melrose Highlands,	35 Amity Street.
Hildreth, Paul Hughes,	Newtonville,	8 Allen Street.
Hill, Charles Chase,	Melrose Higlhands,	Pease Avenue.
Hotis, Ralph P.,	Evans Mills, N. Y.,	52 Amity Street.
Houghton, Arthur Reginald,	South Lancaster,	C. S. C. House.
Hyde, George Frederick,	North Dana,	79 Pleasant Street.
Hyde, Harold Gilmore,	Winchendon,	29 North Prospect Street.
Jackson, John Carleton,	Sherborn,	15 Hallock Street.
Johnson, Arthur,	Bridgeport, Conn.,	Brooks Farm.
Johnson, Bernard Pol,	New York, N. Y.,	College Store, North College.
Jordan, Perley Balch,	Topsfield,	31 North Prospect Street.
Joubert, Sylvester Gordon,	Middletown, Conn.,	31 Lincoln Avenue.
Kane, Paul Vincent,	Worcester,	Brooks Farm.
Karnan, Parker Robert,	Hyde Park,	31 Lincoln Avenue.
Kelliher, Jerome Joseph,	Montague City,	75 Pleasant Street.
Kennedy, Thomas James,	South Hadley Falls,	Brooks Farm.
Kilbon, Ralph Gillette,[1]	Springfield,	19 Pleasant Street.
Komp, William H. Wood,[1]	Rutherford, N. J.,	82 Pleasant Street.
Koplovitz, Samuel,	Chelsea,	112 Pleasant Street.
Lane, Merton Chesleigh,	South Duxbury,	Pleasant Street, care of Mr. Root.
LeDuc, Ashley Cudworth,	Chesterfield,	13 Hallock Street.
Lewis, Daniel James,	Hanson,	120 Pleasant Street.
Lewis, John Kirby,	New Haven, Conn.,	52 Lincoln Avenue.

[1] Work incomplete.

Lincoln, Irving Bowin,[1]	Glens Falls, N. Y.,	55 Pleasant Street.
Little, Harold Greenleaf,	Newburyport,	66 Pleasant Street.
Lovejoy, John Sumner,	Newburyport,	12 Cottage Street.
MacDonald, Norman Duncan,[1]	Melrose,	47 Pleasant Street.
MacNeil, Ralph Langdell,	Chelsea,	52 Amity Street.
Macy, Philip Arthur,	Oak Bluffs,	12 Cottage Street.
Mahan, Harold Butterworth,	Boston,	13 Phillips Street.
Marsh, Franklin Winter,	Amherst,	9 Woodside Avenue.
Marsh, Herbert Verner,	Greenfield,	79 Pleasant Street.
Masse, Sidney Merton,	Dorchester,	3 McClellan Street.
McKechnie, Ray Farrar,[1]	Natick,	5 McClellan Street.
McLain, Ralph Emerson,	Melrose,	10 Allen Street.
Melican, George Deady,[1]	Worcester,	66 Pleasant Street.
Moberg, Carl David,	Campello,	5 McClellan Street.
Moberg, Eldon Samuel,	Campello,	5 McClellan Street.
Montague, Enos James,	Northampton,	Nutting Avenue, care of Mr. Plumb.
Moore, Elbert Francis,[1]	Waltham,	81 Pleasant Street.
Moore, Roger Henry,	Beverly,	79 Pleasant Street.
Munger, George Draper,	Worcester,	– –
Murray, John Kean,	Winthrop,	Mt. Pleasant, care of Mr. Greene.
Navas, Miguel,	New York,	56 Pleasant Street.
Norton, Chester Harold,	Chelsea,	2 Allen Street.
Parmenter, Ernest Brigham,	Dover,	79 Pleasant Street.
Patten, Merrill Campbell,	Brighton,	52 Lincoln Avenue.
Patterson, Robert Earley,	Dorchester,	9 Woodside Avenue.
Pendleton, Harlow Libby,	Dorchester,	31 North Prospect Street.
Perkins, Olney Hilton,[1]	Brockton,	55 Pleasant Street.
Perry, Gerald Eugene,	Amherst,	17 Amity Street.
Phillips, Ralph Edward,	Mendon,	15 Hallock Street.
Pike, Joseph Stevens, Jr.,	Somerville,	3 Nutting Avenue.
Poole, Joseph Ellsworth,	Needham,	– –
Po, Shue Lo,	Canton, China,	31 Lincoln Avenue.
Potter, George Raymond,	Ludlow,	1 Allen Street.
Price, James Albert,	New York, N. Y.,	15 Beston Street.
Prouty, Langdon,	Littleton,	35 East Pleasant Street.
Quincy, Knight,	Roslindale,	35 East Pleasant Street.
Ray, George Burrill,	Hingham,	Brooks Farm.
Rendall, Raymond Eaton,	Melrose,	Lincoln Avenue and Amit Street.
Rhoades, Paul Whitney,	Malden,	2 Allen Street.
Rogers, Harold Merriman,	Southington, Conn.,	Mt. Pleasant, care of Professor Sears.
Saben, Maxwell Boehm,	Newport, R. I.,	83 Pleasant Street.
Sauchelli, Vincent,[1]	Waterbury, Conn.,	11 High Street.
Sauter, John Martin,	Turners Falls,	75 Pleasant Street.
Scott, Lincoln Bain,	Melrose,	3 McClellan Street.
Sears, William Richardson,	Arlington,	31 East Pleasant Street.
Severance, Verne Lincoln,	South Hanson,	Pleasant Street, care of Mr. Root.
Seton, George Patrick,	Darien, Conn.,	31 East Pleasant Street.
Shaylor, Fred Wright,[1]	Lee,	Kappa Sigma House.
Sherman, Milton Francis,	South Lincoln,	Dickinson House.
Simon, Isaac Barney,	Revere,	Brooks Farm.
Smith, Francis Albert,[1]	West Newton,	29 McClellan Street.
Smith, Philip Lawrence,[1]	Kingston,	East Experiment Station.
Spofford, Chester Porter,	South Groveland,	66 Pleasant Street.
Strauss, Abraham,[1]	Boston,	101 Pleasant Street.
Taft, Richard Craig,	Oxford,	88 Pleasant Street.
Tarr, Lester Winslow,	Rockport,	44 Pleasant Street.
Thayer, Granville Martyn,	South Hanson,	15 Beston Street.

[1] Work incomplete.

Tonry, Albert Joseph,	Winthrop,	17 South College.
Tower, William Reginald,	Sheffield,	120 Pleasant Street.
Tower, Ralph Ernest,	Becket,	Brooks Farm.
Towne, Edwin Chester,	Waltham,	19 Pleasant Street.
Upton, Raymond Melville,	Peabody,	19 Hallock Street.
Vinal, Stuart Cunningham,	East Weymouth,	8 Allen Street.
Warner, Lewis Pomeroy,[1]	Sunderland,	13 Phillips Street.
Weed, Frank Hammond,[1]	Great Neck, L. I.,	83 Pleasant Street.
Wellington, Benjamin,	Waltham,	Care of E. F. Gaskill.
White, Homer Beethoven,	Melrose,	35 South Pleasant Street.
White, Harry Dexter,	Boston,	56 Pleasant Street.
White, Henry Harrison,	West Peabody,	79 Pleasant Street.
Whitmore, Philip Ferry,	Sunderland,	13 Phillips Street.
Whorf, Paul Francis,	Forest Hills,	87 Pleasant Street.
Wilkins, Alfred Emerson,	Wakefield,	83 Pleasant Street.
Willey, Harold Cleland Clancey,[1]	Orange,	101 Pleasant Street.
Williams, Donald,[1]	Catasauqua, Pa.,	C. S. C. House.
Williams, Henry Chester,[1]	Topsfield,	21 McClellan Street.
Wright, Elvin Stanley,	Worcester,	15 Fearing Street.

UNCLASSIFIED STUDENTS.

Chambers, Maude Burdick,	Harpers Ferry, W. Va.,	3 Fearing Street.
Chow, Tse Ki,	Canton, China,	Care of Professor White.
Chu, Alfred Wen,	Tientsin, China,	90 Pleasant Street.
Crosby, Stanley,	Warren,	Theta Delta Chi House.
Dearth, Newman,	Ashland,	86 Pleasant Street.
Fisher, Earl Jarvis,	Falmouth,	23 Pleasant Street.
Fuller, Richard,	Salem,	6 Nutting Avenue.
Goodnow, Edna Minnie,	Amherst,	15 Spring Street.
Hart, Edward Haskell,	Falmouth,	86 Pleasant Street.
Howe, James Sullivan, Jr.,	Brookline,	Prospect House.
Kaulback, Hugh Arms,	Greenfield,	Care of Professor Gaskill.
Kennedy, Worthington Chester,	Hardwick,	15 Hallock Street.
Liang, Foo Tso,	Canton, China,	90 Pleasant Street.
Mott, Percival,	Nashua, N. H.,	81 Pleasant Street.
Moyle, John, Jr.,	Groton,	77 Pleasant Street.
Nash, Henry Clark, Jr.,	Amherst,	67 Pleasant Street.
Noble, Howard Ermy,	Tyngsborough,	"Lovers Lane."
O'Brien, Daniel William,	Wayland,	Brooks Farm.
Pease, Willard Noah M.,	Altoona, Pa.,	North Amherst.
Phelps, Benjamin Austin,	Northampton,	8 Allen Street.
Prouty, LeRoy Fletcher,	Rockland,	15 Hallock Street.
Rae, George Little,	Needham Heights,	3 Nutting Avenue.
Ray, Frederick Almar,	Hyde Park,	116 Pleasant Street.
Richards, Edwin Henry,	Hartford, Conn.,	2 Allen Street.
Selkregg, Edwin Reimund,	Amherst,	12 Cottage Street.
Stanford, Ernest Elwood,	Rowe,	71 South Pleasant Street.
Taplin, Warren Hartt,	Colorado Springs, Col.,	13 Hallock Street.
Trider, George Henry,	Waltham,	19 Pleasant Street.
Wright, George Ellery,	Brockton,	29 North Prospect Street.

[1] Work incomplete.

Summary by Classes.

Graduate students,	17
Senior class,	85
Junior class,	97
Sophomore class,	127
Freshman class,	169
Unclassified students,	29
Total,	524

Geographical Summary.

Massachusetts,	443
New York,	25
Connecticut,	20
New Hampshire,	6
New Jersey,	5
Pennsylvania,	4
Rhode Island,	4
Vermont,	2
Colorado,	1
Delaware,	1
Georgia,	1
Virginia,	1
West Virginia,	1
Iowa,	1
Maine,	1
China,	7
Scotland,	1
Total,	524

Graduate Students — Candidates for a Degree.

Allen, Rodolphus Harold, ... Fall River.
B.Sc., Massachusetts Agricultural College, 1910.

Anderson, David Wadsworth, ... Manchester, N. H.
B.Sc., New Hampshire State College, 1910.

Bartlett, Oscar Christopher, ... Westhampton.
B.Sc., Massachusetts Agricultural College, 1909.

Bourne, Arthur Israel, ... Amherst.
A.B., Dartmouth College, 1907.

Crossman, Samuel Sutton, ... Needham.
B.Sc., Massachusetts Agricultural College, 1909.

Holland, Edward B., ... Amherst.
B.Sc., Massachusetts Agricultural College, 1892; M.Sc., Massachusetts Agricultural College, 1898.

Hourdequin, Leon Remy, ... Brooklyn, N. Y.
A.B., Williams College, 1911.

McLaine, Leonard Septimus, ... New York, N. Y.
B.Sc., Massachusetts Agricultural College, 1910.

Merrill, Joseph Henry, ... Danvers.
B.Sc., Dartmouth College, 1905.

Smulyan, Marcus Thomas, ... Amherst.
B.Sc., Massachusetts Agricultural College, 1909.
Thomas, Frank Lincoln, ... Athol.
B.Sc., Massachusetts Agricultural College, 1910.
Thompson, Edward Joseph, ... Cambridge.
B.Sc., Harvard College, 1911.
Watkins, John Bedford, ... Midlouthian, Va.
B.Sc., Virginia Polytechnic, 1911.
Regan, William Swift, ... Northampton.
B.Sc., Massachusetts Agricultural College, 1908.

GRADUATE STUDENTS — NOT CANDIDATES FOR A DEGREE.

Adams, Harold Stanard, ... Pittsfield.
A.B., Williams College, 1911.
Butler, Aubrey Bickford, ... Chelsea.
A.B., Dartmouth College, 1911.
Crocker, Bartow, ... Cambridge.
B.Sc., Harvard College, 1911.

ADDENDUM.

ADDENDUM.

MAJORS.

GENERAL STATEMENT.

Beginning with September, 1912, a plan of major courses will become operative for members of the junior and senior classes. A major will consist of 30 hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their department. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

CLASS OF 1913.

Since it will not be possible for the class of 1913 to conform fully with the regulations concerning majors given above, the following regulations will apply to them in making their elections: —

As stated below, the minimum semester credits will be 15 hours, the maximum 21 hours, and the members of the class of 1913 will fill out their elective cards with these facts in mind. For the class of 1913 the required work after the sophomore year is to be counted as follows: —

5 credits in the junior year in Military Science and Physical Education.
3 credits in Economics 1.
3 credits in English; other subjects in the Humanities, or Rural Social Science.

Each member of 1913 must obtain on June 5, from the registrar, an elective card to be filled out with his election of courses for the senior year.

Members of 1913 must from the list given below choose any instructor as his adviser. After the card has been filled out for both semesters of the senior year, and has received the approval of the adviser, it must be returned to the registrar's office on or before June 15.

RULES.

RULE 1. *Election.* — Each student, in the second semester of his sophomore year, shall elect a major subject from the list of majors given below; and this major shall consist of 30 credit hours of correlated work.

RULE 2. *Minimum Credits.* — The minimum number of credits for the junior and senior years shall be 65, inclusive of Military Drill and Physical Education.

RULE 3. *Maximum Credits.* — The maximum number of credits for any semester of the junior or senior year shall be 21.

RULE 4. *Humanities and Rural Social Science.* — A minimum of 15 credit hours in the Divisions of the Humanities and of Rural Social Science shall be required of all students during their junior and senior years, with the following restriction: that a minimum of 3 credit hours will be required in each of the divisions.

RULE 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 30 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

RULE 6. *Free Electives.* — Each student is required to take 30 hours in his major and 15 hours in the Divisions of the Humanities and of Rural Social Science, making a total of 45 hours. He is allowed free choice for the remaining part of his required hours, this remainder amounting to 15 hours minimum for the two years, or 35 hours maximum.

RULE 7. *Registration.* — No upper classman shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office on June 5.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the year and will countersign the same.

(3) Each course card must be filled out, giving the name of student, with his college address, also the name of parent or guardian,

with the home address. When the elections have been entered on this card, and the balance of hours added by the student, the card must be returned to the registrar not later than June 15.

RULE 8. *Changes.* — Applications for changes may be made to the dean in writing at any time, and, when approved by him and by the committee on scholarship, become operative at the beginning of the semester following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

LIST OF MAJORS.

Agriculture.

Prof. JAMES A. FOORD, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 6,	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 9,	3
Dairying 1,	3
Dairying 2,	3
Farm Administration 3,	3
Farm Administration 4,	3
Chemistry 7,	3
Veterinary Science 1,	3
	31

Agronomy.

Assistant Prof. SIDNEY B. HASKELL, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 4,	3
Agronomy 5,	3
Agronomy 6,	3
Agronomy 8,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Farm Administration 4,	3
Chemistry 7,	3
Chemistry 8,	3
	30

Animal Husbandry.

Associate Prof. J. ALLAN McLEAN, Adviser.

Course.	Credit.
Agronomy 3,	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 10,	3
Animal Husbandry 11,	2
Dairying 1,	3
Farm Administration 3,	3
Farm Administration 4,	3
Veterinary Science 3,	3
	29

Dairying.

Associate Prof. WILLIAM P. B. LOCKWOOD, Adviser.

Course.	Credit.
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 11,	2
Dairying 1,	3
Dairying 2,	3
Dairying 3,	3
Dairying 4,	3
Farm Administration 3,	3
Farm Administration 4,	3
	29

Poultry Husbandry.

Associate Prof. JOHN C. GRAHAM, Adviser.

Course.	Credit.
Poultry Husbandry 1,	2
Poultry Husbandry 2,	2
Poultry Husbandry 3,	1
Poultry Husbandry 4,	1-3
Poultry Husbandry 5,	1
Poultry Husbandry 6,	3
Poultry Husbandry 7,	3
Poultry Husbandry 9,	3
Pomology 1,	3
Agronomy 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Veterinary Science 1,	3
	31

General Horticulture.

Prof. Frank A. Waugh, Adviser.

This major will consist of courses selected from the Departments of Pomology, Floriculture, Market Gardening, Landscape Gardening and Forestry, to suit the particular needs of the student. In special cases, courses from the Department of Agronomy will also be counted toward the major in general horticulture.

Floriculture.

Prof. Edward A. White, Adviser.

Course.	Credit.
Floriculture 1,	4
Floriculture 2,	4
Floriculture 3,	3
Floriculture 4,	3
Horticulture 3,	3
Horticulture 4,	3
Entomology 1,	3
Market Gardening 2,	3
Botany 2,	4
	30

Note. — Horticulture 3 and 4 is a junior subject, but to balance the work for the two years it would be better for the floricultural students to take the course in the senior year.

Forestry.

Associate Prof. Frank F. Moon, Adviser.

Course.	Credit.
Forestry 1,	3
Forestry 2,	3
Forestry 3,	3
Forestry 4,	3
Forestry 5,	2
Forestry 6,	2
Entomology 5,	3
Horticulture 3,	3
Horticulture 4,	3
Botany 13,	4
	29

Landscape Gardening.

Prof. Frank A. Waugh, Adviser.

Course.	Credit.
Landscape Gardening 1,	3
Landscape Gardening 2,	3
Landscape Gardening 3,	3
Landscape Gardening 4,	3
Landscape Gardening 5,	2
Landscape Gardening 6,	2
Landscape Gardening 7,	3
Landscape Gardening 8,	3
Drawing 1,	3
Drawing 2,	3
Horticulture 3,	3
	31

Landscape Gardening 6 will probably be given quite differently in alternate years, and thus should be open to *both* juniors and seniors.

Courses for juniors *only*: Landscape Gardening, 1, 2, Drawing, 1 and 2.

Courses for seniors and graduates *only*: Landscape Gardening, 7 and 8.

Courses open to juniors and seniors, both if possible: Horticulture 3 and 4 and possibly Landscape Gardening 3 and 4.

This grouping of subjects is offered only as an example. Other groupings may be approved by the adviser, but such other groupings must be subject to the class schedule.

Pomology.

Prof. Fred C. Sears, Adviser.

Course.	Credit.
Pomology 1,	3
Pomology 2,	3
Pomology 3,	3
Pomology 4,	3
Botany 5,	2
Botany 7,	5
Agronomy 6,	3
Farm Administration 3,	3
Farm Administration 4,	3
Entomology 1,	3
	31

Agricultural Chemistry.

Assistant Prof. Charles A. Peters, Adviser.

Course.	Credit.
Chemistry 5,	5
Chemistry 6,	5
Chemistry 9,	5
Chemistry 10,	5
Chemistry 11,	5
Chemistry 12, 14 or 16,	5
Chemistry 13,	3
Chemistry 15,	3
Chemistry 18,	2
	38

The major will consist of 30 credit hours selected from this list. The student will be advised concerning other subjects suited to be taken in connection with Chemistry.

Economic Entomology.

Prof. Henry T. Fernald, Adviser.

Course.	Credit.
Entomology 1,	3
Entomology 2,	2
Entomology 3,	4
Entomology 4,	4
Entomology 5,	3
Entomology 8,	3
Botany 3,	4
Botany 4,	2
Zoölogy 3,	3
Zoölogy 4,	3
	31

A major in Economic Entomology does not necessarily include all the entomological subjects, as implied at the top of this list.

Plant Physiology and Pathology.

Prof. George E. Stone, Adviser.

Course.	Credit.
Botany 3,	4
Botany 4,	2
Botany, 10,	4 or 5
Botany 14,	4
Chemistry 5,	5
Chemistry 6,	5
Entomology 1,	3
Entomology 2,	2
	29 or 30

Agricultural Education.

Prof. William R. Hart, Adviser.

Course.	Credit.
Agricultural Education 1,	3
Agricultural Education 2,	3
Agricultural Education 3,	2
Agricultural Education 4,	3
Dairying 5,	2
Farm Administration 3,	3
Floriculture 1,	4
Poultry Husbandry 1,	2
Poultry Husbandry 2,	2
Market Gardening 2, or Agronomy 3,	3
Botany 5,	2
	29

A minimum of 15 credit hours should be elected by the student from the group of subjects offered by the Divisions of the Humanities and of Rural Social Science. Not less than 3 credit hours must be taken in each division.

Elective Courses offered in Division of Humanities.				Elective Courses offered in Division of Rural Social Science.		
Economics and Sociology	History and Government	English	Modern Languages	Agricultural Economics	Agricultural Education	Rural Sociology
1 Elementary Economics	1 Elements of Political Science	7 Expository Writing	7 Scientific French 11 German Literature		1 Meaning of Education	3 Literature of Rural Life
3 Social Institutions and Social Problems	3 History of New England	9a. Introductory Rural Journalism (2 hrs.) 9b. Journalistic Prac. (2 hrs.) 9c. Adv. Journalistic Practice (1 hr.) (Ind.)	9 French Literature	7 Problems in Agr. Econ. (2 hrs. Ind.)	3 Methods (2 hrs. Ind.)	7 Rural Institutions
5 Public Finance, Money, Banking	5 History of Ideals	13 English Writers and Thought	1 Elementary Spanish	9 Seminar (Ind.)	5 Seminar (Ind.)	5 Social Conditions of Rural People
		15 English Language and Literature	9 Scientific German	5 Historical and Comparative Agr.		9 Social Psychology of Rural Life
		P. S. 9 Debating (Ind.) (2 hrs.)	7 Modern German			11 Soc. Aspects of Current Agric. Quest.
		17 Adv. Comp. and Literature (2 hrs.)				
			1 History of Music (Ind. evening)			13 Seminar
2 Industrial Problems	2 Local Political Institutions	8 Expository Writing (technical)	8 Scientific French		2 Vocational Educ.	4 Rural Law (Ind.)
4 Mod. Soc. Ref. Movements		10a. Reporting and News Writing (2 hrs.) 10b. Jour. Prac. (2 hrs.) 10c. Adv. Jour. Prac. (1 hr.) (Ind.)	10 French Literature	5 Co-operation in Agr. (2 hrs. Ind.)	4 Teachers' Agric.	6 Soc. Aspects of Co-op. among Farmers
6 Economic History		14 English Writers and Thought	2 Modern Spanish Authors	10 Seminar (Ind.)	6 Seminar (Ind.)	8 The State and the Farmer.
8 Anthropology		16 English Language and Literature	10 Scientific German	4 Elements of Agric. Economics		10 Farmers' Organizations
		18 Advanced Literature	8 Modern German			2 Rural Community
		P. S. 8 Occasional Oratory	2 History of Music (Ind.)			

Ind. = hours may be arranged independent of schedule.

SUMMARY.

There are four preliminary steps which a student should take in arranging for his major work.

1. Select a major.

2. Confer with major adviser for arrangement of courses, the plan to be approved by adviser in accordance with Rule 5 previously stated.

3. Select courses covering the four semesters of the junior and senior years in such a way that a minimum of 15 credits will be taken in the Divisions of Humanities and of Rural Social Science; the distribution of all but 3 of these credits may be decided by the student.

4. Choose other courses so that the total number of credits for any semester shall be not less than 16 or more than 21. (See Rules 2 and 3.)

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Public Document No. 31

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OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.,

BEING PART III. OF THE FORTY-NINTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1912.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.

INTRODUCTION.

In accordance with the provision of the act of the Legislature relative to the publication of the reports of the Massachusetts Agricultural College, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. contains the formal reports of the director, treasurer and heads of departments, and papers of a technical character giving results of research work carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to all those on our general mailing list as well as to agricultural colleges and experiment stations, to workers in these institutions and to libraries in Massachusetts.

WM. P. BROOKS,
Director.

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Part I.

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-FOURTH ANNUAL REPORT.

PART I.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
ARTHUR G. POLLARD.
CHARLES E. WARD.
HAROLD L. FROST.
THE PRESIDENT OF THE COLLEGE, *ex officio.*
THE DIRECTOR OF THE STATION, *ex officio.*

Station Staff.

WILLIAM P. BROOKS, Ph.D., Director, 28 Northampton Road.
JOSEPH B. LINDSEY, Ph.D., Vice-Director, 47 Lincoln Avenue.
FRED C. KENNEY, Treasurer, Mount Pleasant.
CHARLES R. GREEN, B.Agr., Librarian, Mount Pleasant.

Department of Plant and Animal Chemistry.

JOSEPH B. LINDSEY, Ph.D., Chemist, 47 Lincoln Avenue.
EDWARD B. HOLLAND, M.Sc., Associate Chemist, in charge of Research Division, 28 North Prospect Street.
FRED W. MORSE, M.Sc., Research Chemist, 44 Pleasant Street.
HENRI D. HASKINS, B.Sc., In charge of Fertilizer Section, Amherst House.
PHILIP H. SMITH, M.Sc., In charge of Feed and Dairy Section, 102 Main Street.
LEWELL S. WALKER, B.Sc., Assistant, 19 Phillips Street.
JAMES C. REED, B.Sc., Assistant, Nutting Avenue.
JOSEPH F. MERRILL, B.Sc., Assistant, North Prospect Street.
CLEMENT L. PERKINS, B.Sc., Assistant, 32 North Prospect Street.
RUDOLF W. RUPRECHT, B.Sc., Assistant, 31 Amity Street.
JAMES T. HOWARD, Collector, North Amherst.
HARRY J. ALLEN, Laboratory Assistant, 89 Main Street.
JAMES R. ALCOCK, Assistant in Animal Nutrition, North Amherst.

Department of Agriculture.

William P. Brooks, Ph.D., Agriculturist, 28 Northampton Road.
H. J. Franklin, Ph.D., In charge of Cranberry Investigation, Wareham.
Edwin F. Gaskill, B.Sc., Assistant, North Amherst.

Department of Horticulture.

Frank A. Waugh, M.Sc., Horticulturist, Massachusetts Agricultural College.
Fred C. Sears, M.Sc., Pomologist, Mount Pleasant.
Jacob K. Shaw, Ph.D., Research Assistant, 1 Allen Street.
David W. Anderson, B.Sc., Graduate Assistant, 32 North Prospect Street.

Department of Botany and Vegetable Pathology.

George E. Stone, Ph.D., Botanist and Vegetable Pathologist, Mount Pleasant.
George H. Chapman, M.Sc., Research Assistant, 13 Fearing Street.
Edward A. Larrabee, B.Sc., Assistant, Clark Hall.

Department of Entomology.

Henry T. Fernald, Ph.D., Entomologist, 44 Amity Street.
Burton N. Gates, Ph.D., Apiarist, 42 Lincoln Avenue.
Arthur I. Bourne, B.A., Assistant, 66 North Pleasant Street.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., Veterinarian, 42 Lincoln Avenue.

Department of Meteorology.

John E. Ostrander, A.M., C.E., Meteorologist, 35 North Prospect Street.
R. N. Hallowell, Observer, Massachusetts Agricultural College.

Other Officers of the Experiment Station.

Herbert J. Baker, B.Sc., Secretary to the Director, Experiment Station.
Mrs. Lucia G. Church, Stenographer to the Director, 4 Hallock Street.
Miss Alice M. Howard, Stenographer, Department of Plant and Animal Chemistry, North Amherst.
Miss F. Ethel Felton, Stenographer, Department of Plant and Animal Chemistry, Phillips Street.
Miss Jessie V. Crocker, Stenographer, Department of Botany and Vegetable Pathology, Sunderland.
Miss Bridie O'Donnell, Stenographer, Department of Entomology, Hadley.

REPORT OF THE DIRECTOR.

Changes in Staff.

During the past year there have been no changes in the more important positions in the experiment station staff. A number of our younger assistants, however, have resigned for various reasons, among which the offer of higher salaries, plans to pursue graduate studies, or to engage in business are among the more prominent. The changes in detail are as follows: —

Sumner C. Brooks, B.Sc., assistant in botany, replaced by Edward A. Larrabee, B.Sc.; Joseph F. Merrill, B.Sc., assistant in plant and animal chemistry, resigned; Clement L. Perkins, B.Sc., assistant in plant and animal chemistry, resigned; David W. Anderson, B.Sc., graduate assistant in department of horticulture, resigned, this position still being vacant. Erwin S. Fulton, B.Sc., assistant agriculturist, resigned, his position being taken by Edwin F. Gaskill, B.Sc., promoted. Charles M. Damon, observer in the meteorological department, replaced by R. N. Hallowell.

The position of second assistant agriculturist has not been filled, but instead the position of secretary to the director has been created. This position has been filled by the appointment of Herbert J. Baker, B.Sc., a recent graduate of the Massachusetts Agricultural College. This change has made possible a sharper division between outdoor and office work, Mr. Gaskill taking charge of the former, while Mr. Baker takes charge of the books, attends to routine correspondence, assists the director in preparation of material for publication, as well as in many other directions.

Two of our most experienced and valuable stenographers, Miss Brown and Miss Cobb, have resigned during the year, their places being taken by Mrs. Church and Miss Felton.

Lines of Work.

There have been no important changes in the general character of station work during the year, although in scope and amount it constantly increases. It includes general experiments both on the home grounds and at substations as well as in co-operation with farmers, research, police or control work, and dissemination of information.

General Experiments.

In order to give a general idea of the nature of the work which is being carried on I cannot do better than to quote a statement in the last annual report: —

> Under this head are included a large number of experiments relative to the following subjects: soil tests with fertilizers, with different crops in rotation; comparisons of different materials which may be used as sources, respectively, of nitrogen, phosphoric acid and potash for different field and garden crops; the results of the use of lime; systems of fertilizing grass lands, both mowings and pastures; comparisons of fertilizers for both tree and bush fruits; different methods of applying manures; variety tests of field and garden crops and of fruits; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems and methods of management in feeding poultry for eggs; and co-operative work with selected farmers in the trial of crops and systems of fertilizing them.

In addition we have two substations where work of a highly diversified character is being carried on, viz., asparagus substation in Concord and cranberry substation in Wareham. In later pages will be found brief reports on the work in these substations, while a short account of the results of our co-operative experiments with alfalfa will be found in Part II. of this report.

No full general account or discussion of experimental work in progress will be given. Brief reports on some of the general experiments will be found under the departments in which they are being prosecuted.

Research.

The research work in progress at the station is, for the most part, carried on under the Adams fund. The work during the past year along certain lines has been somewhat interrupted owing to the necessity of making extensive additions and improvements in our chemical laboratory. These improvements were, however, very carefully planned and executed under the general supervision of Dr. J. B. Lindsey and his associates, and the extent to which they were allowed to interfere with the progress of laboratory work was, on the whole, surprisingly small.

The following are the principal Adams fund problems which at present engage our attention: —

1. To determine the principles which should underlie practice in the use of fertilizers for the cranberry crop.

2. To determine the principles which should underlie practice in the use of fertilizers for asparagus.

3. Work in plant breeding in the endeavor to produce more rust-resistant types of asparagus. (In co-operation with the Bureau of Plant Industry, United States Department of Agriculture.)

4. Investigation of the solubility effect of ammonium sulfate on the soil of one of our experimental fields. (Field A.)

5. The effect of food on the composition of milk and butter fat and on the consistency or body of butter.

6. The cause of the digestion depression produced by molasses.

7. Why insecticides burn foliage.

8. The relations of climate to development of plants and crops both in health and disease.

9. The causes of calico or mosaic disease as affecting especially the tobacco and the tomato.

10. Malnutrition of plants; causes and prevention.

11. The intensity and amount of sunshine as affecting disease of plants.

12. The causes of winter-killing.

13. Determination of physiological constants.

14. Plant breeding, especially with peas, beans and squashes, to determine the extent to which the Mendelian laws appear to govern heredity.

15. The relations of climate to variation in leading varieties of apples.

16. The economic importance of digger wasps in relation to agriculture.

17. Color vision in bees.

A number of these lines of investigation are well advanced, though none can be regarded as brought to completion. Sufficient progress has, however, been made in connection with a number of them to warrant publication, and technical papers covering some phases of this work will be found in later pages. The more important are as follows: —

The natural fertility of cranberry bogs.

Tobacco injury due to malnutrition or overfertilization.

Variation, correlation and heredity in garden peas.

The effect of fertilizer on variation in corn and beans.

The chemistry of arsenical insecticides.

Cranberry Substation.

Dr. H. J. Franklin remains in local charge of the business and investigational work connected with our cranberry substation. He has devoted himself to the matters in his charge with the greatest faithfulness and enthusiasm, and it is a pleasure to testify to the great value of his services.

During the past year our equipment for work in the interests of cranberry growers at the substation in East Wareham has been much increased and a large amount of construction work has been done. The principal improvement made has been the erection of a building. This building contains a large screening and packing room, living and office rooms for the local officer in charge, a small laboratory, and large basement and cellar storage rooms. The cost of the building was about $2,000.

Dr. Franklin furnishes the following description of special construction at the station bog completed during the year: —

1. *Flooding Areas.* — Five separate areas were diked off on the station bog for experiments in flooding. Four of the areas contain about one-fifteenth of an acre each and the fifth contains about an eighth of an acre. These areas are all separated from each other by dikes and narrow check strips. The dikes were built of turf and sand in the usual way, and average about 20 inches in height and 3 feet in width. In all, about 1,100 running feet of this diking was built. A canal, about 450 feet long and 3 feet wide, was constructed around the margin of the

bog, and connected with the main flooding canal in order to flow and drain these areas. Short side canals were dug to connect this canal with the separate areas. Small canals were also dug to connect the check strips with this canal system. In these various canals 13 wooden flumes were built for controlling the water.

2. *Skinner System Installation.* — On the station bog at East Wareham two lines, 70 and 100 feet long, respectively, of ¾-inch galvanized piping were installed, 60 feet apart, after the usual manner of Skinner system installation. The longer line was supported at intervals by concrete posts of sufficient height to allow a man to walk beneath the piping without stooping. The other line was hung in rings suspended from a wire cable drawn taut between two concrete posts. Both of these methods of support have disadvantages. In the former the concrete posts are too numerous and too heavy to give good satisfaction on the usually soft bottom of a cranberry bog. In the latter it is hard to get rid of a certain amount of sag in the piping, which makes proper pipe drainage difficult in freezing weather. Probably a better method than either of these would be to support the piping on wooden posts reaching up only a foot or two from the surface of the bog, and placed close enough together to prevent the pipe from sagging perceptibly. Skinner "Outdoor No. 2" nozzles were used in this installation. The water for running the system was pumped from Spectacle Pond by means of a Myer's pump driven from the big engine used in flooding the bog. It was arranged to pump this water through 350 feet of 1¼-inch galvanized piping before it reached the Skinner unions, leading into the ¾-inch pipe lines. This 1¼-inch pipe was, for the most part, buried in the ground. A special device driven by water pressure, for turning the pipes back and forth so as to throw the water on both sides, was also installed. The piping in the pump house was arranged to provide for heating the water by pumping it first through the cooling jacket of the 40 horse-power Fairbanks-Morse engine, and then through a coil in the exhaust pot of the engine.

For this installation, the Skinner Irrigation Company, Troy, O., through the courtesy of its president, Mr. W. H. Coles, provided nozzles and Skinner unions and loaned the station a Skinner drilling machine.

The small piece of upland referred to in the last report as desirable in order to give better access to our building has been purchased during the year.

The Crop of 1911.

The yield of fruit on the station bog during the past year was in round numbers 850 barrels of berries. These were sold for the sum of $4,988.33. The ordinary running expenses for the season amounted to $1,817.08. The bog, therefore, yielded a net income over and above ordinary running expenses of $3,171.25.

The crop of the season was probably better than the average crop will be, and it sold for good prices. We can hardly anticipate so large a net income annually, but there would seem to be no question that the product of the bog will be sufficiently large to furnish a considerable share of the funds that will be needed for paying the costs of experimental work.

Principal Lines of Cranberry Work.

Three principal lines of investigation with cranberries are in progress. These relate respectively to the fertilizer requirements of the crop, the relations of insects to the cranberry industry, and the study of injurious fungi.

Fertilizer Experiments.

The fertilizer experiments in Red Brook bog at Waquoit have again given indecisive results. These experiments will be discontinued. We have found it exceedingly difficult to care for them properly on account of their distance from our center of operations, and we are convinced, moreover, that certain natural inequalities in the character of the bog soil in the different plots must always considerably reduce the value of the results obtained.

During the past season a new series of plots has been laid out in the station bog. The results of the season do not show a well-defined benefit following from the use of either of the different fertilizers employed. The crop where nitrate of soda is applied, indeed, showed a small average decrease. Both acid phosphate and high-grade sulfate of potash show a very small average increase, — not in either case enough to cover the cost of the fertilizer material applied. The results of the year, therefore, do not lend encouragement to the belief that the use of fertilizers on bogs of as good productive capacity as that belonging to the station will be followed by a profitable increase in the crop. It is important, however, to point out that the application of fertilizers this season was not made until about the middle of July. It seems probable that this is too late for the best results.

Dr. H. J. Franklin furnishes the following report concerning some of his principal lines of investigation during the past two years: —

Cranberry Investigations, 1910.

I. INSECTS.[1]

Of the important cranberry pests heretofore known, those which received attention were the fruit worm, the fire worm and the cranberry girdler.

The Fruit Worm (*Mineola vaccinii* (Riley)).

Experiments in submerging cocoons containing larvæ of this insect, for varying lengths of time during the fall of 1909 and winter and spring of 1910, were carried on without very satisfactory results, due, perhaps, to failure to perfectly imitate natural bog conditions.

Spraying experiments were also carried on, the insecticides used being mostly combinations of adhesives and arsenicals. The combination found most effective consisted of the following mixture in 50 gallons of water: —

	Pounds.
Resin fish-oil soap,	4½
Bordeaux mixture: —	
(*a*) Stone lime,	4
(*b*) Copper sulfate,	3
Paris green,	1

As the soap had adhesive and spreading qualities, and the Bordeaux mixture gave body to the combination and also acted to some extent as an adhesive, this combination spread over the smooth surface of

[1] Dr. H. T. Fernald has aided Dr. Franklin in the insect work in an advisory way, and for his helpful suggestions Dr. Franklin acknowledges his indebtedness and expresses his appreciation.

the partly grown berries and adhered to it much better than did any arsenical with water alone. In this mixture, Paris green seemed to give better results than arsenate of lead. Best results were obtained by spraying twice with an interval of at most only a few days between the two applications, the first application thus acting as a basis for putting a thicker coating of poison on the fruit than would be possible with one spraying alone. This spraying was done about July 20 on berries of a late variety on a strictly dry bog (*i.e.,* no winter flowage). The fruit at this time varied greatly in size, the largest berries being nearly half grown. On some plots the fruit worm injury was reduced as much as 60 per cent.

The Fire Worm (*Eudemis vacciniana* (Pack.)).

The work with this insect consisted entirely of spraying experiments. In the spring, arsenicals alone and in combination with Bordeaux mixture and resin fish-oil soap were tested as insecticides for the larvæ. It became evident that an insecticide of good sticking properties was needed for this purpose as the new foliage of the cranberry is smooth and glossy and holds the water sprays very poorly. Furthermore, this new growth develops rapidly during the time of the hatching of the first brood, and sometimes this hatching period is strung out for fully a month. The experiments indicated that a combination of Bordeaux mixture, Paris green and resin fish-oil soap, like the one given above for the fruit worm, would be most effective for this insect also. One test with this combination showed about three-fifths as much arsenic present on the foliage, after an all day's rain followed by a complete ten-hour flooding, as was present when the spray was first applied. The material for this combination is about as cheap as the arsenate of lead capable of doing the same work. The work connected with its preparation, however, is considerable.

Late in the fall, the value of scalecide and commercial lime-sulfur, as insecticides for destroying the eggs of this insect, was tested. Several plots were sprayed with different strengths of each of the two insecticides mentioned. On some plots a plank drag was used in advance of the spraying to turn the vines over, in order better to allow the spray to reach the lower surfaces of the leaves (on which the eggs are usually laid). The results of this spraying were observed early in June, 1911. Though many eggs hatched on all the plots, it was evident that on those treated with scalecide, a large percentage had been destroyed. However, on all plots on which many of the eggs were killed by the treatment, a large percentage of the winter buds were destroyed also. The fire worm injury appeared to be considerably worse on the plots which had been sprayed with the lime-sulfur than on unsprayed portions of the bog, though the reason for this was not apparent. This method of treatment does not appear promising.

Cranberry Girdler (*Crambus hortuellus* (Hübner)).

The work with this insect was confined to applying different depths of sand to infested plots, to find out what depth was necessary to smother the insect and prevent the moths from coming through. The sand was applied evenly, late in May, to depths varying from 1 to 3 inches. Means for catching and counting the moths which came through the sand on the various plots were provided. An unsanded check plot was also placed under observation and control. No moths came through the sand on any of the sanded plots, while a large number were captured from the check plot. Future work may show that less than a full inch of sand, when evenly spread, is sufficient. However, an inch is not too much to be practicable, especially as the vines are usually heavy where this insect becomes troublesome. To be effective, this treatment must be applied between December 1 and the following June 1 (when the insect is in its cocoon under the vines), and the sand must be spread evenly.

A New Pest.

During 1910 a Lepidopterous insect, known to science as *Gelechia trialbamaculella* Chambers, did great injury to a few strictly dry bogs. Neither the food plant nor the life history of this insect had been heretofore known. Its habits and life history were largely worked out during the season. The insect passes the winter in the moth state, as does the yellow-headed cranberry worm (*Peronea minuta* Robinson), and its larvæ, though considerably smaller, resemble somewhat the larvæ of that insect, both in general appearance and in habits. It is heavily parasitized, and will probably never do noticeable injury on winter-flowed bogs.

II. FUNGI.

The 1910 fungus work, done in co-operation with the Bureau of Plant Industry, consisted in obtaining the assistance of certain of the cranberry growers in practical spraying experiments, and in collecting specimens for examination by Dr. C. L. Shear, the expert of the Bureau of Plant Industry.

Investigations during 1911.

During 1911 the cranberry investigation work was divided between experiments and observations and construction work for future investigations.

Experiments and Observations.

This work came under the seven following heads, viz: Insects, Fertilizers, Fungous Diseases, Weather Observations, Fertilization of the Cranberry Blossom, Prolificness of Varieties, and application of Skinner Irrigation System to the Needs of the Cranberry Industry. The work under these heads is here outlined: —

1. Insects.

Observations were continued and experiments conducted with the fruit worm and the fire worm (black-headed cranberry worm). Numerous growers treated the yellow-headed cranberry worm (or, as it might be called in Massachusetts, the dry-bog fire worm), under advice given out by the station, apparently with universally satisfactory results. Heavy sanding done by various growers, in some cases, proved successful against the cranberry girdler. In others it failed to give satisfaction, the failure in every case observed being due to the fact that the sand was not applied evenly over the infested areas.

THE FRUIT WORM (*Mineola vaccinii* (Riley)). — Work was begun on the natural enemies of this insect, with the following objects in view: —

1. To find out what these enemies are.
2. To determine their relative abundance on flowed and dry bogs.

Spraying experiments with arsenicals and adhesives were continued. It was learned that too much resin fish-oil soap had been used in 1910. While the spraying was not timed so as to give the best results, the experience of 1911 indicates that the following formula will be found more satisfactory than the one given as the result of the 1910 experiments: —

Resin fish-oil soap (pounds),	2
Bordeaux mixture: —	
(*a*) Stone lime (pounds),	5
(*b*) Copper sulfate (pounds),	2½
Paris green (pound),	1
Water (gallons),	50

Much more of the soap than is here recommended causes bad clogging of nozzles and pumps.

While the fruit worm injury was reduced about one-third, this gain was largely offset by the loss due to tramping on the vines and berries while spraying, so that the amount of fruit obtained from the sprayed plots was but little greater than that picked from equal areas on the surrounding bog.

THE FIRE WORM (*Eudemis vacciniana* (Pack)). — The season's observations on this insect seem to indicate that the character of the vine growth has a strong influence on the length of the hatching period of the spring brood. Among thin vines most of the eggs seem to hatch within a few days after hatching begins. With deep, dense vines, this period seems to be so drawn out that numerous eggs are always present throughout the year, the two broods overlapping in this stage. If these observations are correct, the character of the vine growth must have an important bearing on the efficacy of both flowing and spraying treatments. In practice, it seems to be an easy matter, on a thinly vined bog, to control this insect sufficiently to keep it from doing serious injury, either by spraying with arsenate of lead or by flowing, while it is apparently impossible to prevent serious injury on a densely vined bog by either of these treatments. The control of this insect, therefore, seems to hinge on the acquirement and maintenance of a thin vine growth, which is also the most desirable condition for maximum crops. Unfortunately, it seems difficult to get a thin vine growth on some bogs. However, this can probably be readily accomplished in most cases, at least, by heavy sanding and proper adjustment of water conditions. This adjustment might be along either or both of the following distinct lines: —

1. Early withdrawal of winter flowage with no long-continued reflowage.

2. Sufficient drainage.

Experiments to test the methods of controlling this insect, here suggested, have already been started. Observations seem to show that large bogs, when compact (*i.e.*, approaching a circle or square) in general form, are, other conditions being the same, much more troubled with this insect than are small ones. Probably the chief reason for this is the fact that, during the summer, parasitic and predacious insects and spiders do not become so thoroughly distributed over the large bogs, at least until the periods of fire-worm activity are nearly over, and so do not become to so great an extent a controlling factor. On a winter-flowed bog, most of these forms are probably either destroyed or driven ashore by the flooding every year. They should not, during the summer, become as uniformly distributed on a large, compact bog as on a small one for two reasons, viz.: —

1. The distance which the parasitic and predacious forms must go to reach the central portion of the bog is, of course, greater on a large bog.

2. As the area from which these forms come onto the bog is probably restricted, for the most part, to a fringe at most only a few hundred feet wide, the area of the bog as it increases in size, if it is compact in shape, increases out of proportion to the increase of the area of this fringe. This argument agrees well with the following previously reported observations: —

1. The fire worm is only very rarely, if ever, troublesome on strictly dry bogs in Massachusetts.

2. When a winter-flowed bog becomes infested the infestation first noticed is always some distance away from the upland, usually where the winter flowage is deep.

The fact that, on a compact bog, there is a larger acreage within a given distance of any point, up to a distance that would take in the whole bog, than there is on a long, narrow one of equal acreage, may also be, to some extent, a factor in favor of this insect. If it gained a foothold on one portion of such a compact bog, it would more readily and quickly spread to all other portions.

It seems probable, from the various observations made, that if a large bog, round or squarish in shape, is by any means whatever entirely freed from this insect (even by burning or by long-continued summer flowage), it will not, as a rule, long remain so if all the following conditions are allowed to exist: —

1. Winter flowage, especially if it is deep, over a considerable portion of the bog.
2. Not more than one reflowage after the 25th of May.
3. Conditions favoring heavy vine growth.

New Pests. — During the season two new insect pests did considerable injury in some localities on cranberry bogs. One of these is a scale insect (*Aspidiotus oxycoccus* Woglum) which superficially resembles the San José scale somewhat but is very distinct from that species. This species did much injury on a bog in Yarmouth and was noted in smaller numbers in a few other places.

The other insect is a species of white grub (*Lachnosterna* sp.). It caused the dying of circular areas on several bogs, principally in Carver, these patches varying in diameter from 3 to 30 feet. This injury observed superficially might easily be mistaken for the "ringworm" injury caused apparently by fungous disease.

2. *Fungous Diseases.*

This work, as during the previous season, was done in co-operation with the Bureau of Plant Industry. Co-operative spraying experiments were carried on by several practical growers. In addition 3 plots on the station bog, each 4 rods square, were sprayed with fungicides and the results noted, as shown by the quantity and keeping quality of the fruit obtained. The amount of fruit gathered from these plots in every case was somewhat less than that from checks marked on the surrounding bog. This was due, apparently, to the injury done by tramping on the vines while spraying. Loss due to decay up to December 4 was reduced, on an average, about one-half by the treatment. One plot was sprayed three times and the others twice with mixtures and on dates as follows: —

Fungicide.	Plots.				
	A.	B.	C.	D.	E.
Bordeaux mixture, . .	June 22, July 17	July 17	July 17	July 17	July 18
Neutral copper acetate, .	August 2	August 2	August 2	August 3	August 3

The Bordeaux mixture was made up with 3 pounds of lime and 4 of copper sulfate to 50 gallons of water. One pound of the neutral copper acetate was used to 50 gallons of water. Two pounds of resin fish-oil soap were used with the Bordeaux mixture in all cases and with the acetate.

3. Weather Observations.

The weather instruments were installed on May 15, from which date until October 15 observations were taken every morning at the station at East Wareham, and records of the following made: —

Maximum thermometer in shelter.
Maximum thermometer on bog.
Minimum thermometer in shelter.
Minimum thermometer on bog.
Precipitation.
Wind direction.
Continuous thermograph readings.
Continuous barograph readings.

The readings of the maximum and minimum thermometers and the amount of precipitation were telegraphed to the local office of the Weather Bureau at Boston every morning after May 15 during the spring and fall periods of frost danger.

4. Fertilization of the Cranberry Blossom.

Numerous experiments were carried out and observations made on the cross-fertilization of the cranberry blossom. Bees of all kinds were shut out from half a square rod of vines, during the blossoming period, by means of a mosquito-netting tent, with the result that only about 2⅔ quarts of berries developed, while on any equal area on the surrounding bog as much as 20 quarts were picked, the average crop of the entire bog being about 70 barrels to the acre. From a check plot of equal area laid off close to this tent 28 quarts were gathered. Another larger tent was erected and the honey bee alone allowed to enter it during the bloom, a hive being placed so as to open into it. Under this tent as good a crop developed as on the surrounding bog. These experiments seem to prove that bees are necessary to the satisfactory cross-pollination of the cranberry blossom and that the honey bee is efficient in this work.

As the vines approached full bloom under the tent from which the bees were excluded the blossoms quite generally began to take on a peculiar vivid pink color, and as the blossoming advanced this became more and more striking. Only a small percentage of the blossoms on the bog outside of the tent took on this color, while inside there were few which did not show it strikingly. This tent was on Early Black vines. The tent into which honey bees were admitted was placed on

Howe vines. This variety came to full bloom in the midst of a period of unusually hot weather in July, and had a larger percentage of the pink blossoms than did the Early Blacks which blossomed earlier. The vines under the tent, into which the honey bees were admitted, had a very noticeably smaller proportion of these pink blossoms than did the surrounding bog. They were, in fact, almost entirely absent. These observations seemed to indicate that the peculiar pink color of the bloom was a sign of fertilization failure. This pink coloring certainly always accompanies lack of fertilization with the Early Black variety, for it was just as noticeable in a 1910 experiment, in which bees were shut out by mosquito netting, as it was in the 1911 experiment. To make this matter more certain a large number of Howe blossoms, showing this pink coloring, were marked with yarn and examined late in August. Hardly 2 in 11 had succeeded in producing berries. This was less than one-half of the proportion of berries to blossoms on the bog as a whole. In other words, a much smaller proportion of pink blossoms than of normally colored ones produced berries, thus confirming the indications obtained from the tent experiments. To go with this there is the possibility that fertilization may take place to some extent, though abnormally retarded, after a blossom has taken on the pink color.

After the unfertilized blossoms turned pink in the tent experiments the corolla always hung on abnormally, so that the vines under the tent, from which bees were excluded, appeared to be in full bloom when, on the surrounding bog, the bloom was almost entirely past.

The conclusion arrived at, from these and other observations, is that it will often pay to keep honey bees near cranberry bogs during the blossoming season. There are, undoubtedly, years in which this practice will not repay anything for the extra labor and expense involved. It is probable, however, that it will pay well to keep bees in any season in which wild bees are scarce, or in which there is much bad weather during the blossoming period to reduce the length of time in which the bees can work. Unfortunately, we have not yet sufficient data to make an estimate of the number of hives necessary for the satisfactory pollination of a bog of any given acreage.

With most varieties, an upright having 5 blossoms will probably, as a rule, produce as many berries, if only 2 of those blossoms are cross-fertilized, as it would if all were fertilized. This is because the cranberry, in common with other plants, always produces the means of reproduction far in excess of what it uses. This is borne out by the fact that the crop of berries under the hive-bee tent was not greater than on the surrounding bog, though the lack of pink blossoms seemed to indicate a more perfect pollinization.

5. *Prolificness of Varieties.*

Examination of a considerable number of varieties on numerous bogs showed a marked variation, between varieties, in the average number of berries borne by the individual upright and in the proportion of berries to blossoms. Moreover, this variation seemed, to a certain degree, constant for the different varieties wherever found, even when they were side by side on the same bog and under the same conditions. Some varieties averaged less than 2 berries, and others more than 3, to the upright. Then, too, there was a noticeable varietal variation in the proportion of sterile uprights present. This condition of things obviously is not due to relative lack or abundance of pollen-carrying agents (bees), or to differences in fertility of the bottom on which the vines grow, but is the result of a varying quality of natural prolificness in the vines themselves.

During the season, work was begun with the idea of eventually producing, if possible, a much more prolific variety than any at present known. A large number of uprights of three different varieties were selected and marked for planting in separate plots in the spring. Only uprights were marked which produced during the season 4 or 5 good berries. It will be observed that this is in line with similar work already carried out successfully with corn, potatoes and other crops.

6. *Skinner System of Irrigation.*

This plant has been installed to test thoroughly the value of this system as applied to the following needs of a dry cranberry bog: irrigation, frost protection, winter protection and possibly spraying. This system is not expected to supplant water supply by other methods in vogue, where these methods are available. Late in the fall, the feasibility of heating the water so as to raise the temperature by radiation, without sprinkling over the entire surface of the bog, was tried. It was thought that the amount of piping and the size of the pump necessary in practice might in this way be reduced. The tests, however, showed this to be impracticable.

Asparagus Substation, Concord.

Mr. Charles W. Prescott, to whose hearty interest, enthusiasm and efficient supervision we are greatly indebted, has continued in charge of the details of the work in progress.

Two distinct lines of investigation are being carried on: —

1. Breeding experiments which have for their object the production of a rust-resistant type of asparagus of good commercial quality.

2. Fertilizer experiments planned with a view to determining if possible the relation of different fertilizer elements to the crop as regards yield, quality and capacity to resist rust.

Breeding Experiments. — The breeding work in progress is conducted on the basis of a co-operative understanding with the Bureau of Plant Industry of the United States Department of Agriculture. The details of the work have been looked after the past season by Mr. J. B. Norton, who has carried it forward with the same enthusiasm and energy which has characterized his work heretofore.

A number of rust-resistant types have been produced. From among these those which show the best commercial characteristics and the greatest vigor will be propagated as rapidly as possible for further trial and ultimate distribution. In view of the great improvement already made it is confidently anticipated that complete success in attaining the ends in view will soon be realized.

Fertilizer Experiments. — The results of the fertilizer experiments in progress are not as yet sufficiently decisive to make it seem advisable to publish a full report. Owing to the thorough preparation which the entire field received before it was divided into plots, even those to which no manure or fertilizer has been applied still continue to give an excellent yield. These plots, however, are now beginning to fall behind those which receive the different applications of manure and fertilizer materials which are under trial. The field contains 40 plots of one-twentieth acre each, and the past season was the fifth since the plots were set. The yield was fairly satisfactory both as to quantity and to quality. The cutting season lasted from May 8 to June 24. The total yield of all the plots was 9,347 pounds, 5 ounces.

On the basis of recorded yields and observations the following conclusions appear to be warranted: —

1. Nitrate of soda used in connection with acid phosphate and muriate of potash proves beneficial, but an increase above the rate of 466 pounds per acre does not appear to be useful.

2. Nitrate of soda used in connection with an application of barnyard manure at the rate of 10 tons per acre proves benefi-

cial, but in this case, also, an increase above the rate of 466 pounds per acre of nitrate is not followed by a further increase in the crop.

3. Nitrate of soda has been applied according to three distinct plans: —

(*a*) All applied in early spring.

(*b*) One-half applied in early spring and the balance at the close of the cutting season.

(*c*) All at the close of the cutting season.

These variations in method of applying have been tried with nitrate of soda in differing amounts and in varying combinations.

The variation in season of application is not followed by any well-defined difference in yield, but the amount of rust has appeared to be less with the larger applications applied at least in part after the cutting season. In other words, nitrate of soda so applied and in such liberal quantities as to promote a continuous vigorous growth of the plant after the close of the cutting season seems to increase the capacity of the plants to resist rust.

4. Among the different materials used as the source of potash, viz., muriate, high grade sulfate, low grade sulfate, wood ashes, and kainit, the plot receiving the latter showed the least rust. It is important, however, to point out that this may have been in part a consequence of the fact that the plot was located on the side of the field lying at the greatest distance from the fields which are believed to have been the chief sources of rust infection. The comparative freedom from rust of the plants on the kainit plot, therefore, may have been due in large measure to location. The decided difference, however, in the amount of rust on this plot and on the one immediately adjoining it, the location of which with reference to rust infection is not very different, lends probability, at least, to the conclusion that the kainit exercised a favorable influence in preventing rust.

5. Acid phosphate used in connection with nitrate of soda and muriate of potash has given a considerable increase in crop. This increase is greatest where the acid phosphate is used at the maximum rate of 188.7 pounds per acre.

6. Muriate of potash used in connection with nitrate of soda

and acid phosphate increases the crop, but an increase in the quantity of muriate above the rate of 260 pounds per acre does not result in further increase in the crop.

Control Work.

Reports in full detail covering the various lines of control work carried on by the station have been prepared by the chemists in charge. These will be found in later pages of this report.

Fertilizer Law. — The fact was pointed out in the last annual report that a new law had been drafted for presentation in the Legislature of 1911. This law was enacted by the Legislature and went into effect Dec. 1, 1911. The new law is working smoothly and satisfactorily. It is bringing in the increased revenue needed for more thorough work, and the principal change introduced, viz., bringing agricultural lime under its provisions, is proving of much value to our farmers.

Dairy Law. — The draft for a new dairy law referred to in the last annual report failed of enactment in the Legislature of 1911. It will be reintroduced in the Legislature of 1912, and it is confidently anticipated that it will be enacted. The most important change from the existing law consists in bringing milk inspectors, and the Babcock machines and apparatus which they use, under the provisions of the law.

Feed Law. — The fact was referred to in the last annual report that the appropriation received from the State for carrying out the provisions of the existing feed law were proving insufficient to cover the costs of thorough work. During the past year a draft for a new law has been prepared. Its preparation has involved a great deal of study and many conferences with parties affected by the law. The principal changes proposed are to bring the various wheat offals under the provisions of the law, to require a guarantee of the maximum percentage of crude fiber present, to require the statement of ingredients contained in each feeding stuff, and to require the registration of each brand of feeding stuff before it is sold. The amount of the appropriation provided under the new draft is $6,000 in place of $3,000 as under the present law. Besides these changes the phraseology has been made more explicit, violations are more clearly defined, and the director is given discretionary power regarding prosecutions.

In form and general content the new draft has been closely modeled after the uniform feed law adopted by the Association of Feed Control Officials of the United States. It is believed that the provision of a uniform feed law for the entire country is desirable in the interests alike of the buying public and manufacturers and dealers.

Dissemination of Information.

The station endeavors to reach the public with helpful information in three rather distinct lines: distribution of publications, private correspondence, and lectures and demonstrations.

Publications. — The station issues three classes of publications: an annual report in two parts, bulletins and circulars.

Part I. of our annual report contains the formal reports of the director, treasurer, and heads of departments and technical papers giving the results of research work. Part II. contains papers of a more popular character. It is our aim to include in this part of the report such matters as are of most immediate interest on the farm.

The demand for bulletins and circulars constantly increases. With the further growth and development of the extension department of the Massachusetts Agricultural College it is expected that this demand will be increasingly met by means of its publications, while our own publications will be, for the most part, restricted to such as deal with the results of our investigations. It must be recognized that satisfying this popular demand is extension work rather than experimental.

The following tables show the publications of the year 1911 and those of that and earlier years which are still available for free distribution: —

Publications during 1911.

Annual report: —

Part I., 356 pages; Part II., 95 pages.

Bulletins: —

No. 136. Inspection of Commercial Feed Stuffs, P. H. Smith and C. L. Perkins. 56 pages.

No. 137. The Rational Use of Lime, Wm. P. Brooks; The Distribution, Composition and Cost of Lime, H. D. Haskins and J. F. Merrill. 19 pages.
No. 138. Tomato Diseases, George E. Stone. 32 pages.
No. 139. Inspection of Feed Stuffs, P. H. Smith and C. L. Perkins. 32 pages.
No. 140. Inspection of Commercial Fertilizers, H. D. Haskins, L. S. Walker, J. F. Merrill and R. W. Ruprecht. 86 pages.

Circulars: —

No. 30. Balanced Rations for Dairy Stock, J. B. Lindsey. 7 pages.
No. 31. Lime and Sulphur Solutions, G. E. Stone. 4 pages.
No. 32. An Act to regulate the Sale of Commercial Fertilizers (chapter 388, 1911). 4 pages.

Meteorological bulletins, 12 numbers. 4 pages each.

Publications Available for Free Distribution.

Bulletins: —

No. 33. Glossary of Fodder Terms.
No. 64. Concentrated Feed Stuffs.
No. 76. The Imported Elm-leaf Beetle.
No. 84. Fertilizer Analyses.
No. 90. Fertilizer Analyses.
No. 115. Cranberry Insects.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 125. Shade Trees.
No. 127. Inspection of Commercial Fertilizers.
No. 130. Meteorological Summary — Twenty Years.
No. 131. Inspection of Commercial Fertilizers, 1909.
No. 132. Inspection of Commercial Feed Stuffs, 1910.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 135. Inspection of Commercial Fertilizers, 1910.
No. 136. Inspection of Commercial Feeds, 1911.
No. 137. The Rational Use of Lime.
No. 138. Tomato Diseases.
No. 139. Inspection of Commercial Feed Stuffs, 1911.
No. 140. Inspection of Commercial Fertilizers, 1911.

Index to bulletins and annual reports of the Hatch Experiment Station previous to June, 1895.

Index to bulletins and annual reports, 1888–1907.

Circulars: —

No. 12. The Unprofitable Cow and how to Detect her.
No. 20. Lime in Massachusetts Agriculture.
No. 25. Cottonseed Meal.
No. 26. Fertilizers for Potatoes.

No. 27. Seeding Mowings.
No. 28. Rules Relative to Testing Dairy Cows.
No. 29. The Chemical Analysis of Soils.
No. 32. An Act to regulate the Sale of Commercial Fertilizers.
Summer Soiling Crops.
Home-mixed Fertilizers.
Dairymen losing Money on Low-Grade Feeds.
Balanced Rations for Business Cows.
Orchard Experiment.
Fertilizers for Turnips, Cabbages and Other Crucifers.
Fertilizers for Corn.
Annual reports: 10th, 12th, 13th, 14th, 15th, 16th, 17th, 20th; 21st, Part II.; 22d, Parts I. and II.; 23d, Parts I. and II.

Circulation of Publications. — As provided by act of our Legislature, Part I. of our annual report is printed with the report of the secretary of the State Board of Agriculture, and those on the mailing list of that Board will receive this publication. The act provides, also, that 5,000 copies of Part I. shall be furnished to the station. These are used in supplying libraries and directors of agricultural experiment stations, libraries and presidents of agricultural colleges, the public libraries of Massachusetts and other public libraries on our mailing list, individuals on the mailing list of the United States Department of Agriculture, and institutions and periodicals on our exchange list.

The State prints an edition of 16,000 copies of Part II. of our annual report for the use of the station. This part of the report and our bulletins are sent to all those on our general mailing list, to the public libraries of the State, to individuals on the mailing list of the United States Department of Agriculture likely to be interested, and to experiment stations and the agricultural colleges.

It is our practice to reserve a considerable number of each publication to meet subsequent demands, but such demands have of late been so numerous that our supply of most of our earlier editions is exhausted.

Our meteorological bulletins are sent only to agricultural college and experiment station libraries, presidents and directors of agricultural colleges and experiment stations, to the department of agriculture and office of experiment stations, to newspapers and libraries and to individuals who have especially requested them.

The circulars which we issue are not sent out to a regular mailing list. They are prepared for use in connection with the correspondence of the station, for it is by the use of such circulars only that we find it possible to give the full information and advice needed by those consulting us by letter. Any of these circulars, however, will be sent on special request.

The newspapers of the State receive an abstract of all important publications, and as a rule we find them ready to publish such abstracts.

Mailing Lists. — A large amount of work is required in keeping our mailing lists accurate and thoroughly alive. We are constantly dropping names and as constantly adding new ones. The tendency is towards an increase, although just at present our total is a few hundred less than shown in the last annual report, owing to the fact that some lists not previously revised for a number of years have undergone very careful revision resulting in dropping a number of addresses which had undoubtedly been for some time dead. The following table shows the nature of the lists which we maintain and the number of addresses in the several classes: —

Residents of Massachusetts,	12,651
Residents of other States,	2,438
Residents of foreign countries,	242
Newspapers,	518
Libraries,	306
Exchanges,	151
Cranberry growers,	1,395
Beekeepers,	2,866
Meteorological,	389
Total,	20,956

Correspondence. — During the year 1911 the number of letters of inquiry answered by members of the station staff has been about 12,000. This is a somewhat smaller number than for 1910. It is apparent that the public in increasing degree is recognizing that the extension department is especially manned and equipped for service of this character, and it would seem, therefore, that we may confidently anticipate still further relief from this work in the near future, — a consummation long wished for, as it will give station men more time for the more legitimate station work of research and experiment.

Lectures and Demonstrations. — The public demand for lectures and demonstrations has been particularly active, and station men have been frequently engaged in service of this character. The general management and arrangements are, for the most part, looked after by the extension department, but even under this plan the draft upon the time of some of our men has been so heavy as to leave little opportunity for attention to experiment or research. This has been particularly true of the men in our poultry and apicultural departments, which are greatly in need of additional men in order that the requirements of both lines of work — extension and research — may be more fully met.

Buildings.

Extensive improvements and repairs have been made during the year in the chemical laboratory of the station at a cost of $7,500, appropriated by the last Legislature. The following are the principal improvements secured: two additional rooms for research work; enlarged office room; greatly increased space for storage of apparatus, chemicals and samples; a fire-proof vault; and a library and reading room. Central steam heat has been introduced in place of the independent hot-water system. Numerous minor repairs have been made and the entire building has been replumbed, rewired and repainted. As a consequence of the various changes and improvements the building now fairly satisfies the needs of the chemical department of the station, but the chemical work increases so rapidly that it cannot be many years before additional laboratory accommodations will be needed.

There has been but one other important building operation during the year, — the erection of the building at the cranberry substation in East Wareham, already mentioned and briefly described in the report on the work at that substation. The cost of the building (about $2,000) was nearly covered by an unexpended balance of the $15,000 appropriation made by the Legislature in 1910.

WM. P. BROOKS,
Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College.

For the Year ending June 30, 1911.

The United States Appropriations, 1910–11.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1911, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$15,000 00
Cr.		
By salaries,	$13,269 05	$11,659 35
labor,	321 49	1,079 94
publications,	8 50	–
postage and stationery,	2 89	51 44
freight and express,	–	–
heat, light, water and power,	1 38	170 47
chemicals and laboratory supplies,	31 74	137 54
seeds, plants and sundry supplies,	478 69	356 20
fertilizers,	542 04	75 27
feeding stuffs,	196 35	1 46
library,	–	7 53
tools, machinery and appliances,	–	4 50
furniture and fixtures,	61 75	50 00
scientific apparatus and specimens,	86 12	1,343 17
live stock,	–	–
traveling expenses,	–	18 13
contingent expenses,	–	–
buildings and land,	–	45 00
Total,	$15,000 00	$15,000 00

State Appropriation, 1910–11.

Cash balance brought forward from last fiscal year,	$4,198 48	
Cash received from State Treasurer,	13,500 00	
fertilizer fees,	6,239 83	
farm products,	2,068 85	
expert services,	25 00	
miscellaneous sources,	9,601 69	
		$35,633 85
Cash paid for salaries,	$9,875 92	
labor,	10,342 73	
publications,	2,443 03	
postage and stationery,	982 42	
freight and express,	407 18	
heat, light, water and power,	579 55	
chemicals and laboratory supplies,	636 97	
seeds, plants and sundry supplies,	2,507 67	
fertilizers,	350 99	
feeding stuffs,	1,548 98	
library,	451 10	
tools, machinery and appliances,	69 50	
furniture and fixtures,	408 79	
scientific apparatus and specimens,	649 06	
live stock,	44 00	
traveling expenses,	2,303 89	
contingent expenses,	250 00	
buildings and land,	895 17	
balance,	866 90	
		$35,633 85

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS.

As has been the case for many years, the problems which have chiefly engaged the attention of the department of agriculture during the past year are such as are connected with the selection, adaptations, and methods of application of manures and fertilizers. In most cases a definite and uniform plan of experiment has been followed for a considerable number of years. The work will not be reported in detail, but attention is called to a few of the more striking results.

I. Comparison of Different Materials as a Source of Nitrogen (Field A).

The different materials under comparison are manure, one plot; nitrate of soda, two plots; dried blood, two plots; and sulfate of ammonia, three plots. In the case of both nitrate of soda and dried blood one of the two plots receives muriate as a source of potash; the other, high-grade sulfate. The sulfate of ammonia is used on two plots in connection with muriate, and on one in connection with sulfate of potash. The field contains three no-nitrogen plots, on two of which muriate is used as a source of potash; on the other, high-grade sulfate. All the plots in the field receive an equal liberal application of dissolved bone black as a source of phosphoric acid, while all the different materials furnishing either nitrogen or potash are used on the different plots in such amounts as to furnish, respectively, equal quantities per plot of nitrogen and of potash.

The crops grown in this experiment in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, corn, clover for four years and corn.

The corn crop of the past season made an excellent growth, but was rather seriously injured by an exceptionally early and severe frost on September 13. So serious was the injury that it was deemed best to allow the crop to stand until the ears were thoroughly dry. It is believed that the proportion of sound corn obtained by following this plan was greater than it would have been had the crop been cut and shocked in accordance with the usual custom.

On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen fertilizers and the no-nitrogen plots as measured by total yield during the past season was as follows: —

	Per Cent.	
	Grain on Cob.	Stover.
Nitrate of soda,	100.00	100.00
Barnyard manure,	98.20	100.00
Sulfate of ammonia,	101.41	98.25
Dried blood,	101.58	101.58
No nitrogen,	95.67	108.06

The relative standing of the different materials as indicated by total yield for the twenty-two years during which the experiment has continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.26
Dried blood,	92.80
Sulfate of ammonia,	87.53
No nitrogen,	73.04

In making up the table on relative standing for the twenty-two years the grain only for 1911 was included, as, owing to the manner in which the crop was handled, there had been breakage and waste from the frost-bitten stalks and leaves, the amount of which was not uniform for the different plots.

On the basis of increase as compared with the no-nitrogen plots the relative standing for the different nitrogen fertilizers for the twenty-two years is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	78.71
Dried blood,	73.29
Sulfate of ammonia,	53.74

It will be noted that nitrate of soda, as in previous years, shows a much greater average increase than either of the other sources of nitrogen.

One of the most striking results of the past season was the relatively large yield produced on the no-nitrogen plots. It amounts to about 95 per cent. of the average yield on all the different plots which have received an application of nitrogen annually. This result, it will be readily understood, was no doubt due to the fact that clover for three years had preceded the corn crop of the past year. The figures emphasize in a most striking way the extent to which rotations including a legume may be made to take the place of the use of nitrogen fertilizers.

II. Muriate as compared with Sulfate of Potash.

These comparisons were begun in 1892. Five pairs of plots are under comparison. From 1892 to 1899 potash salts were used in quantities (varying in different years, but always in equal amounts, on the two members of a pair of plots) ranging from 350 to 400 pounds per acre. Since 1900 the quantity used has been uniform on all plots, and at the rate of 250 pounds per acre annually. The only other fertilizer material applied has been fine-ground bone to each plot at the uniform rate of 600 pounds per acre. The past year is the twentieth year of these experiments. The crops during the year were alfalfa on one pair of plots, clover on one pair, and asparagus, rhubarb and blackberries, each occupying a part of a pair of plots. The rates of yield per acre on the different potash salts are shown in the following table: —

	Rate per Acre (Pounds).				
	Alfalfa.	Asparagus.	Rhubarb.	Blackberries.	Clover.
Muriate of potash, . . .	1,627.9	6,181.2	14,128	2,086.5	2,905.4
Sulfate of potash, . . .	2,041.4	5,161.6	19,315	5,907.4	3,689.6

It will be noted that the asparagus is the only crop which gives a larger yield on the muriate, and that the superiority of the sulfate is quite marked in the case of each of the others.

There was a characteristic and remarkable difference in the appearance of the alfalfa on the two salts throughout the entire season, that on the sulfate being of a richer, darker green and far more vigorous growth. A similar difference characterized the appearance of the clover on the two salts. In the case of rhubarb the proportion of leaf to stalk, as in previous years, was considerably greater on the sulfate than on the muriate. This appears to be a highly characteristic effect, and is one for which at present we are unable to offer an explanation.

III. Manure alone compared with Manure and Sulfate of Potash.

This experiment has been in progress since 1890. It occupies the south corn acre, which is divided into 4 plots of one-quarter acre each. On two of these plots good barnyard manure from well-fed dairy cows has been applied at the rate of 6 cords per acre. On the other two plots similar manure has been applied, at first at the rate of 3 cords per acre, but since 1895 at the rate of 4 cords per acre, and together with these smaller applications of manure high-grade sulfate of potash at the rate of 160 pounds per acre has been applied. The object in view is to determine the crop-producing capacity of the smaller amount of manure combined with sulfate of potash as compared with that of the larger application of manure.

The general practice has been to apply manure annually, but in a number of instances, when it was feared that if this should be done the newly seeded grass and clover would lodge badly, the customary application has been withheld; but in all cases if withheld from one plot it was of course withheld from all.

The plan of cropping this field for the last thirteen years has been corn and hay in rotation in periods of two years for each. During the past season the crop has been corn. The rates of yield per acre are shown in the following table: —

	Yield per Acre.		
	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1, manure alone,	89.140	2.460	4,780
Plot 2, manure and potash,	85.260	1.430	4,740
Plot 3, manure alone,	88.570	2.230	4,580
Plot 4, manure and potash,	83.490	1.890	4,580
Averages: —			
Plots 1 and 3, manure alone,	88.855	2.345	4,680
Plots 2 and 4, manure and potash,	84.375	1.660	4,660

The crop on all the plots was an excellent one, and it will be noted that the larger application of manure alone gave a yield of hard corn about 4½ bushels greater than that produced on the smaller amount of manure and potash. The combination produced a slightly smaller yield both of soft corn and stover. The difference in crop is not sufficiently great to cover the difference in cost between the two systems of manuring.

IV. Average Corn Fertilizer compared with Fertilizer Richer in Potash.

These experiments are carried on on what is known as our north corn acre, which is divided into 4 one-quarter acre plots. The experiments began in 1891. Continued corn culture was the rule at first, but for the past sixteen years corn and hay, two years of each, have regularly alternated. Two of the plots in the field, 1 and 3, are fertilized with a home-made mixture furnishing nitrogen, phosphoric acid and potash in highly available forms, and in the same proportions in which they are contained in the average corn fertilizer offered on our markets. The other two plots are fertilized annually with a home-made mixture containing much less phosphoric acid and more potash than is applied to the other plots.

The crop of the past season was corn, and it was an excellent one on all plots. The average yields were at the following rates per acre: —

	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
On the fertilizer rich in phosphoric acid and low in potash,	88.66	1.89	4,230
On the fertilizer low in phosphoric acid and rich in potash,	86.69	2.02	4,486

The larger proportion of phosphoric acid has evidently been favorable to the production of sound, well-ripened grain.

V. Top-dressing for Hay.

Since 1893 we have been using barnyard manure, wood ashes, and a mixture of bone meal and muriate of potash as top-dressing for permanent mowing. The total area included in these experiments is about 9 acres divided into 3 plots, so that each year each system of top-dressing is represented. The order in which the different materials is applied to any given plot is as follows: barnyard manure; next year, wood ashes; and in the succeeding year a combination of fine ground bone and muriate of potash. The rates of application per acre: —

1.	Barnyard manure,	8 tons.
2.	Wood ashes,	1 ton.
3.	Fine-ground bone,	600 pounds.
	Muriate of potash,	200 pounds.

The crop of the past year was very much lighter than usual on account of the marked deficiency of rainfall and the extreme heat. The average yield for the entire area this year was at the rate of 3,993 pounds per acre. The yields on the different materials used in top-dressing were at the following rates per acre: —

	Pounds.
Barnyard manure,	3,840
Fine-ground bone and muriate of potash,	4,304
Wood ashes,	3,736

The average yields to date under the different systems of top-dressing have been at the following rates per acre: —

	Pounds.
Barnyard manure,	6,211
Wood ashes,	5,681
Fine-ground bone and muriate of potash,	6,061

Poultry Work.

For a considerable number of years experiments on the best methods of feeding poultry for egg production have been conducted in this department. In the spring of 1911 all poultry work was transferred to the head of the poultry department of the college. There has been so much construction work in this department during the past year, however, in the effort to get it properly established and equipped, that the poultryman has no report to offer at this time.

REPORT OF THE HORTICULTURIST.

FRANK A. WAUGH.

The work in horticulture has gone on during the year on much the same lines as heretofore, but plans have been forming for certain new kinds of work. The work on heredity and variation in peas has developed a considerable mass of data from which publication is made in this report. Certain correlative topics are still under study and will be reported on later.

The work on Mendelism in beans has been going on successfully during the last year. We now have on record full data for about 15,000 plants. It is expected that one or two years further study will be required to bring this subject to the point of publication. Somewhat similar work with squashes is also under way and will be carried forward as fast as opportunity permits. A few minor problems are studied as time and opportunity offers.

The work in apple variation, already reported upon in one or two publications, still progresses. The plan of work now contemplates a more intensive study of variation and its correlation with local climatological factors.

A research experiment in the mutual influence of stock and cion has been planned to extend over a period of twenty years or more. Work has begun on a small scale, but it will probably require another year or two to get the experiment fully under way. The planning and inauguration of this experiment have been chiefly due to the efforts of Dr. J. K. Shaw.

There is a strong demand for experimental work in other lines of horticulture aside from those already taken up at this station. Work is urgently needed in lines of market gardening and floriculture, and some steps should be taken at once to serve these important and significant industries. For this purpose additional funds should be provided by the State.

All the experimental work herein referred to has been under the direct management of Dr. J. K. Shaw. In order to carry out the work now under way, and other work imperatively needed, it will be very desirable to have an additional assistant within the year.

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

This report gives a brief outline of the work of this department for the year ending Dec. 1, 1911.

1. Correspondence.

There have been sent out substantially 5,500 letters during the year, the estimate being based on the number of stamps used. It is not believed that more than the usual number of letters of inquiry have been received by this department. The increase of 500 over the year 1910 was probably due to the increased correspondence in connection with the control and cow testing work.

2. Numerical Summary of Substances examined in the Chemical Laboratory.

The following substances have been received and examined: 114 samples of water, 527 of milk, 2,799 of cream, 204 feedstuffs, 209 fertilizers and fertilizer refuse materials, 63 soils, 36 lime products, 27 ash analyses of plants and 4 miscellaneous. There have also been examined in connection with experiments in progress by the several departments of the station 116 samples of milk and cream, 57 cattle feeds and 377 agricultural plants. In connection with the control work there have been collected 1,063 samples of fertilizer and 773 samples of feedstuffs. The total for the year was 6,369.

The above does not include the work of the research section. In addition, 15 candidates have passed the examination and secured certificates to operate the Babcock test, and 4,466 pieces of Babcock glassware have been tested for accuracy, of which only 12 pieces or .27 of 1 per cent. were condemned as inaccurate.

3. Work of the Research Section.

Work has continued along much the same lines as heretofore. It has been considerably impeded, however, by the extensive repairs made to the laboratory during the summer and autumn.

(*a*) Messrs. Holland and Reed have devoted a large amount of their time to the devising of methods for the making of chemically pure insecticides, and have furnished the entomological department with Paris green, acid arsenate of lead and metarsenite of lime. A paper on this work will probably be found elsewhere in this report. Some progress has been made in the quantitative determinations of the insoluble fatty acids, and numerous factors have been studied such as strength of alcohol, ratio of fatty acids to solvent, amount of precipitant, conditions favoring the formation of a crystalline precipitate, etc. This work will be given more attention during the present year.

(*b*) Mr. Morse has continued his studies relative to the effect of fertilizers on asparagus and has brought together a considerable amount of data on the subject. It is not believed, however, that the work is sufficiently advanced to warrant an extended paper on the project. The same chemist has also continued his work with cranberries, devoting his time principally to a chemical examination of the drainage water in the cylinders. These cylinders, it may be stated, are made of large, glazed tile sunk in the earth and filled with peat and sand so as to represent miniature cranberry bogs.

(*c*) Dr. Lindsey has continued his work on the cause of the digestion depression produced by molasses. Butyric acid — a product of carbohydrate fermentation — has been fed to sheep in different amounts, but without apparently causing any noticeable depression. This work is being continued.

Numerous digestion experiments have been made including plain and molasses beet pulp, grain screenings and Creamo feed.

Attention has also been given and experiments are now in progress relative to calf meal substitutes for milk in rearing dairy calves, and also to the cost of milk production.

Papers relative to the digestibility of cattle feeds and on corn best suited for the silo in Massachusetts will be found elsewhere in this report.

4. Report of the Fertilizer Section.

Mr. H. D. Haskins makes the following report: —

The work of the division has been devoted chiefly to the inspection of commercial fertilizers, although quite a variety of other work has also claimed attention. The collection and analysis of the various brands of agricultural lime sold in the Massachusetts markets was made during the early winter months; these have served in the preparation of a lime bulletin (No. 137), which was published in April. The complete ash analysis of 19 samples of asparagus roots has also been made in connection with the Concord field experiments; analytical work has likewise been completed on 44 samples which was begun during the previous year. Complete ash analyses have been made on 4 samples of corn kernels and 4 samples of corn stover in connection with field experiments conducted by the agricultural department. Considerable work has been done in the study of normal tobacco soils and subsoils in order to obtain comparative data in connection with cases of overfertilization or malnutrition; the analyses will be found in a short article entitled "Tobacco Injury due to Malnutrition or Overfertilization," to be found on later pages in this report. An unusually large amount of time has been devoted to co-operative work in connection with the Association of Official Agricultural Chemists. Work was done on nitrogen and potash, and the writer has served in the capacity of referee on phosphoric acid. The planning of this work, the preparation of the samples to be used by various chemists in obtaining analytical data, and the subsequent preparation of the report presented to the association took both time and energy. As the object, however, is to improve our present methods of analysis, and to introduce new and better methods, the time was unquestionably well spent. The examination of home-mixed fertilizers, refuse by-products and soils sent on by farmers has been attended to as in the past, and a more detailed report of this portion of the work will be found on a subsequent page.

The work of the collection and analysis of registered fertilizers shows a substantial increase over that of the previous year; in fact, a larger number of commercial fertilizers has been registered, collected and analyzed during the season than for *any previous* year. A new fertilizer law was enacted during the season and went into effect Dec. 1, 1911. The full text of the law is given in Bulletin No. 140.

As a result of co-operative studies made by the experiment stations of New England, New York and New Jersey we have been able this year, for the first time in the history of the fertilizer control work, to publish analytical data as to the character of the organic nitrogen supplied by the various brands sold in the State. The additional work entailed has required the assistance of one extra man during the greater part of the season.

On a few subsequent pages will be found summaries covering the fertilizer control work: —

(*a*) Fertilizers licensed.
(*b*) Fertilizers collected.
(*c*) Fertilizers analyzed.
(*d*) Trade values of fertilizing ingredients.
(*e*) Unmixed fertilizing material.
  (1) Nitrogen compounds.
  (2) Potash compounds.
  (3) Phosphoric acid compounds.
(*f*) Grades of fertilizer.
(*g*) Summary of analyses and guarantees.
(*h*) Quality of plant food.
  (1) Nitrogen.
  (2) Phosphoric acid.
  (3) Potash.
(*i*) Miscellaneous fertilizers, by-products and soils for free analysis.

(*a*) *Fertilizers licensed.*

During the year, 88 manufacturers, importers and dealers, including the various branches of the trusts, have secured certificates for the sale of 492 different brands of fertilizer, agricultural chemicals and raw products in the Massachusetts markets. Inspection fees have been paid on 27 more brands than during the previous year. These brands may be classed as follows: —

Complete fertilizers,	332
Fertilizers furnishing phosphoric acid and potash,	10
Ground bone, tankage and dry ground fish,	53
Chemicals and organic nitrogen compounds,	97
Total,	492

(*b*) *Fertilizers collected.*

The samples were taken by our regular inspector, Mr. Jas. T. Howard, assisted by Mr. E. C. Hall and Mr. E. L. Winn. An effort has been made in all cases to get representative samples. At least 10 per cent. of the bags found present have been sampled by means of an instrument taking a core the entire length of the bag. In no case has there been less than 10 bags of each brand sampled wherever that number has been found in stock. In case of bulky mixed goods, which might have a tendency to mechanical separation in transit, a sample has been taken from both sides of the bag, so that in case any of the fine heavier chemicals, such as potash salts, had sifted through the more bulky portion, the sample taken would be more representative.

Whenever possible, samples of the same brand have been collected in various parts of the State, the object being to sample as large a proportion of the tonnage shipped into the State as possible. In most cases, where duplicate samples have been drawn, a composite made up of equal weights of the various samples served for the analysis. In some instances several analyses have been made of the same brand; this has been done at the request of large consumers who have bought heavy shipments of some special brand.

It is difficult to tell how large a per cent. of the total tonnage shipped into the State has been sampled. An effort was made at the end of the season of 1910 to ascertain approximately the number of tons sold, but some of the larger manufacturers refused to furnish the data. As complete and extensive a collection as possible has been made in the limited time at our disposal and with the means available for the work.

During the season 116 towns were visited and 1,063 samples representing 519 distinct brands were drawn from stock found in the possession of 284 different agents, as against 897 samples and 487 distinct brands collected and examined in 1910. Some of these brands represent private formulas which would have been sent to the station for analysis by the consumer had they not been taken by our inspectors. Arrangements can be made in most cases to have large shipments of private formulas sampled by one of our regular collectors, provided notification is given sufficiently early in the season so that the various places may be visited while the collectors are in that vicinity.

(c) *Fertilizers analyzed.*

Six hundred and sixty-two analyses have been made in connection with the 1911 fertilizer inspection. The analyses made may be grouped as follows: —

Complete fertilizers,	427
Fertilizers furnishing phosphoric acid and potash, such as ashes, etc.,	18
Ground bones, tankage and fish,	73
Nitrogen compounds, including the mineral forms of nitrogen; also the various organic forms, both animal and vegetable,	69
Potash compounds,	50
Phosphoric acid compounds,	25
Total,	662

(d) *Trade Values of Fertilizing Ingredients.*

The following table of trade values was adopted by the experiment stations of New England, New York and New Jersey at a conference held the 1st of March, 1911, and have served as the basis of valuing the fertilizers published in this bulletin. The schedule for 1910 is also given for comparison.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals for 1910 and 1911.

	Cents per Pound.	
	1910.	1911.
Nitrogen: —		
In ammonia salts,	16	16
In nitrates,	16	16
Organic nitrogen in dry and fine-ground fish, meat and blood,	20	23
Organic nitrogen in fine[1] bone, tankage and mixed fertilizers,	20	20
Organic nitrogen in coarse[1] bone and tankage,	15	15
Organic nitrogen in cottonseed meal, castor pomace, linseed meal, etc.,	–	21
Phosphoric acid: —		
Soluble in water,	4½	4½
Soluble in neutral ammonium citrate solution (reverted phosphoric acid),[2]	4	4
In fine[1] ground bone and tankage,	4	4
In coarse[1] bone, tankage and ashes,	3½	3½
In cottonseed meal, linseed meal and castor pomace,	3½	3½
Insoluble (in neutral ammonium citrate solution) in mixed fertilizers,	2	2
Potash: —		
As sulfate, free from chlorides,	5	5
As muriate (chloride),	4¼	4¼
As carbonate,	8	8
In cottonseed meal, castor pomace, linseed meal, etc.,	–	5

The basis for these trade values was the average wholesale quotations of chemicals and raw materials as taken from the commercial publications during the six months preceding March 1, 1911, plus about 20 per cent. They are supposed to represent the average cost per pound for cash at retail of nitrogen, phosphoric acid and potash as found in unmixed fertilizing material in the principal markets in New England and New York. There has been but little change in the cost of the various forms of plant food, with the exception of the better forms of organic nitrogen which have shown a considerable advance as compared with the previous year.

(*e*) *Unmixed Fertilizing Material.*

Thirty-three samples of ground bone have been collected and analyzed. Ten were found deficient in phosphoric acid and 5 in nitrogen. The average retail cash price for ground bone has been $31.32 per ton, the average valuation $29.80, and the per-

[1] Fine and medium bone and tankage are separated by a sieve having circular openings one-fiftieth of an inch in diameter. Valuations of these materials are based upon degree of fineness as well as upon composition.

[2] Dissolved by a neutral solution of ammonium citrate, specific gravity 1.09, in accordance with method adopted by Association of Official Agricultural Chemists.

centage difference 5.10. Two of the brands analyzed showed a commercial shortage of 50 cents or over a ton.

Eighteen samples of tankage have been analyzed. Three were found deficient in nitrogen and 5 in phosphoric acid. The average retail cash price per ton was $34.14, the average valuation per ton $32.69, and the percentage difference 4.43. Nitrogen in fine tankage has cost on the average 20.89 cents; nitrogen in coarse tankage has cost 15.65 cents per pound. Three samples have shown a commercial shortage of over 50 cents per ton.

Twenty-two samples of dry ground fish have been examined. Three were found deficient in nitrogen and 2 in phosphoric acid. The average retail cash price per ton was $41.90, the average valuation $42.71, and the percentage difference in excess 1.93. Nitrogen from dry ground fish has cost on the average 22.56 cents per pound. None of the brands showed a commercial shortage of over 50 cents per ton.

(1) *Nitrogen Compounds.* — Three samples of sulfate of ammonia have been analyzed and found well up to the guarantee. The average cost of a pound of nitrogen in this form has been 16.78 cents.

Twenty-three samples of nitrate of soda have been analyzed and 3 were found deficient in nitrogen. The average cost of nitrogen in this form has been 16.19 cents per pound.

Four samples of dried blood have been examined which, with one exception, showed overruns in nitrogen. The pound of nitrogen from blood has cost 23.29 cents.

Four samples of castor pomace have been analyzed. The average cost of nitrogen in this form has been 26.11 cents per pound.

Twenty-three samples of cottonseed meal have been examined, all of which were purchased as a nitrogen source for tobacco. Nitrogen from this source has cost on the average 23.08 cents per pound. Six samples have shown a nitrogen deficiency which has, in 3 cases, amounted to 50 cents or more per ton.

(2) *Potash Compounds.* — Twenty-one samples of high grade sulfate of potash have been examined, and the potash guarantee was maintained in all but one instance. The pound

of actual potash in this form has cost on the average 5.2 cents. Two cases of misbranding were discovered by our inspectors. Material put out by the Nitrate Agencies Company as high-grade sulfate of potash proved upon analysis to be muriate of potash. The sale of the material as sulfate of potash was discontinued and the material was properly labeled.

Six samples of potash-magnesia sulfate have been examined and all but 2 were found fully up to the guarantee. The pound of actual potash in this form has cost 5.91 cents. Several cases have been detected where high-grade sulfate of potash has been reduced with sand and kieserit. The parties registering the material have disclaimed any knowledge of such a practice, and state that the material was bought for potash-magnesia sulfate and sold by them in the original bags as imported from Germany. The matter was taken up with the German syndicate, who traced the adulteration back to the mine that originally produced the goods. A statement was made by the importers that the mine had been heavily fined for the practice, and large shipments of the adulterated product had been returned to the mine. The importers offered to compensate the buyers, who in turn would rebate the farmer, for the value of the deficient magnesia less the value of the overrun in potash.

Eighteen samples of muriate of potash have been examined and 3 were found deficient in potash. The pound of actual potash as muriate or chloride has cost on the average of 4.43 cents. Two brands have shown a commercial shortage amounting to 50 cents or over per ton. There seems reason to believe that it is not improbable that some cases of apparent shortage in case of muriate of potash may be due to absorption of moisture, resulting, of course, in a greater weight of the material without any actual loss of potash, provided the material is sold in the original package and each package is only credited with a weight of 200 pounds.

Three samples of kainit have been analyzed and found well up to the guarantee. The pound of actual potash from kainit has cost 4.34 cents.

(3) *Phosphoric Acid Compounds.* — Two samples of dissolved bone black have been analyzed and both showed a commercial shortage of over 50 cents per ton. The pound of avail-

able phosphoric acid from this source has cost on the average 6.11 cents.

Fifteen samples of acid phosphate have been examined and all but 2 were found well up to the minimum guarantee. No commercial shortage of over 50 cents a ton occurred. The pound of available phosphoric acid from acid phosphate has cost 5.44 cents.

Seven samples of basic slag phosphate have been analyzed and all were found well up to the guarantee. The pound of available phosphoric acid from basic slag, as determined by Wagner's method, has cost on the average 5.12 cents.

(*f*) *Grades of Fertilizer.*

The grouping of the complete fertilizers into three different grades furnishes a convenient means of showing the superior advantages to be derived from the purchase of *high-grade fertilizers.* In the tables below the high-grade fertilizers are represented by those brands having a commercial value of $24 or over a ton; the medium grade by those which value between $18 and $24; and the low grade by those which value $18 or less per ton. A table showing average cash price, commercial value, money difference between cash price and valuation, and percentage difference of the three grades of fertilizer follows: —

	High Grade.		Medium Grade.		Low Grade.	
	1910.	1911.	1910.	1911.	1910.	1911.
Average cash price per ton,	$38 40	$40 87	$33 51	$35 08	$27 80	$29 64
Average ton valuation,	$28 81	$28 89	$21 04	$21 04	$15 61	$15 37
Average money difference,	$9 59	$11 98	$12 47	$14 04	$12 19	$14 27
Percentage difference,	33.28	41.47	59.26	66.73	78.08	92.84

Table showing the Average Composition of the Three Grades of Fertilizer.

Grade.	Number of Brands.	Per Cent. of Whole Number.	Per Cent. of Nitrogen.	Per Cent. of Phosphoric Acid. Soluble.	Per Cent. of Phosphoric Acid. Reverted.	Per Cent. of Phosphoric Acid. Available.	Per Cent. of Potash.	Pounds of Available Plant Food in 100 Pounds of Fertilizer.
High, ...	153	46.22	4.12	4.00	3.32	7.32	7.64	19.08
Medium, ...	103	31.12	2.61	2.93	2.94	5.87	5.12	13.60
Low, ...	75	22.66	1.66	4.53	2.82	7.35	2.90	11.91

What is shown by the above tables: —

1. That the average ton price for the three grades of fertilizer has been nearly $2 more for 1911 than for the previous year, although but little difference is noticed in the average valuation per ton for the two years.

2. That the percentage excess of the selling price over the valuation in the low-grade fertilizers is about two and one-fourth times more than it is in the high-grade goods, and over one and one-half times more than in the medium-grade fertilizers.

3. That with a 38 per cent. advance in price over the low-grade fertilizer, the high grade furnishes about 88 per cent. increase in commercial value.

4. The average high-grade fertilizer with a 16.5 per cent. advance in price over the medium goods, furnishes 47.6 per cent. more plant food and 37.3 per cent. increase in commercial value.

5. That with a 38 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes more than 60 per cent. increase in available plant food.

6. A ton of the average high-grade fertilizer furnishes 49.2 pounds more nitrogen and 94.8 pounds more of actual potash than does a ton of the low-grade goods.

7. A ton of the average high-grade fertilizer furnishes 30.2 pounds more nitrogen and 50.4 pounds more potash than does a ton of the medium-grade goods.

Table showing the Comparative Pound Cost, in Cents, of Nitrogen, Potash and Phosphoric Acid in its Various Forms in the Three Grades of Fertilizer.

Element.	Low-grade Fertilizer.	Medium-grade Fertilizer.	High-grade Fertilizer.
Nitrogen,	38.6	33.4	28.3
Potash (as muriate),	8.2	7.1	6.0
Soluble phosphoric acid,	8.7	7.5	6.4
Reverted phosphoric acid,	7.7	6.7	5.7
Insoluble phosphoric acid,	3.9	3.3	2.8

This table shows: —

1. That the purchase of high-grade fertilizers in place of low-grade goods has saved over 10 cents on every pound of nitrogen and over 2 cents on every pound of potash and phosphoric acid.

2. That the purchase of high-grade fertilizers in place of medium-grade goods has saved over 5 cents on every pound of nitrogen and over 1 cent on every pound of potash and phosphoric acid.

3. Taking the average analysis of the high-grade fertilizer as a basis, the purchase of the high-grade in place of the low-grade goods would mean a saving of $14.23 on every ton purchased; the purchase of the high-grade in place of the medium-grade would mean a saving of $7.12 on every ton purchased.

4. About 54 per cent. of the number of brands sold in Massachusetts are classed as medium or low-grade fertilizers. Assuming that the tonnage of these goods was as large as for the high-grade brands, there would have been a tremendous saving to the Massachusetts farmer had he bought only high-grade fertilizer.

5. The purchaser of fertilizers should look to the guaranteed analysis and remember that he is buying pounds of plant food as well as tons of fertilizer. He should know the form and about the proportion of the various elements of plant food and should purchase the brand which sells for the least money which comes nearest fulfilling his requirements.

6. Every one should consider and profit by the lessons taught by the above data.

(g) Summary of Results of Analyses of the Complete Fertilizers as compared with the Manufacturers' Guarrantee.

Manufacturers.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	2	–	1	–	2	–
American Agricultural Chemical Company,	73	30	69	29	14	–
Armour Fertilizer Works,	13	8	13	5	–	–
Atlantic Fertilizer Company,	4	1	3	1	1	1
Baltimore Pulverizing Company,	2	1	2	–	1	–
Beach Soap Company,	6	3	5	1	1	1
Berkshire Fertilizer Company,	8	5	8	2	1	–
Bonora Chemical Company,	1	–	1	1	–	–
C. M. Bolles,	1	1	1	–	–	–
Bowker Fertilizer Company,	32	10	26	16	6	–
Jos. Breck & Sons,	3	3	3	–	–	–
Buffalo Fertilizer Company,	8	4	7	3	1	–
E. D. Chittenden Company,	6	3	5	2	1	–
Clay & Son,	1	1	1	–	–	–
Coe-Mortimer Company,	18	1	12	9	7	1
Eastern Chemical Company,	1	1	1	–	–	–
Essex Fertilizer Company,	11	1	8	9	1	–
C. W. Hastings,	1	–	–	1	–	–
Listers Agricultural Chemical Works,	9	4	9	5	–	–
J. E. McGovern,	1	1	1	–	–	–
Mapes' Formula and Peruvian Guano Company,	20	10	19	8	2	–
National Fertilizer Company,	17	7	14	7	3	–
Natural Guano Company,	1	1	1	–	–	–
New England Fertilizer Company,	7	1	3	3	2	1
New England Mineral Fertilizer Company,	1	1	1	–	–	–
Nitrate Agencies Company,	1	–	1	1	–	–
Olds & Whipple,	6	3	6	3	–	–
Parmenter & Polsey Fertilizer Company,	10	1	5	6	2	1
Patrons' Co-operative Association,	2	2	2	–	–	–
Pulverized Manure Company,	1	1	1	–	–	–
Rogers Manufacturing Company,	9	7	9	2	–	–

(*g*) *Summary of Results of Analyses of the Complete Fertilizers as compared with the Manufacturers' Guarantee* — Con.

Manufacturers.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
Rogers & Hubbard Company,	8	5	7	3	–	–
Ross Bros. Company,	4	1	4	2	1	–
N. Roy & Son,	1	–	1	1	–	–
Sanderson Fertilizer and Chemical Company,	7	6	7	1	–	–
M. L. Shoemaker & Company,	2	1	2	1	–	–
Swift's Lowell Fertilizer Company,	17	7	15	5	5	–
20th Century Specialty Company,	1	1	1	–	–	–
Wm. Thomson & Sons,	2	1	2	1	–	–
Whitman & Pratt Rendering Company,	4	2	4	2	–	–
Wilcox Fertilizer Company,	9	6	9	3	–	–
A. H. Wood & Co.,	3	1	3	2	–	–

The above table shows: —

1. That 334 brands of registered complete fertilizers have been collected and analyzed.

2. That 191 brands (57 per cent. of the total number analyzed) fell below the manufacturers' guarantee in one or more elements.

3. That 135 brands were deficient in one element.

4. That 51 brands were deficient in two elements.

5. That 5 brands were deficient in three elements.

6. That 41 brands (over 12 per cent. of the whole number analyzed) showed a commercial shortage; that is, when the overruns were used to offset shortages they did not show the amount in value of plant food as expressed by the smallest guarantee.

The deficiencies found were divided as follows: —

96 brands were found deficient in nitrogen.
90 brands were found deficient in available phosphoric acid.
66 brands were found deficient in potash.

As compared with the previous year the guarantees have not been as generally maintained. Thirty-six more brands were found deficient in nitrogen and 10 more in available phosphoric acid than for the season of 1910. The brands showing a commercial shortage were 17 more than during the previous year; in many cases, however, the commercial deficiency was small, amounting to less than 25 cents per ton.

Table showing Commercial Shortages (25 Cents or Over) in Mixed Complete Fertilizers for 1910 and 1911.

Commercial Shortages.	Number of Brands.	
	1910.	1911.
Between $1 and $2 per ton.	6	9
Under $1, not less than 25 cents per ton,	18	17

Some brands have suffered serious deficiencies in some element of plant food without showing any commercial shortage, the deficiency being made up by an overrun of some other element. This is due, probably, either to carelessness or poor mixing rather than a disposition to furnish less plant food value than is called for in the guarantee. It furnishes a condition not to be commended, however, as the fertilizer may be rendered seriously out of balance.

(*h*) *Quality of Plant Food.*

(1) *Nitrogen.* — Sixty or more per cent. of the total nitrogen in the average mixed fertilizer is derived from organic sources, and until recently it has not been possible to tell the consumer much concerning its activity or immediate availability. Heretofore there has been published the nitrogen from nitrates and ammoniates as well as the water soluble and water insoluble organic nitrogen. It has seemed evident, however, that some of the brands contained at least a portion of their nitrogen in low-grade forms, but a lack of a suitable method of analysis has rendered it impossible to procure sufficient evidence to definitely substantiate the supposition. In 1910 the chemists in charge of the fertilizer control work in New England, New York

and New Jersey co-operated in an effort to make a careful study of the Jones' modification of the "Alkaline permanganate method" and Street's "Neutral permanganate method" for testing the activity of the water insoluble organic nitrogen in mixed fertilizers. Satisfactory results were obtained with the Jones' modification, which were confirmed on the same samples by means of vegetation experiments conducted at the Rhode Island Experiment Station. The work proved so satisfactory that in March, 1911, the Jones' modification was adopted provisionally by the New England, New York and New Jersey experiment stations.

All of the complete fertilizers reported in this bulletin have, therefore, been tested as to their organic nitrogen activity. Out of a total of 334 brands analyzed, 43 or nearly 13 per cent. of the whole number, have shown an activity of their water insoluble organic nitrogen of less than 50 per cent.

So far as one is able to judge from the analytical data and the explanations furnished, the following facts may be deduced: —

1. Some manufacturers used nitrogen-containing material of a low availability.

2. In some cases it was used as a direct source of nitrogen to bring the material up to its minimum guarantee. In other cases it was used to raise the guarantee above the minimum. In still other cases it was employed as a filler or to improve the mechanical condition of the fertilizer.

3. It is possible that the inactive materials employed were not sufficiently treated to render their nitrogen available.

It is hoped that manufacturers will endeavor to improve conditions another season, for it is believed that the consumer of commercial fertilizers — at least of the better grades — is entitled to receive all of his nitrogen in such an available form as is called for by the 50 per cent. alkaline permanganate standard.

(2) *Phosphoric Acid.* — Many of the fertilizer mixtures contained large overruns in total phosphoric acid, while the available phosphoric acid on the same brands has shown a considerable shortage. This may have been due to incomplete acidulation of the bone or raw mineral phosphate used, or to the addition of considerable unacidulated rock phosphate, bone

or roasted iron or alumina phosphate. Of the total phosphoric acid found in all of the brands analyzed, 84 per cent. was present in available forms. In case of the available phosphoric acid found, 58 per cent. was present in water soluble form.

(3) *Potash.* — As in previous years, the form in which the potash was present has been noted in every fertilizer analyzed. Very few cases have been found showing the absence of chlorides in those brands where sulfate is guaranteed. In the majority of cases, however, the amount of chlorine found present has been so small as to be counted as incidental. A quantitative test, however, has in all cases been made. In case of some of the tobacco brands, quite a considerable quantity of chlorine has been found where carbonate of potash was guaranteed. This would indicate the use of carbonate of potash from the beet sugar industry. The latter material frequently contains as high as 10 to 12 per cent. muriate of potash. It is reasonable to suppose that if the consumer pays for carbonate of potash he expects that the fertilizer will exclude both soluble chlorides and sulfates.

(*i*) *Miscellaneous Fertilizers, By-products and Soils for Free Analysis.*

Including the materials which have been tested for the various departments of the experiment station, there have been received and analyzed 339 different substances. They may be grouped as follows: 209 fertilizers and by-products used as fertilizers, 63 soils, 36 lime compounds, 27 ash analyses of plants and 4 miscellaneous products. Whenever possible, the fertilizer and lime samples have been taken by one of our regular inspectors and by means of the regulation sampling tube. In all other cases the samples have been taken according to printed instructions furnished from this office. In reporting results, information has been furnished as to the best manner of using the material, and in case of soils the rational treatment of the same as regards fertilizers, cultivation and crop rotation. The analyses of most of the lime products appear in Lime Bulletin, No. 137. The analyses of home-mixed fertilizers and private formulas collected by our inspectors will appear in a table by themselves in the fertilizer bulletin. The other analyses mentioned will not be published.

5. Report of the Feed and Dairy Section.

Mr. P. H. Smith submits the following: —

The Feed Law (Acts and Resolves for 1903, Chapter 122).

During the year 733 samples of feeding stuffs have been collected and examined. A regularly employed inspector covers the State at intervals during the year, collects samples and ascertains if the provisions of the law are being complied with. Protein, fat, fiber and in some instances moisture and ash determinations are made. It is a matter of satisfaction to note that practically all feeding stuffs are as represented. This statement should not be interpreted to mean that all feeding stuffs offered are of good quality, but that all articles in the market correspond to the guarantee placed upon them.

Violations of Law. — The principal violation of the law as heretofore has been that local dealers, either through carelessness or through the neglect of shippers to furnish tags, fail to guarantee. The experiment station, through its representative, does what it can to prevent violations of this character. In order that the law may be fully enforced in this respect, the co-operation of consumers is needed. The consumer can be of material assistance by insisting that all feeding stuffs that he purchases, with the exception of wheat by-products and ground whole grains, shall bear the guaranteed analysis together with the name and address of the manufacturer.

It is believed that adulteration is seldom practiced. There are some feedstuffs on the market to which low-grade products are occasionally added. Wheat feeds and hominy feed to which ground corn cobs have been added are of this character. The manufacturers ship these goods with the proper guarantee, but they occasionally reach the consumer with the tags removed. It seems evident that the local dealer is responsible for this, desiring to conceal the real identity of the article. The purchaser should not without careful investigation purchase wheat feeds or hominy feeds that are unguaranteed or that are offered very much below the ruling price.

New Law. — The officers in charge of the feeding stuffs law have felt for some time that the present law was inadequate to meet present conditions, and this year a new law will be presented to the General Court for its consideration and adoption. The proposed law differs from the present law in the following particulars: —

1. It is modeled as closely as local conditions will permit after the uniform law proposed by the Association of Feed Control Officials.

2. It carries an increase in revenue which is necessary if it is to be satisfactorily enforced. This increase is also made necessary by the increase in number of brands at present on the market.

3. Wheat feeds, now exempt, have been included.

4. It has been so revised as to render it easier of enforcement and more explicit.

The Dairy Law (Acts and Resolves for 1901, Chapter 202).

This law requires that all persons who are using the Babcock test as a basis of payment for milk and cream, either in buying or selling, must secure a certificate of proficiency from the experiment station. It also requires that Babcock machines be inspected by an experiment station official annually, and that all glassware used be tested for accuracy by the station.

Chapter 425, Acts and Resolves for 1909, added to the law by giving the director of the experiment station the authority to revoke a certificate if it is found that an operator is using dirty or untested glassware, or if he is doing the work in an improper manner.

The station makes the following suggestions to operators: —

1. Every operator must have a certificate, and no person without a certificate is legally entitled to make the test. The operator may employ a person without a certificate to *aid* him in his work, but he must work with him and be responsible for the working of the machine, and must read the tests in person.

2. Great care should be taken in getting accurate samples. The test from a sample carelessly drawn will not represent the value of the milk or cream from which it is taken, no matter how carefully the testing is done.

3. Cream and curdled samples of milk should be weighed and not pipetted. The only reason that milk or cream is ever pi-

petted is as a matter of convenience and on the supposition that 18 cubic centimeters of cream or 17.6 cubic centimeters of milk will weigh 18 grams. It is difficult and often practically impossible to get exactly 18 grams of sour milk or thick cream with the use of the pipette.

4. In reading the *milk* test include the *entire* fat column. In *cream* tests read from the lowest point of the fat column to the bottom of the upper meniscus or curve. In case of *cream* tests, if the entire fat column is included the reading will be about 1 per cent. too high.

Summary of Dairy Inspection. — During the year 15 candidates have been examined and given certificates to operate the Babcock test. Four thousand, four hundred and sixty-six pieces of glassware have been examined for accuracy and only 12 have been condemned, a smaller percentage than for any preceding year.

Following is a summary for the eleven years the law has been in force: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
Totals,	34,152	1,897	5.56[1]

The testing outfits in 30 creameries and milk depots have been inspected. Nine of these, an exceptionally large number, required reinspection. A machine that vibrates badly, caused

[1] Average.

by worn bearings or an insecure foundation, cannot be expected to do satisfactory work, neither can a machine give a clear separation of fat where the speed is insufficient. A number of operators were found using untested glassware. The director of the experiment station has the right to prosecute the owners of the plant where this is being done, and also to revoke the license of the operator. Thus far this matter has been corrected when called to the attention of the creamery men. Continued violations will, however, make prosecution necessary.

Following is a list of creameries and milk depots visited: —

1. *Creameries.*

Location.	Name.	President or Manager.
1. Amherst,	Amherst,	R. W. Pease, manager.
2. Amherst,	Fort River,[1]	E. A. King, proprietor.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	W. C. Solomon, proprietor.
11. Monterey,	Berkshire Hills Creamery,	F. A. Campbell, manager.
12. North Brookfield,	North Brookfield,	H. A. Richardson, proprietor.
13. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
14. Shelburne,	Shelburne Co-operative,	I. L. Barnard, manager.
15. Wyben Springs,	Wyben Springs Co-operative,	H. C. Kelso, manager.

2. *Milk Depots.*

Location.	Name.	President or Manager.
1. Boston,	D. W. Whiting & Sons,	Geo. Whiting.
2. Boston,	H. P. Hood & Sons,	W. N. Brown.
3. Boston,	Boston Dairy Company,	W. A. Graustein.
4. Boston,	Boston Jersey Creamery,	T. P. Grant.
5. Boston,	Walker-Gordon Laboratory,	G. Franklin.
6. Boston,	Oak Grove Farm,	C. L. Alden.
7. Boston,	Maine Creamery Company,	E. H. Smith.
8. Boston,	Turner Center Dairying Association,	L. L. Smith.
9. Boston,	Plymouth Creamery Company,	W. L. Johnson.
10. Cambridge,	C. Brigham Co.,	J. R. Blair.
11. Cheshire,	Ormsby Farms,	W. E. Penniman.
12. Dorchester,	Elm Farm Milk Company,	J. K. Knapp.
13. Sheffield,	Willow Brook Dairy,	F. B. Percy.
14. Southborough,	Deerfoot Farm Dairy,	S. H. Howes.
15. Springfield,	Tait Bros.,	Tait Bros.
16. Springfield,	Emerson Laboratory,	H. C. Emerson.

[1] Pays by test. Testing done at Massachusetts Agricultural Experiment Station.

Milk, Cream and Feeds for Free Examination.

With certain restrictions the resources of the experiment station are available to residents of Massachusetts who desire information relative to the composition of milk, dairy products and cattle feeds. When necessary, samples taken in accordance with the directions furnished will be analyzed free of cost. On account of the large amount of data on file, it is often possible to furnish the information desired without recourse to analysis. The experiment station will not undertake to act as commercial chemists, and, on account of the limited funds at its disposal, must use its own discretion as to what samples it will analyze.

Water Analysis.

The station has analyzed 114 samples of water. All probably came from private water supplies. Public water supplies are under the charge of the State Board of Health, and all matters pertaining to such supplies should be referred to them. Of the 114 samples received 80 were from wells, 30 from springs and 4 were taken from ponds.

The results show that farm wells situated near buildings are quite susceptible to pollution and may become sources of infection for typhoid fever and other bacterial diseases, while springs situated at a distance from all buildings are the most satisfactory and safest. Where a good spring is not available the well should be located as far as possible from dwellings and barns.

Lead pipe was used in 49 cases. In 9 instances water flowing through such pipes contained lead in appreciable amount, rendering the water absolutely dangerous for consumption.

If a water analysis is desired, application should be made to the experiment station, when a container will be shipped to the applicant together with instructions for taking the sample. Water received in receptacles other than those furnished will not be analyzed. A fee of $3 is charged for a water analysis. The experiment station does not make bacterial examinations.

Miscellaneous Work.

In addition to the work already described, this section has conducted investigations and made other analyses as follows: —

1. It has co-operated with the officials of the Massachusetts

Corn Exposition in making analyses of corn in connection with the awarding of prizes.

2. It has co-operated with the Bowker and Coe-Mortimer Fertilizer companies in making analyses of corn in connection with the awarding of prizes.

3. It has arranged and furnished exhibits and speakers, in co-operation with the extension department, for fairs, farmers' meetings and expositions.

4. It has co-operated with the agricultural department of the college in making analyses of milk in connection with the awarding of prizes at a dairy show held during "farmers' week."

5. In connection with the experimental work of this and other departments of the experiment station, this section has made analyses of 116 samples of milk, 57 samples of feed and 377 samples of agricultural plants.

6. In addition to the work already enumerated, it has received and tested 527 samples of milk, 2,799 samples of cream for butter fat, and 204 samples of feedstuffs

Testing Pure-bred Cows.

The testing of pure-bred cows for advanced registry is in charge of this section. Work of this character can be grouped under two divisions. The yearly tests for the Guernsey, Jersey and Ayrshire breeds are based upon two-day monthly tests under the supervision of an experiment station representative; while the Holstein-Friesian tests are usually of from seven to thirty days' duration and require the presence of the supervisor during the entire testing period. The large number of yearly tests now in progress require the employment of two men continuously and of an additional man for a portion of the time. Work of this character can be planned ahead and more readily taken care of than the Holstein-Friesian tests. For this latter work a list of available men is kept, and applications for supervisors are filled in the order received. Men who make the Holstein-Friesian tests are recruited largely from the short-course graduates who have gone back to the farm and who do not find it difficult to get away during the winter months. During the summer months considerable difficulty is experienced in getting men for the work. Fourteen different men have been used on work of this character during the year.

From Dec. 1, 1910, to Dec. 1, 1911, 38 Guernsey, 117 Jersey and a number of Ayrshire tests have been completed. There are now on test 43 Guernseys, 99 Jerseys, and 12 Ayrshires, located at 18 different farms.

For the Holstein-Friesian Association there have been completed 103 7-day tests, 2 30-day tests and 1 14-day test.

REPORT OF THE BOTANIST.

G. E. STONE.

The routine and research work of this department during the year has followed prescribed lines, although, as occasion has demanded, new lines of research were taken up. Mr. G. H. Chapman, besides assisting in carrying on the routine work, has had considerable opportunity for the study of special problems. He has completed his investigations on mosaic and allied diseases, as well as a piece of work on the "Microscopic Identification of the Components of Cattle Feeds."

Mr. Sumner C. Brooks, who served one year in the laboratory, resigned his position in October to take up graduate work at Harvard, but unfortunately just before his year expired he was severely stricken with typhoid fever and is at present in a convalescent state. Mr. Brooks is a keen and tireless observer, and our best wishes are extended to him in his graduate work. His place has been filled by Mr. E. A. Larrabee, of the class of 1911 of this college, who has had considerable experience in our laboratory as an undergraduate student. Miss J. V. Crocker, who is thoroughly familiar with our work, has been of great service in attending to correspondence, assisting in the seed work and in other ways. Much help has also been received from Mr. R. E. Torrey and Messrs. Larsen and Ellis, all of whom are associated with the laboratory as undergraduate students.

Besides giving considerable time to such routine work as correspondence and the diagnosis of diseases, our own attention has been directed to the investigation of a dozen or more original problems. Much time has also been spent in studying and devising apparatus designed for the better control of the various foes of plant life.

Besides the correspondence relating to seed work and the control of diseases, we are constantly called upon to answer letters of a very special and technical nature. These inquiries come from everywhere and cover a multitude of subjects, such as electricity and plant growth, electrical injury to trees, illuminating and other gases, chemical treatment of reservoirs, modern tree surgery, court decisions regarding shade trees, different stimulating factors in the growing of plants, requests for advice in regard to devices for the extermination of various pests, etc.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

The work of the entomological department during 1911 has been mainly on subjects previously outlined, and any report is, therefore, practically a report of progress.

The insect collection of the station has received considerable attention during the year. Numerous additions by gift from former students of the college and others, and the addition of more cases and other equipment in order to provide room for the proper care and growth of the collection as a whole, have made it possible to put it in better condition than ever before. As it is in constant use for reference and study, this improvement has been greatly appreciated.

The time at the disposal of those working in entomology is divided between four different lines of work. These are: correspondence with persons desiring the assistance of the department; care and improvement of the station collections of insects and their work; experimental work and studies under the Hatch act; and research under the Adams fund. These may be considered in the order named.

The correspondence the past year has been as large or somewhat larger than heretofore, but very different in nature from what it was formerly. For many years most of the inquiries received were about noticeably injurious insects. More recently, however, the inquiries have had reference to the less evident, though often equally serious pests. This indicates progress in the knowledge of our injurious insects among those most concerned and is certainly gratifying, being at least indirect evidence of the efficiency of this department and of the other sources through which entomological information has been distributed in this State. From this time on, however, it will be more difficult than formerly to determine from the correspondence itself the nature of the insect concerned, and it is probable that visits to places where damage is being caused will be much more frequently necessary in order to give intelligent advice as to the proper methods of control.

The importance of a collection of insects and of their work would seem to be almost self-evident. Any entomologist taking up duties either State or station in character, who finds no collection or only a small one where he goes, labors under an immense handicap, and within a year or two a number of letters expressing this in most emphatic terms have been received by the writer from friends laboring under such conditions. This station is fortunately situated in this regard, having a good collection, containing many entire life histories, and well cared for. It is far from complete, however, and is deficient in many different stages, even of common forms. To be what it should be, it is important not only to maintain it in its present condition, but to add to it as rapidly as possible specimens of all the injurious insects which can possibly be obtained, in their different stages, together with samples showing the nature of the injuries they cause. As much work of this kind as possible has been carried on during the past year.

Under the Hatch act experimental studies of various kinds have been continued. The destruction of seed corn by wire-worms has been studied as in previous years, in co-operation with Mr. Whitcomb. As stated in the last report, tests of tar and Paris green proved successful, but when tried by many different persons in various parts of the country were not always satisfactory. The trouble in most cases seems to have been that so much tar was applied as to give the corn a waterproof covering, which prevented germination. This was not the fault of the method, but was due to its improper application. A real defect of the method was that it required two treatments, first with the tar and second with the Paris green and dust. To avoid this, tests were made last spring with arsenate of lead diluted to the thickness of paint. The results were not wholly satisfactory, partly because wire-worms were not everywhere abundant throughout the test fields, and partly because the arsenate showed a tendency to flake and drop off the corn. In most cases the corn made a good start and escaped all injury, even though wire-worms were clustered around the seeds in the row. In fact, the treatment, though it did not seem to kill the wire-worms, did appear to protect the corn from injury in nearly every case. Further experiments along this line will be made in 1912.

The testing of new spray materials has not usually been looked upon favorably by this department, as it has no trees under its control upon which these may be used. A new material called "Entomoid," for use against the San José scale, sent to the station last year for trial, seemed so promising, however, that considerable attention was given to it, trees loaned for the purpose by individuals being used. Entomoid is claimed by its inventor to be a combination of lime-sulfur and a miscible oil, and therefore to combine the good qualities of both of these materials. It was applied to young apple and plum trees considerably to badly infested with scale, shortly before the buds opened in the spring, at strengths of 1 part Entomoid to 20 of water, and to 30 of water, using a fine Vermorel nozzle. The trees were under almost continual observation thereafter, until October, and the results were very satisfactory with both strengths. Very few living scales could be found in June, and those were all in such protected positions as would indicate a probable failure of the spray to reach them. By late fall the trees were well infested again, but only to such a degree as would be easily accounted for by the few scales which escaped treatment, and by restocking from badly infested trees nearby. During the past year the inventor has modified his formula somewhat, and it is the intention to continue tests with this modified material the coming spring.

In addition to the experiments outlined above, observations on the dates of hatching of the oyster-shell scale, scurfy scale and pine-leaf scale have been continued, and it is planned to conduct tests of methods for the control of the onion maggot next season, should satisfactory opportunities become available.

While not forming a part of the work done under the Hatch act, it may be well to mention that exhibits of injurious insects and their work, with directions for treatment to control these pests, have been prepared and exhibited at a number of fairs and exhibitions during the past year, the department co-operating with the extension department of the college whenever it has been requested to do so. Samples of pests and their work have also been put up and sent to libraries, schools and individuals in some cases where the material could be obtained and the time necessary to prepare these exhibits could be spared from more pressing duties.

Calls for the fumigation of houses to destroy various household pests have been frequent. As there is no one near Amherst who makes a business of work of this kind, and as experience in handling hydro-cyanic acid gas is necessary, if danger to human life is to be avoided, it has seemed wise to do more or less of this, partly as an educational measure. During the past year perhaps 15 or 20 places have, therefore, been fumigated by members of this department at the request of persons concerned, who were willing to meet the cost of the work.

Under the Adams fund the two projects previously accepted have been continued. Studies of the causes of the burning of foliage by arsenicals, postponed by failure to obtain materials of known composition and purity, have now been taken up, and 120 different spraying tests were made during the season, followed in each case by examination of the results, at least every second day for about a month. The results are interesting, but the work thus far represents only a small fraction of that which will be necessary before this subject has been developed to the point desired, and the results of such a fragmentary part of the work, it is, of course, not desirable to publish.

Study of the real value of wasps as parasitic friends of man have been continued, and one small paper incorporating a few of the more technical preliminary observations has been completed. Both of the Adams fund projects will be prosecuted farther the coming year.

Aside from what has thus far been mentioned, a study of the distribution of insect pests in the State has been continued. It is increasingly evident that some portions of Massachusetts are outside of territory liable to serious injury by certain insects. The determination of the limits of these areas and the reasons for their existence are important problems awaiting solution. The possibility that in one part of the State certain southern crops can be successfully grown is supported by the continued existence in that section of plants, reptiles, birds and insects which normally occur much farther south. If this should prove to mean that some southern crops can be raised in that section, and our city markets be supplied with them after the supply from the south has ended, it might result in marked changes in the crops in that portion of the State. Evidence bearing upon this has been and is being gathered at every opportunity, in the hope that the results may justify practical tests of the idea here suggested.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

During the past year the veterinary department has carried on its work in accordance with the following scheme: —

1. Research.
2. Diagnosis.
3. Correspondence.

Since the inauguration of the department in the experiment station it has been the aim and practice to carry on each year one or more lines of original investigation of some of the obscure animal diseases or phase of the same, preferably one of immediate interest to the stock owners of the State. The large number of diseases occurring among the different farm animals, the cause, course, successful treatment or prevention of which are not fully understood, offers a large field for investigation and profitable study. Such obscure diseases exist among all varieties of farm animals, — horses, cattle, sheep, swine and poultry. The latter presents some of the most difficult and interesting problems for investigation.

For nearly two years prior to last September the head of the veterinary department, in addition to his regular work of instruction in the college, performed the duties, in part, of the dean of the college. This required a greater part of each afternoon of the days when college was in session. It was, therefore, during this time not possible to engage as extensively in the lines of original investigation as was desired. The remainder of the work in the station falling under divisions of diagnosis and correspondence were taken care of in a satisfactory manner.

For something more than two years an original investigation has been carried on to determine to what extent unsterilized, mixed milk from herds of common dairy cattle, not tuberculin tested, may be responsible for the transmission of bovine tuberculosis. The work is nearly completed and will appear as a separate contribution to the report, or in bulletin form, at an early date.

The general plan of the experiment has been to make it of a practical nature by carrying it out under conditions as nearly like those as are found in the farmers' stables and herds, and at the same time sufficiently guarded against error to give it a scientific value in the determination of the relation of milk as an agency for the transmission of the disease under ordinary farm conditions. The investigation has its practical application in the eradication of tuberculosis from herds by the use of tuberculin as a diagnostic and by every other known means. If the disease is to be stamped out in a herd of cattle it is not alone sufficient to discover and remove those animals already affected, but also to discover and remove the source from which the infection comes. The experiences of the past of those who have tried to rid a herd of tuberculosis by the use of tuberculin and by slaughter of affected animals and disinfection of stables, have shown that it is not easily accomplished, owing to the difficulty of detecting the origin of the cases that are almost certain to appear after diseased animals have been removed and the stable thoroughly and effectively disinfected. It frequently happens that after a variable period of several weeks to as many months more indications of the existence of the disease are discovered among the animals which necessitate the repetition of the tuberculin testing and disinfection. The possible source of reinfection has in some instances been directed to milk from infected and nontuberculin-tested animals not showing marked physical symptoms of tuberculosis, but excreting tubercle bacilli in their milk.

In the case of large dairy herds or those of large public institutions, where sufficient milk is not produced by the herd at all seasons to supply a trade or for home consumption, it frequently happens that milk from untested cattle is purchased and brought onto the farm, and possibly some remaining unsold or unused is fed to calves or hogs and proves the source of the infection, which accounts for the recurrence of the disease. To determine to what extent this may be the source of such recurrence of tuberculosis of farm animals is the chief aim of the present investigations.

In addition to the experiment with milk, to determine to what extent it may be the medium for the transmission of bovine tuberculosis, there have been started preliminary studies to determine the nature, cause, means of spread, treatment and prevention of several other animal diseases, including an extremely obscure and fatal one of fowls. The work has not progressed sufficiently, at this date, to warrant more than a mention of the fact in this report.

The diagnosis work consists of the examination of material that is sent in by stockmen from animals suffering with disease, and of material suspected of causing disease. During the past year specimens have been received in larger numbers than ever before, and from practically every part of the State. As soon as such specimens arrive they are subjected to a variety of examinations, microscopic and bacteriological, to determine the nature of the material and the possible relation to the disease causing a loss to the stockman. After the completion of the examination, a report upon the nature of the specimen and directions for the treatment or prevention of the disease is sent to the farmer from whom the material was received. While not possible to arrive at a correct diagnosis in every instance, in many cases it is possible to return to the sender of the specimen such definite information as to the nature of the material and the disorder as to enable him, by following the directions sent in the report, to eradicate, cure or prevent the disease.

Some of the most interesting and important specimens that have come under observation in the diagnosis work the past year are: tuberculosis of garbage-fed hogs; tubercular orchitis of bull; pulmonary phthisis of man; pericarditis of cattle due to foreign bodies; lobar pneumonia; papilloma and fibroma of bovines; Paris green poisoning of pigs; chicken pox; coccidiosis and favus of birds.

In addition, a large number of samples of fodder, grain, beef scrap and other food materials have been examined as to quality and the presence of substances liable to cause disease when fed to animals. One particularly interesting sample of poor quality corn stover and corn on the ear was received that had caused the death of several cattle in a herd owing to the presence of large amounts of alcohol and other products of fermentation and decomposition that it contained.

Several samples of milk sent in for examination have been found to be contaminated with bacteria, giving rise to disagreeable odors, bitter tastes and offensive discolorations.

While the diagnosis work requires a great amount of time it certainly is fruitful of the best results. Notwithstanding the fact that it is not possible from the nature of the specimen sent, or the condition in which it may be received, to make a correct diagnosis in every instance, in the majority of cases it is possible to return to the farmer information of value that may enable him to avoid or arrest diseases that cause considerable loss. It is a means of bringing the veterinary service of the experiment station to the aid of those farmers who are so situated that they cannot avail themselves of the services of the private veterinary practitioner.

The correspondence branch of the service is closely co-ordinated with the diagnosis work. It frequently happens that farmers write to the department for information relative to some disease that exists among their animals. From the details of symptoms given in such cases it is often possible to arrive at a correct diagnosis of the trouble and advise the writer what course to follow to stamp out, successfully treat or prevent the disease. In other instances no satisfactory conclusions can be reached from the communication received and a specimen is asked for, by which a correct diagnosis of the trouble can be made and satisfactory directions given, by mail, for the successful treatment of the case. Specimens from diseased animals obtained in this manner not only furnish a means for making a correct diagnosis, and enable us to give intelligent advice to the owner of the animals, but they also supply materials of the best quality for classroom and laboratory demonstrations for students taking the courses in veterinary science and bacteriology in the department.

The correspondence of the past year has called for information covering a wide range of subjects relative to the care and feeding of farm animals and numerous animal diseases, among which may be mentioned: milk fever of cows; contagious and sporadic abortion; hog cholera; intestinal parasites of horses, cattle, sheep and swine; tuberculin testing, etc.

An especially large number of letters have been received asking for information concerning the source, symptoms and treatment of hog cholera. From the increase of inquiries over previous years and the press reports, it appears that this disease has been much more prevalent in the State during the past twelve months than ever before.

If the stockmen could only realize that the great majority of the outbreaks of hog cholera have their origin in swill containing scraps of uncooked western pork from centers of infection, and that thorough cooking will destroy the infection, many of the troublesome outbreaks could be easily prevented, and the swill from hotels and boarding houses into which such contaminated pork scraps are almost certain to find their way could be fed with safety and profit in the rearing and growing of hogs in Massachusetts.

HEREDITY, CORRELATION AND VARIATION IN GARDEN PEAS.

J. K. SHAW.

During the past five years a portion of the time devoted to experimental work in the department of horticulture has been directed toward the solution of problems of plant breeding, the work being done mostly with garden peas. Certain phases of this work have been previously reported.[1] It is felt that sufficient progress has now been made to warrant a more complete and definite statement of results attained.

The original purpose of the work was a study of variation, and the subsequent development along lines of correlation and inheritance has been a gradual one, with no endeavor to prove or disprove any of the current theories bearing on these questions, but with an earnest purpose to secure facts. After five seasons' work it was felt that sufficient data had been accumulated to afford a basis for a few deductions, and following last season's crop, results have been worked over and are here presented. This explanation may make clear the seeming lack of definiteness and direction of the work towards the results obtained.

The work began in 1907 with a study of variation in a commercial lot of Excelsior peas, and in 1908 a lot of First of All was added; since then various commercial sorts have received more or less attention. The most important results have been reached by means of the Excelsior variety. This is a second early wrinkled pea growing usually about 40 centimeters in length and bearing about four pods to the vine. It is a sort considerably grown by gardeners in New England.

The principal characters dealt with have been vine length and pods per vine. The first gives a good measure of the vegetative

[1] Reports, Massachusetts Experiment Station, 20, p. 171; 21, p. 167; 22 Part I., p. 168.

vigor of the plant and the second of its productiveness, — two qualities of the greatest economic importance.

All the measuring for the past three years, when most of the plants have been handled, has been done by one individual, thus avoiding the slight differences that might result from the work of different men.

The vines have been carefully pulled when well ripened and carried to a convenient table where the measurements have been made. Vine length has been taken from the surface of the ground to the uppermost node of the main stem. Where there were branches they have been measured, but are not used in the computations, though it might have been more desirable to have done so. However, it is not felt that in that case the results would have been materially different. All pods have been counted whether large enough for commercial purposes or not, as have the peas in the pod. The measurements have been recorded on 5 by 8 cards, recording the data as shown in Fig. 1.

Plant.	Vine Length.	No. Pods.	Peas per Pod.	Total Peas.	Notes.
B-10-7-1	62	5	7-7-5-6-6	31	
2	85	6	5-6-3-6-7-4	31	
3	64	6	1-4-6-0-5-6	22	
4	70	6	4-6-5-6-5-5	31	
5	70	5	6-1-5-5-0	17	
6	53	5	4-2-0-4-4	14	
7	54	4	2-5-5-2	14	Seed
8	63	6	5-6-6-4-3-2	26	
9	50	3	3-6-2	11	
10	44	4	4-4-5-1	14	
11	52	5	4-5-6-5-3	23	
12	70	5	5-5-6-5-5	26	
13	64	6	0-6-6-6-6-4	28	
14	55	4	5-3-3-3	14	
15	63	6	5-5-5-7-5-2	29	
16	35	4	4-4-3-3	14	
17	45/36	8	4-3-5-2/3-4-3-3	27	
18	63	6	4-6-6-6-5-6	33	

Fig. 1.—Pea Record Card.

The plants have been grown each year upon a different plot of ground and these have not always been as satisfactory, especially as to uniformity, as might be desired. In 1908 the plot, while fairly uniform, was gravelly, and suffered somewhat from drought, which modified the character of the plants grown to a considerable degree. In 1909 the soil was heavier, but one end of the plot was inferior as shown by the appearance of the plants grown. In 1910 the soil of the plot seemed fairly uniform, but the error was made of applying fertilizer in the row. While an effort was made to have this uniform all through the plot, it appeared that it was not fully successful, some portions of the rows receiving more stimulus than others. The plots used in 1911 appeared to be more desirable than those used previously, and were so on the whole, yet they were not all that could be desired, some portions being evidently poorer than the average, as indicated by the slightly less flourishing plants. Perfect uniformity of soil, however desirable in work of this kind, is very difficult and perhaps impossible to attain, and this must be compensated for by duplication of results. It is felt that in this work sufficient duplication has been carried out to neutralize this variation in soil conditions, and that the conclusions reached are not materially affected thereby.

The mathematical calculations have been carried out with the aid of millionaire and comptometer calculating machines and fully checked, and it is felt that they are free from errors that could sensibly affect the results. The methods that have been used are for the most part the usual ones and substantially as set forth in "Principles of Breeding," by E. Davenport.

Heredity.

In what degree may individual pea plants be expected to transmit their characters to their descendants? Table I. sums up the measure of inheritance of vine length and productiveness of about 10,000 plants in an effort to throw light on this question. Before discussing this table it is necessary to set forth the history and nature of the four groups dealt with.

TABLE I. — *Coefficients of Heredity.*

Vine Length.

Plant.	1908-09.	1909-10.	1910-11.	Average.
First of All,	-	+.0486 +.0242	+.0407 +.0257	+.0447
Excelsior I.,	+.2159 ±.0167	+.0236 ±.0170	+.0583 ±.0196	+.0993
Excelsior II.,	-	+.3095 ±.0172	+.0892 ±.0236	+.1994
Variety "C,"	—.0801 ±.0392	+.0372 ±.0241	—.0161 ±.0409	—.0197
Pods per Vine.				
First of All,	-	+.0435 +.0242	—.0564 +.0256	—.0065
Excelsior I.,	+.0782 ±.0174	—.0159 ±.0170	+.0140 ±.0197	+.0254
Excelsior II.,	-	+.0145 ±.0189	+.2317 ±.0225	+.1231
Variety "C,"	—.0433 ±.0395	—.0914 ±.0239	+.0046 ±.0399	—.0434

The plants grouped as First of All are from a lot of commercial seed of the variety bought in the open market. They were first grown in 1907, but the seed from individual plants was not saved separately until the fall of 1909, so that no coefficients of heredity are available except for the crops of 1910 and 1911. The number of plants of this group grown each year is in the vicinity of 700. The method of choosing seed plants is as follows: In the fall of 1908 seed from every tenth plant was saved, a special effort being made to make the tenth plant a random choice. In the following year the seed of one plant, chosen at random from the descendants of each of these tenth plants, has been saved for planting. In this way the number of plants has been kept fairly constant.

The same remarks will apply to the group Excelsior II., except that the number of plants has been greater, varying from 800 to 1,200 each year.

The groups called Excelsior I. and Variety " C " are both from the same lot of commercial seed, originally as Excelsior II., but these are descended from 10 plants selected in the fall of 1907, the seed of each being saved separately. In the spring of 1908 the seed of each of these plants was sown separately and 227 plants grown therefrom. The seed of each of these was separately saved and grown in 1909, resulting in 1,770 plants.

In the fall of 1909 and subsequent years a random selection of one plant from each of the groups of 1909 has been made, thus keeping the number of plants fairly constant. It will be seen that Excelsior I. and Variety " C " are made up of the descendants of 10 plants selected from commercial seed. The reason for separating one of the 10, " C ", is that it has proved to be a distinct variety, being larger, more productive and a week or ten days later than the other 9. This difference was not suspected when the original plant was selected. Between these 9 lines of descent there are no evident differences, though some are shown later in this paper to be present.

With these explanations in mind we may proceed to a discussion of the figures shown in Table I. The following conclusions seem warranted: —

1. With three exceptions the coefficients are very small, many are insignificant and some are even negative.

2. They are very irregular both in the same groups in different years and in different groups in the same year.

3. They are generally lower for pods per vine than for vine length.

4. They are on the whole lower for Variety " C " than for the other groups.

It will be remembered that Variety " C " comprises the descendants from 1 of 10 plants selected from a lot of Excelsior in 1907, the progeny of the other 9 being brought together to form the group Excelsior I. We have the figures for these 9 lines taken separately, and we may inquire if they, like Variety " C ", are insignificant or nearly so. They are given in Table II.

TABLE II. — *Coefficients of Heredity of Single Lines.*

Vine Length.

PLANT.	1908-09.	1909-10	1910-11.	Average.
A,	+.1701 ±.0482	—.0632 ±.0454	—.1737 ±.0516	—.0223
B,	+.2202 ±.0515	+.2841 ±.0460	+.0075 ±.0545	+.1706
D,	—.0556 ±.0471	—.0016 ±.0459	+.1242 ±.0477	+.0223
E,	+.0823 ±.0865	—.2122 ±.0587	—.0610 ±.0611	—.0636
F,	+.1472 ±.0812	+.1820 ±.0810	+.1651 ±.1110	+.1648
G,	—.1380 ±.0390	—.1652 ±.0351	—.0391 ±.0490	—.1141
H,	—.0549 ±.0462	+.1232 ±.0450	+.1353 ±.0498	+.0679
J,	+.1563 ±.0591	+.2165 ±.0663	+.2535 ±.0859	+.0679
K,	+.0298 ±.0554	+.2348 ±.0570	+.0689 ±.0720	+.1112
Average,	+.0619	+.0663	+.0534	+.0450 +.0605

Pods per Vine.

PLANT.	1908-09.	1909-10	1910-11.	Average.
A,	+.1372 ±.0488	—.1948 ±.0438	—.2106 ±.0508	—.0894
B,	+.2392 ±.0511	+.1748 ±.0485	—.1423 ±.0534	+.0906
D,	—.0521 ±.0471	+.0872 ±.0456	—.0477 ±.0483	—.0042
E,	+.0626 ±.0867	—.2371 ±.0642	—.0147 ±.0613	—.0631
F,	—.3311 ±.0775	+.0986 ±.0835	+.1414 ±.1102	—.0304
G,	+.0277 ±.0390	—.2317 ±.0341	—.0453 ±.0490	—.0498
H,	+.0681 ±.0436	—.0658 ±.0456	+.1165 ±.0500	+.0396
J,	+.1398 ±.0594	—.0469 ±.0696	—.1180 ±.0905	—.0084
K,	+.1337 ±.0545	+.2293 ±.0572	+.0463 ±.0718	+.1364
Average,	+.0472	—.0207	—.0305	+.0024 —.0013

A study of this table shows it to be in harmony with the first three conclusions drawn from Table I. It indicates further that the true coefficient of heredity within these single lines of Excelsior peas is about +.06 for vine length and practically zero for pods per vine.

There is generally a positive correlation between seed weight and the size of the plant produced. The question which now arises is whether this is sufficient to account for the small plus correlation in vine length shown in Table II. We have a few figures bearing on this point, but not enough to determine positively whether this is the case or not. The seed weights available were taken from another selection of plants from Excelsior I., not already dealt with, and from a commercial lot of Alaska. The latter is a variety with small, round, green seeds and with somewhat longer vines than Excelsior. These selections were of the long and short vines, and the more productive and less productive vines. This explains the small number of medium-length vines in Tables III. and IV. A few points brought out in Table III. should be noted: —

Table III. — *Correlation of Vine Length and Average Weight of Seeds borne, Excelsior I.*

Average Seed Weight (Grams).	Vine Length (Centimeters).												
	13	18	23	28	33	38	43	48	53	58	63	68	7	Total.
.10, . .	1	-	-	-	-	-	-	-	-	-	-	-	-	1
.15, . .	-	2	-	-	-	-	-	-	-	-	-	-	-	2
.16, . .	-	-	-	2	-	-	-	-	-	-	-	-	-	2
.17, . .	-	1	2	1	-	-	-	-	-	-	-	-	-	4
.18, . .	-	-	-	1	-	-	-	-	-	-	-	-	-	1
.19, . .	-	-	-	-	-	-	-	-	-	-	-	-	-	-
.20, . .	4	6	4	2	2	-	-	-	-	-	-	-	-	18
.21, . .	-	-	-	-	-	-	-	-	-	-	-	-	-	-
.22, . .	-	-	3	5	-	1	-	-	-	-	-	-	-	9
.23, . .	-	4	1	3	1	1	-	-	2	-	1	-	-	13
.24, . .	-	-	3	-	1	-	1	1	1	2	-	-	-	9
.25, . .	1	1	4	2	1	-	-	2	2	-	-	-	-	13
.26, . .	-	1	1	3	1	-	2	4	7	-	-	2	-	21
.27, . .	-	4	2	3	-	1	2	-	5	5	1	-	-	23
.28, . .	-	-	1	-	1	-	-	1	4	1	1	1	-	10
.29, . .	-	-	-	-	-	1	1	1	3	-	-	-	-	6
.30, . .	-	3	3	1	5	1	-	1	2	-	1	-	-	17
.31, . .	-	-	-	-	-	-	-	-	-	1	-	-	-	1
.32, . .	-	-	-	-	-	-	-	-	1	-	-	-	-	1
.33, . .	-	-	-	1	-	-	-	-	-	1	-	-	-	2
.34, . .	-	-	-	-	-	-	-	-	1	-	-	-	-	1
.44, . .	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Total, .	6	22	24	24	12	5	6	10	28	11	4	3	-	-

TABLE IV. — *Correlation of Vine Length and Average Weight of Seeds borne, Alaska.*

Average Seed Weight (Grams).	Vine Length (Centimeters).																			
	18	23	28	33	38	43	48	53	58	63	68	73	78	83	88	93	98	103	108	Total.
.08,	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
.09,	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
.10,	1	2	5	2	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	14
.11,	-	-	-	1	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-	4
.12,	-	-	2	2	4	3	5	2	1	-	1	1	1	1	-	-	-	-	-	23
.13,	-	1	-	4	4	2	3	-	-	2	-	1	1	-	1	1	-	-	-	20
.14,	-	-	-	-	3	5	5	3	1	-	1	2	3	3	1	-	-	-	-	27
.15,	-	1	1	3	2	5	6	5	2	1	1	-	2	4	5	2	-	-	-	40
.16,	-	-	-	-	-	5	7	4	-	1	1	3	4	4	3	2	2	-	-	36
.17,	-	2	-	1	2	6	3	1	-	-	-	1	6	2	3	3	1	2	-	33
.18,	-	-	-	-	1	2	2	1	2	-	2	-	1	3	1	1	-	-	-	16
.19,	-	-	-	-	-	-	-	-	-	1	1	-	2	2	1	2	1	-	-	10
.20,	-	2	-	-	-	-	1	-	-	-	-	1	-	1	-	1	-	-	-	6
.21,	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2
.22,	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Total,	1	8	8	14	16	30	35	17	7	5	7	9	21	22	15	13	4	2	-	-

1. No vine over 35 centimeters long produced seeds averaging less than .22 grams each.

2. Vines 35 centimeters or less produced many light seeds and also many fairly heavy seeds, but none as heavy as the long vines produced; the average weight is far more variable.

The same is true of the Alaska peas as shown in Table IV., though less strikingly so owing to the smaller variability of average seed weight in this variety.

TABLE V. — *Correlation of Vine Length and Average Weight of Seeds.*

Excelsior I., 40 centimeters or less,	+ .3038 ± .0635
Excelsior I., 41 centimeters or more,	+ .1669 ± .0833
Alaska, 60 centimeters or less,	+ .2779 ± .0534
Alaska, 61 centimeters or more,	+ .1662 ± .0663

In order to compute fairly the coefficient of correlation in these two groups it is necessary to compute for the short and long vines separately. The coefficients are given in Table V.

This table shows, in the case of both varieties, fairly large coefficients, and they are in both cases larger for the short vines than for the long vines. These figures form a too slender basis for a definite conclusion as to the correlation between vine length and the average weight of peas produced, but so far as they go they consistently favor the supposition that the correlation does exist and is fairly large. The average of the four is +.2287.

TABLE VI. — *Correlation of Average Seed Weight and Vines produced.*

Strain A, D, F, G, K,	+.0710 ± .0234
Strain B, E, H, J,	+.1045 ± .0286
Alaska,	+.0146 ± .0178
First of All,	—.0290 ± .0390

Turning now to the consideration of the question as to whether the heavier peas produce larger vines than do the lighter ones, we have the figures shown in Table VI. For reasons shown a little further on in this paper, the group Excelsior I. is divided into two strains, one of 5 lines and the other of 4 lines as shown in the table. The group First of All is from a selection of this variety that is of the same nature as the others. The number of vines is relatively small, and the figures, therefore, of less value than the other groups. It is because of the small numbers that the correlation of parent vine length and weight of their seeds are not given, but as far as they go they are in reasonable agreement with those of the two groups that are given.

It appears from the limited data given in Table VI. that the correlation is larger for the wrinkled Excelsior peas than for the starchy Alaska and First of All varieties. Only the coefficients for the first two groups should therefore be compared with the correlation of about +.06 found to exist between parent and offspring as shown in Table II.

No positive conclusion in this matter can be drawn. The indications are that a part and possibly all of the correlation of .06 may be accounted for by the correlation between length of vine and seed weight.

TABLE VII. — *Averages of the Single Lines.*

Original Plant.	Vine Length (Centimeters).	Mean Vine Length.				
		1908.	1909.	1910.	1911.	Average.
A, . . .	70	39.53 ±0.74	42.19 ±0.47	51.86 ±0.44	42.88 ±0.57	44.12
B, . . .	53	30.19 ±0.76	36.16 ±0.50	45.61 ±0.46	35.75 ±0.52	36.93
C, . . .	64	47.10 ±0.67	59.75 ±0.41	70.95 ±0.25	54.81 ±0.47	58.15
D, . . .	57	37.78 ±0.78	47.56 ±0.54	43.46 ±0.48	42.43 ±0.51	42.81
E, . . .	68	33.06 ±1.14	36.75 ±0.89	43.70 ±0.54	37.42 ±0.60	37.73
F, . . .	63	41.43 ±1.43	48.83 ±1.02	37.62 ±0.66	41.71 ±1.07	42.40
G, . . .	69	42.50 ±0.77	46.36 ±0.39	42.66 ±0.49	43.61 ±0.49	43.78
H, . .	61	34.35.±0.61	41.15.±0.41	36.44 ±0.36	38.76 ±0.46	37.68
J, . . .	65	36.72 ±0.55	38.77 ±0.53	33.80 ±0.60	35.69 ±0.84	36.25
K, . . .	55	44.88 ±0.67	46.55 ±0.51	38.24 ±0.54	35.90 ±0.75	41.39

Original Plant.	Pods per Vine.	Mean Vine Length.				
		1908.	1909.	1910.	1911.	Average.
A, . . .	11	3.00 ±.13	5.23 ±.11	4.78 ±.08	5.85 ±.15	4.72
B, . . .	17	2.91 ±.03	5.00 ±.13	4.70 ±.09	5.13 ±.13	4.44
C, . . .	9	5.32 ±.31	12.45 ±.27	7.77 ±.08	8.62 ±.17	8.54
D, . . .	7	3.26 ±.04	6.79 ±.14	3.88 ±.08	5.34 ±.11	4.82
E, . . .	4	2.81 ±.05	5.52 ±.22	4.18 ±.11	5.36 ±.13	4.47
F, . . .	3	3.57 ±.19	6.10 ±.26	3.16 ±.09	4.80 ±.20	4.41
G, . . .	9	4.70 ±.09	5.96 ±.09	3.59 ±.05	5.61 ±.12	4.97
H, . . .	11	3.15 ±.03	4.78 ±.09	3.02 ±.05	4.64 ±.11	3.90
J, . . .	4	3.05 ±.03	4.92 ±.12	3.16 ±.11	4.56 ±.21	3.92
K, . . .	4	3.75 ±.05	6.11 ±.20	3.62 ±.09	4.30 ±.12	4.45

A study of the averages of vine length and pods per vine of the 9 lines of descent, comprehended in the group Excelsior I., is of interest. These are shown in Table VII. and the remaining line, otherwise known as Variety " C ", is included for purposes of comparison. The most striking thing brought out in the table is the fact that averaging the mean vine length for the four years under observation, we find that 5 of the lines A, D, F, G and K are grouped very closely around 43 centimeters while 4 others, B, E, H and J, are grouped closely around 37 centimeters.[1] The remaining line C being, as already stated, obviously a distinct variety, has a vine length much greater than any of the others.

The two groups above designated may be spoken of as strains, their component parts being known as lines, each of which is, as before explained, composed of the descendants of a single plant. The means of the several lines vary greatly from year to year, due to the varying conditions of weather and of the soil of the different plots on which the crops were grown. The relations of the mean lengths of the several lines in the same years also vary greatly. Much of this is obviously due to varying soil conditions. They are more consistent with the four-year averages, in 1911, than in the previous years, the only very marked departure being the case of line K, which is much below the average. They are extremely variable in 1910, when, as already stated, the unwise method of applying fertilizer in the row was followed.

Whether the slight departure of the averages of the different lines of either strain have any significance in inheritance is questionable. Only further testing under more uniform conditions would determine this.

Great differences are shown in the mean number of pods per vine. They follow the mean vine lengths only in a general way, and do not show very clearly the segregation into two strains as do the mean vine lengths. This might be expected in consideration of the slight coefficient of heredity of pods per vine already shown. Nevertheless, the average number of pods in the long-vined strain is about 15 per cent. greater than in the other, while the vine length is only about 16 per cent. greater. We have here a result of the greater variability of pods per vine over vine length that will be more fully discussed later in this paper.

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[1] This explains the division of Excelsior I. in Table VI.

TABLE VIII. — *Coefficients of Heredity within Strains.*

Vine Length.

	1908-09.	1909-10.	1910-11.	Average.
A, D, F, G, K, ...	+.0081 ±.0225	—.0646 ±.0215	+.0682 ±.0260	+.0039
B, E, H, J, ...	+.1733 ±.0270	+.0355 ±.0276	+.0200 ±.0300	+.0763
Average, ...	+.0907	—.0146	+.0441 +.0401	+.0401

Pods per Vine.

	1908-09.	1909-10.	1910-11.	Average.
A, D, F, G, K, ...	—.0169 ±.0220	—.0072 ±.0216	+.0059 ±.0261	—.0061
B, E, H, J, ...	+.0343 ±.0280	—.0722 ±.0276	+.0292 ±.0299	—.0032
Average, ...	+.0087	—.0397	+.0176 —.0045	—.0047

If these strains are homogeneous, and if the positive correlation shown in the first three groups in Table I. is due chiefly to the mixture of distinct strains or lines having different means, as appears to be the case, we should get when we compute for each of the strains as a unit, coefficients similar to those given in Table II. They are given in Table VIII. It is seen that they are similar on the average, having a little lower positive correlation for vine length and an insignificant negative correlation for pods per vine.

CORRELATION.

The data on vine length and pods per vine already presented give some evidence of a positive correlation between these two characters which is in accordance with common observation. In Table IX. are given some figures that show the value of this

TABLE IX. — *Correlation Coefficients, Vine Length and Pods per Vine.*

PLANT.	Year.	Coefficient of Correlation.	Mean Vine Length.
Variety "C", ...	1910	.4070 ±.0101	71.0
Variety "C", ...	1911	.3104 ±.0359	54.6
Strain A, D, F, G, K, ...	1910	.6544 ±.0124	43.9
Strain A, D, F, G, K, ...	1911	.5653 ±.0178	41.8
Strain B, E, H, J, ...	1910	1.7189 ±.0133	39.9
Strain B, E, H, J, ...	1911	.6016 ±.0191	37.2
Telephone, ...	1911	.4297 ±.0277	98.9
Champion of England, ...	1911	.4766 ±.0371	98.5
Gradus, ...	1911	.5152 ±.0264	52.3
Evolution, ...	1911	.5293 ±.0266	72.2
Alaska, ...	1911	.6103 ±.0231	56.3
Thomas Laxton, ...	1911	.6180 ±.0236	53.7
American Wonder, ...	1911	.6950 ±.0174	23.0

correlation. The nature of the groups in the first part of the table has already been explained. The remaining varieties have been grown from commercial seeds bought in the open market. The table shows that the correlation coefficient is closely related to the mean vine length in different varieties. The rule that is generally, though not invariably, followed is that the longer the vine the lower the correlation between vine length and pods per vine. This is reversed in the case of the different years shown in the first part of the table. This is due to the fact that the vines branched more freely in 1911, owing presumably to weather conditions. Vine length is taken as the length of the main stem, and when there are one or more branches bearing pods it is obvious that the correlation is lessened.

To this same factor is due in part, but not wholly, the smaller correlation in the groups having longer vines.

One or two pods may be borne at each node of the plant, but at many nodes no pod is produced. Whether or not a pod is produced depends presumably on environmental conditions at the time when the early development of the node has reached a certain stage. The period of growth and node production is much longer with long-vined plants, and the plant is subjected to a greater variation of conditions. As successive nodes develop some will experience favorable and some unfavorable conditions, and this will not be in very close correlation with vine growth. In some varieties and in some seasons the production of doubled podded peduncles is more common, and this operates to disturb the correlation. This question will be further dealt with in connection with the later discussion of variation in productiveness.

Variation.

We may now proceed to a discussion of the amount and nature of the variation that has been in evidence in the different groups from season to season.

In Table X. are given the standard deviations and coefficients of variability that are available, and the means are inserted for convenience of immediate comparison, though most of them have already been given in another connection.

TABLE X. — *Variation in Vine Length and Productiveness.*

Plant.	Year.	Vine Length.			Pods per Vine.		
		Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.
A,	1908	39.53 ±0.74	4.80 ±0.53	12.15 ±1.34	3.00 ±0.13	.86 ±0.09	28.67 ±3.49
	1909	42.19 ±0.47	9.45 ±0.33	22.40 ±0.83	5.23 ±0.11	2.12 ±0.07	40.54 ±1.64
	1910	51.86 ±0.44	9.68 ±0.31	18.67 ±0.62	4.78 ±0.08	1.79 ±0.06	37.45 ±1.36
	1911	42.88 ±0.57	10.70 ±0.40	24.96 ±1.00	5.85 ±0.15	2.78 ±0.10	47.52 ±2.15
D,	1908	37.78 ±0.78	6.01 ±0.54	15.91 ±1.50	3.26 ±0.04	.29 ±0.03	8.90 ±0.74
	1909	47.56 ±0.54	11.40 ±0.38	23.97 ±0.85	6.79 ±0.14	3.06 ±0.10	45.07 ±1.78
	1910	43.46 ±0.48	10.46 ±0.34	24.07 ±0.82	3.88 ±0.80	1.68 ±0.06	43.30 ±1.65
	1911	42.43 ±0.51	10.47 ±0.36	24.68 ±0.89	5.34 ±0.11	2.36 ±0.08	44.24 ±1.79
F,	1908	41.43 ±1.48	5.80 ±0.00	14.00 ±2.57	3.57 ±0.19	-	-
	1909	48.83 ±1.02	12.33 ±0.72	25.24 ±1.57	6.10 ±0.26	3.03 ±0.19	49.59 ±3.72
	1910	37.62 ±0.66	7.91 ±0.47	21.03 ±1.30	3.16 ±0.09	1.11 ±0.07	35.13 ±2.34
	1911	41.71 ±1.07	9.36 ±0.75	22.44 ±1.89	4.80 ±0.20	1.75 ±0.14	36.46 ±3.30
G,	1908	42.50 ±0.77	6.29 ±0.55	14.80 ±1.23	4.70 ±0.09	.71 ±0.02	15.11 ±1.31
	1909	46.36 ±0.39	9.93 ±0.27	21.42 ±0.62	5.96 ±0.09	2.27 ±0.63	38.09 ±1.19
	1910	42.66 ±0.49	9.47 ±0.24	22.20 ±0.59	3.59 ±0.05	1.41 ±0.04	39.28 ±1.14
	1911	43.61 ±0.49	9.91 ±0.34	22.72 ±0.83	5.61 ±0.12	2.54 ±0.09	45.28 ±1.86
K,	1908	44.88 ±0.67	3.95 ±0.48	8.80 ±1.06	3.75 ±0.50	.28 ±0.03	7.47 ±0.89
	1909	46.55 ±0.51	9.24 ±0.36	19.85 ±0.81	6.11 ±0.20	3.55 ±1.39	57.63 ±1.87
	1910	38.24 ±0.54	8.96 ±0.38	23.43 ±1.05	3.62 ±0.09	1.54 ±0.07	42.54 ±2.12
	1911	35.90 ±0.75	10.47 ±0.53	29.16 ±1.60	4.30 ±0.12	1.73 ±0.09	40.28 ±2.35
A, D, F, G, K,	1908	40.70 ±0.42	6.30 ±0.30	15.48 ±0.76	3.75 ±0.08	1.19 ±0.06	31.64 ±1.65
	1909	45.97 ±0.22	10.00 ±0.16	21.67 ±0.36	6.05 ±0.06	2.80 ±0.05	46.28 ±0.88
	1910	43.92 ±0.23	10.56 ±0.16	24.04 ±0.39	3.90 ±0.03	1.60 ±0.02	41.03 ±0.72
	1911	41.86 ±0.28	10.61 ±0.20	25.35 ±0.50	5.37 ±0.06	2.47 ±0.05	45.90 ±1.01

TABLE X. — *Variation in Vine Length and Productiveness* — Con.

Plant.	Year.	Vine Length.			Pods per Vine.		
		Mean.	Standard Deviation.	Coefficient of Variability.	Mean.	Standard Deviation.	Coefficient of Variability.
B,	1908	30.19 ±0.76	5.37 ±0.54	17.79 ±1.81	2.91 ±0.03	.21 ±0.02	7.22 ±0.72
	1909	36.16 ±0.50	9.18 ±0.35	25.38 ±1.04	5.00 ±0.13	2.31 ±0.09	39.65 ±1.74
	1910	45.61 ±0.46	9.16 ±0.32	20.09 ±0.73	4.70 ±0.09	1.82 ±0.06	38.72 ±1.56
	1911	35.75 ±0.52	9.55 ±0.37	26.72 ±1.10	5.13 ±0.13	2.40 ±0.09	46.78 ±2.16
E,	1908	33.06 ±1.14	6.74 ±0.80	20.39 ±2.52	2.81 ±0.05	.28 ±0.03	9.96 ±1.19
	1909	36.75 ±0.89	10.23 ±0.63	27.84 ±1.84	5.52 ±0.22	2.58 ±0.16	46.74 ±3.44
	1910	43.70 ±0.54	8.17 ±0.38	19.00 ±0.92	4.18 ±0.11	1.65 ±0.08	39.35 ±2.10
	1911	37.42 ±0.60	9.80 ±0.42	26.18 ±1.21	5.36 ±0.13	2.15 ±0.09	40.15 ±2.00
H,	1908	34.35 ±0.61	5.29 ±0.42	15.40 ±1.29	3.15 ±0.03	.26 ±0.02	8.25 ±0.68
	1909	41.15 ±0.41	9.35 ±0.29	22.72 ±0.73	4.78 ±0.09	2.14 ±0.66	44.86 ±1.63
	1910	36.44 ±0.36	7.99 ±0.26	21.93 ±0.74	3.02 ±0.05	1.13 ±0.37	37.42 ±1.37
	1911	38.76 ±0.46	9.12 ±0.33	23.53 ±0.89	4.64 ±0.11	2.08 ±0.08	44.83 ±1.90
J,	1908	36.72 ±0.55	3.72 ±0.37	10.13 ±1.06	8.05 ±0.03	.19 ±0.02	6.23 ±0.65
	1909	38.77 ±0.53	8.82 ±0.38	22.75 ±1.02	4.92 ±0.12	2.04 ±0.87	41.46 ±2.05
	1910	33.80 ±0.60	8.61 ±0.42	25.47 ±1.33	3.16 ±0.11	1.53 ±0.08	48.26 ±2.87
	1911	35.69 ±0.84	9.16 ±0.59	25.67 ±1.77	4.56 ±0.21	2.28 ±0.15	50.05 ±3.97
B, E, H, J,	1908	34.47 ±0.40	5.80 ±0.28	16.82 ±0.84	3.03 ±0.05	.76 ±0.04	25.08 ±1.30
	1909	38.86 ±0.27	9.49 ±0.19	24.42 ±0.51	4.94 ±0.06	2.23 ±0.04	45.04 ±1.06
	1910	39.94 ±0.27	9.69 ±0.19	24.26 ±0.50	3.76 ±0.05	1.69 ±0.03	45.01 ±1.04
	1911	37.19 ±0.28	9.47 ±0.20	25.45 ±0.57	4.93 ±0.07	2.24 ±0.05	45.44 ±1.15
C,	1908	46.12 ±0.67	8.55 ±0.48	18.53 ±1.58	5.32 ±0.31	2.60 ±0.22	48.87 ±4.81
	1909	59.75 ±0.41	10.38 ±0.29	17.38 ±0.51	12.45 ±0.27	6.71 ±0.19	53.90 ±1.86
	1910	70.95 ±0.25	10.34 ±0.18	14.56 ±0.25	7.77 ±0.08	3.22 ±0.06	41.44 ±0.82
	1911	54.81 ±0.47	11.95 ±0.36	21.80 ±0.64	8.62 ±0.17	4.33 ±0.12	50.24 ±1.73
Excelsior I.,	1908	37.67 ±0.33	6.81 ±0.23	18.09 ±0.64	3.40 ±0.05	1.06 ±0.04	31.29 ±1.17
	1909	43.20 ±0.19	10.68 ±0.13	24.72 ±0.32	5.63 ±0.05	2.66 ±0.03	47.25 ±0.70
	1910	42.41 ±0.18	10.39 ±0.13	24.50 ±0.31	3.85 ±0.03	1.66 ±0.02	43.12 ±0.61
	1911	39.85 ±0.21	10.43 ±0.15	26.17 ±0.39	4.57 ±0.03	1.73 ±0.02	37.86 ±0.60

Excelsior II.,	1909	37.68 ±0.23	11.50 ±0.16	30.52 ±0.48	4.47 ±0.05	2.34 ±0.03	52.35 ±0.93
	1910	44.73 ±0.19	9.89 ±0.13	22.11 ±0.31	5.39 ±0.05	2.51 ±0.03	46.57 ±0.75
	1911	45.78 ±0.19	7.79 ±0.13	17.03 ±0.29	4.71 ±0.04	1.83 ±0.03	38.90 ±0.75
First of All,	1909	41.24 ±0.40	16.02 ±0.28	38.83 ±0.78	3.51 ±0.05	1.84 ±0.03	52.42 ±1.14
	1910	61.89 ±0.42	17.19 ±0.29	27.78 ±0.51	3.99 ±0.04	1.53 ±0.03	38.21 ±0.74
	1911	68.07 ±0.38	14.73 ±0.27	21.64 ±0.39	4.86 ±0.05	2.06 ±0.04	42.45 ±0.90
American Wonder,	1911	23.65 ±0.27	8.15 ±0.19	34.48 ±0.91	3.71 ±0.06	1.74 ±0.04	46.82 ±1.33
Early Prize,	1910	49.21 ±0.72	11.99 ±0.51	24.36 ±1.08	8.95 ±0.27	4.55 ±0.19	50.84 ±2.64
Gradus,	1911	52.29 ±0.56	15.50 ±0.40	29.64 ±0.82	2.18 ±0.04	1.14 ±0.03	52.54 ±1.67
Daniel O'Rouke,	1910	57.04 ±0.52	12.32 ±0.37	21.60 ±0.68	4.56 ±0.08	1.89 ±0.06	41.48 ±1.44
Thomas Laxton,	1910	59.46 ±1.47	19.68 ±1.04	33.10 ±1.93	3.83 ±0.11	1.48 ±0.08	38.65 ±2.32
Thomas Laxton,	1911	53.66 ±0.67	17.57 ±0.47	32.75 ±0.97	3.39 ±0.07	1.85 ±0.05	54.52 ±1.85
Alaska,	1910	64.99 ±0.32	14.88 ±0.23	22.90 ±0.37	3.61 ±0.03	1.41 ±0.02	39.09 ±0.68
Alaska,	1911	56.39 ±0.59	15.93 ±0.42	28.25 ±0.79	4.34 ±0.09	2.33 ±0.06	53.72 ±1.75
Evolution,	1911	72.14 ±0.61	16.56 ±0.43	22.91 ±0.63	4.52 ±0.10	2.65 ±0.07	58.71 ±1.96
Telephone,	1911	98.88 ±0.73	21.47 ±0.52	21.73 ±0.55	3.14 ±0.06	1.68 ±0.04	53.31 ±1.60
Champion of England,	1910	131.80 ±1.15	22.88 ±0.80	17.36 ±0.62	12.89 ±0.36	7.46 ±0.26	57.90 ±2.61
Champion of England,	1911	98.73 ±1.08	22.69 ±0.77	22.98 ±0.82	4.21 ±0.11	2.38 ±0.08	56.52 ±2.46

Considering first the figures for vine length, we find that in 1908 the standard deviation and coefficient of variability were much lower than in any of the following three years. This is due to two factors, the more potent of which, doubtless, was the soil of the plot on which the plants were grown; this was gravelly and the plants suffered severely from drought. The other was the small number of plants grown, the total of 1908 being 227, while in subsequent years the total of the same groups has been more than 1,000. During the years 1909–11 there seems not to have been in Excelsior I., or any of its sub-groups, any constant differences in variation that cannot be ascribed to seasonal influences. In Excelsior II. both constants are notably low in 1911. This may be due to the fact that they were planted later this year than previously and encountered the unusually hot weather of July, 1911, at an earlier stage of development than either the other lots of Excelsior, or this lot in earlier years had encountered the less severe midsummer heat of those years. A comparison of the two strains of Excelsior I. shows that A, D, F, G, K has had uniformly greater standard deviation than B, E, H, J, but this has not been in proportion to the higher mean, so the coefficient of variability is less in the longer vined strain. This same tendency is seen in the distinct varieties, although it is not invariably the case.

We may ask if the variation within the lines of the two strains of Excelsior I. give evidence of individuality of these several lines? Is any line constantly more or less variable than the others of the same strain? With the possible exception of line D, which has a standard deviation uniformly larger or at least as large as its fellows, there seems to be no evidence of such a condition of affairs. It appears that the differences in the variability within the different lines is mostly, if not entirely, environmental and due chiefly to varying soil conditions.

We may now turn our attention to the figures for the number of pods per vine. We see first of all that the coefficient of variability is nearly twice as large as that for vine length, and in many cases the difference is even greater than this. In general, a high variability in vine length is accompanied by a high variability of pods per vine and vice versa, as would be expected from the strong correlation already shown to exist between these two characters. The differences in mean between different groups, more especially in different seasons, is marked. All through the groups of Excelsior I., 1909 was the most productive year, followed in order by 1911, 1910 and 1908. This order is not always followed in the other groups, owing to the fact that different planting dates and varying periods of growth caused the plants to experience different weather conditions at corresponding periods of development. These figures bring out in a striking way that fact familiar to all practical men, that productiveness is a delicate and uncertain character and tremendously influenced by environmental conditions.

The 10 plants of Excelsior selected in 1907 have given rise to at least three types of peas referred to as strains A, D, F, G, K and B, E, H, J and Variety " C." The groups Excelsior II. and First of All contain over 100 lines similar to those arising from these 10 plants, but in no case have we over 25 or 30 individuals in any one year. We may ask whether we have here any evidence of similar differences. No line is as distinct as Variety " C ", but whether there are any of the more similar types, such as the two strains referred to, cannot be positively determined, owing to the small number of individuals grown. If we admit the general application of the very low heredity coefficients shown in Table II. to all such lines, a coefficient materially greater than these must indicate the presence of distinct strains. Reference to Table I. indicates a possibility of such condition in the case of Excelsior II., but with First of All the figures are about the same as those for single lines; it should be remembered, however, that the indications are that the correlation between seed weight and vine length is less in starchy peas. A study of the means of single lines for the two years available has been made, but is of no value, as the variation obviously due to environment, and the small number of individuals grown, totally obscures any inherited likeness that may exist. The existence of a relatively large coefficient of variability should indicate the presence of distinct strains, but these figures for Excelsior II. and First of All are variable and inconclusive.

The conclusion on this point is that there is some evidence of the presence of distinct strains in both Excelsior II. and

First of All, though we cannot say that their presence in either group is conclusively proven. In the opinion of the writer only the growing of these lines in greater numbers, for a period of two or three years under the most uniform conditions possible, can determine whether they are homogeneous or are, like Excelsior I., made up of distinct strains.

Discussion of the Results.

This work deals with two somewhat distinct characters of the garden pea, — vegetative vigor as expressed by vine length and the reproductive power as expressed by the number of pods per vine. The former seems much the more stable character, while the latter is extremely variable and much the subject of environmental influences. Vine length is, therefore, more dependable in studying heredity. The figures for vine length seem to indicate that some and perhaps all varieties of garden peas are composed of strains which have different hereditary vine lengths, which is in harmony with much of the recent investigation along these lines. They do not, in the opinion of the writer, indicate that the progeny of each individual under observation form distinct units which may be distinguished from each other, but rather that there are comparatively few distinguishable units composed of individuals of equal hereditary value to be found within the limits of what we commonly understand as a garden variety.

This work indicates nothing as to the origin or permanency of these units or strains. They may have arisen by mutation, by a gradual differentiation or by hybridization; they may endure permanently or they may not. It will require much further investigation to settle these questions.

It is a little unfortunate that no records of the number and length of internodes have been kept, for they would probably throw light on certain questions of productiveness. Each node, excepting possibly the lower ones, may be considered a possible location for a pod. It is probable that whether or not a pod is produced from any given node is entirely a matter of environment. We see no reason to believe that the number of pods per vine is in itself inherited in any degree. Vine length and presumably the number of nodes may be in some degree inherited, and inasmuch as a longer vine, and presumably more nodes, gives more opportunities for pod setting, productiveness may be thus indirectly passed over from one generation to another; but we see no indication in this work, or any other with which we are familiar, that the ability to produce pods is an inheritable character.

It follows from this that in careful work in selecting for productiveness in peas it will probably be more effective to follow the indirect method of selecting the long vines rather than to select directly the more elusive and variable character of pods per vine.

The difficulties in the way of studying heredity in plants lie largely in differentiating the inherited variations from the environmental; they may be reduced to a minimum by securing as uniform conditions as possible and growing large numbers of individuals. In such ways we may hope to learn the laws of breeding and reduce its practice to a science.

SEED WORK FOR THE YEAR 1911.

G. E. STONE.

The seed work for 1911 has included, as before, seed germination, seed separation and testing for purity. The 355 samples of seed sent in for germination exceeded the number for 1910, and was the largest number received since the work was inaugurated. Sixty-eight samples were tested for purity, and 135 samples were separated. This is not the largest number ever received for separation; the weight in pounds, however — 6,320 — was four times as great as ever before. Eighty-seven samples of tobacco seed and 42 of onion were sent in for separation. The smaller number of samples received is due to a co-operation among the farmers in buying their seed.

The average germination of onion seed for 1911 was 70 per cent., the highest 98 per cent. and the lowest 20 per cent. The average for tobacco was 84 per cent., the highest 95 per cent. and the lowest 21 per cent., neither seed being quite up to the standard.

TABLE I. — *Records of Seed Germination, 1911.*

Kind of Seed.	Number of Samples.	Average Per Cent.	Per Cent. of Germination.	
			Highest.	Lowest.
Onion,	126	70.4	98.5	20.0
Tobacco,	11	84.9	95.0	21.0
Clover,	25	81.3	97.0	61.5
Rye,	5	84.5	97.0	63.0
Grasses,	38	77.7	99.0	15.5
Lettuce,	43	48.7	99.0	3.0
Celery,	21	30.2	91.0	-
Tomato,	9	58.3	98.0	-
Parsley,	5	56.4	85.0	20.0
Spinach,	7	28.0	39.5	12.0
Parsnip,	7	7.5	30.0	-
Miscellaneous,	65	42.8	98.5	-
	355	-	-	-

More seed separation is apparently being done at this station than at any other, and this work is constantly increasing. The advantages to be derived from seed separation are not fully appreciated as yet. Onion and tobacco growers, we believe, are realizing these advantages more fully year by year, and this is true of some lettuce and celery growers, but much more use could be made of the practice by market gardeners. Seed separation results in better seed, more perfect germination and much more uniform and larger plants, which in seedbeds saves space and a great deal of labor in selecting uniform seedlings.

The selection from strains is also being made much of in the growing of corn and other crops, but market gardeners and farmers are by no means making use of all the opportunities in any of these directions.

Table II. — *Records of Seed Separation, 1911.*

Kind of Seed.	Number of Samples.	Weight (Pounds).	Per Cent. of Seed retained.	Per Cent. of Seed discarded.
Onion,	42	6,206.210	72.1	27.9
Tobacco,	87	85.820	86.3	13.7
Lettuce,	3	27.720	83.6	16.4
Celery,	6	.926	84.8	15.2
Total,	135	6,320.676	-	-

The percentage of onion seed discarded runs higher than usual, a fact due, apparently, to the relatively larger number of small seeds present than usual.

A summary of the seed work carried on at the station for a period of twelve years is shown in Table III. Previous to 1899 little seed testing and separation were done here, and no systematic records were kept of the work. Table III. gives a recapitulation of the work done in seed germination, purity testing and seed separation since 1899.

TABLE III. — *Showing Number of Samples of Seed Purity and Germination Tests made, and Seed Separation Work done, at the Station since 1899.*

Year.	Number of Samples.			Pounds separated.
	Germination.	Purity.	Separation.	
1899,	27	-	-	-
1900,	17	-	-	-
1902,	53	-	-	-
1903,	42	-	-	-
1904,	131	-	-	-
1905,	217	-	-	-
1906,	126	18	87	144
1907,	247	27	112	472
1908,	196	12	160	1,370
1909,	273	100	143	1,501
1910,	296	30	115	1,552
1911,	355	68	135	6,320
Total,	1,980	255	752	11,359

This table gives some idea of the increased interest manifested in seed work by the farmers and market gardeners of the State. Nearly 2,000 tests have been made for germination. 255 tests for purity, and 752 separations made. The total weight of seeds separated is 11,359 pounds. It must be remembered that all the seeds separated were small, particularly tobacco seed, of which it requires a great many to make a pound. A record of the number of samples, with the average, maximum and minimum germination of onion, tobacco and celery seed, is shown in Table IV.

TABLE IV. — *Showing Germination of Onion, Tobacco and Celery received at the Station since 1899.*

Year.	Onion.				Tobacco.				Celery.			
	Number of Samples.	Average.	Maximum.	Minimum.	Number of Samples.	Average.	Maximum.	Minimum.	Number of Samples.	Average.	Maximum.	Minimum.
1899,	27	72.0	90.0	45.0	-	-	-	-	-	-	-	-
1900,	12	85.6	92.0	70.0	-	-	-	-	-	-	-	-
1902,	6	89.0	94.0	83.0	-	-	-	-	-	-	-	-
1903,	21	85.5	97.0	52.5	-	-	-	-	-	-	-	-
1904,	25	77.8	96.5	45.5	-	-	-	-	-	-	-	-
1905,	15	91.8	98.5	84.0	-	-	-	-	4	89.0	97	79
1906,	32	79.0	100.0	28.0	-	-	-	-	6	67.0	99	43
1907,	40	86.0	98.5	57.0	2	91.0	92	90	3	83.0	91	70
1908,	65	74.2	98.5	-	10	78.0	97	20	24	79.0	98	35
1909,	92	82.2	97.0	25.0	8	93.6	97	85	8	69.0	85	25
1910,	75	77.4	100.0	3.0	7	95.0	99	89	-	-	-	-
1911,	126	70.4	98.5	20.0	11	84.9	95	21	21	30.2	91	-
Total,	536	-	-	-	38	-	-	-	66	-	-	-

During the period from 1899 to the present time 536 germination tests of onion seed, 38 of tobacco and 66 of celery have been made, representing about one-fourth of the seed which we have tested. The principal feature to be noted is, perhaps, the variation in the percentage of germination occurring from year to year in different seeds. While it is perhaps not legitimate with the data at hand to draw too close deductions, we have noted in our seed work the effects of unfavorable climatic conditions upon the size and weight of seeds and seed vitality. The lowest average for onion seed was obtained in 1911, most of this seed probably having been grown in 1910; the highest average germination for onion in 1905, and for tobacco in 1910. The tobacco seed are practically all grown in the Connecticut valley, and obtained from carefully selected plants the year before. The variation in vitality is of some significance here. The celery seed tested is of uncertain origin, and the variation has little significance for us. There is no doubt but that unfavorable seasons and other factors show their effect in the percentages of germination given in these tables. In the case of tobacco seed another factor probably enters in, viz., gradual improvement in the vitality brought about by care in the selection of the seed plants.

TABLE V. — *Showing Number of Samples and Pounds of More Important Varieties of Seeds separated from 1906 to 1911, inclusive.*

KIND OF SEED.	Number of Samples.	Weight (Pounds).	Per Cent. of Seed retained.	Per Cent. of Seed discarded.
Onion,	187	8,923.30	83.6	16.3
Celery,	29	555.64	89.3	10.7
Tobacco,	418	272.43	85.4	14.6
Lettuce,	6	67.72	86.8	13.2
Total,	640	9,819.09	–	–

In Table V. is shown the number of samples and pounds of four typical seeds, with the percentage retained and discarded in our separation work, covering a period of five years, from 1906 to 1911. It will be seen from this table that the total number of samples separated is 640, equalling nearly 10,000 pounds in weight. The average percentage discarded was about 15 per cent., representing small, inferior seeds. Since these were all small seeds the weight in pounds is rather insignificant, as the number of onion seed in a pound is approximately 130,-000, that of celery seed 2,000,000, of lettuce, 400,000 and of tobacco 7,000,000. All the seed work has been done here gratuitously since its inauguration, the only exception being in the case of retailers who sometimes wish their seed tested in large quantities. The only expense incurred by the grower at present is return postage or express charges, and we are glad to say that this condition is almost invariably complied with.

In our opinion this work has proved of great value to our agriculturists. So far as seed separation is concerned, the value is greater than some of them realize, and perhaps less than others of the more enthusiastic may believe. The many careful tests which we have been making for years have shown us what seed separation actually accomplishes, and we therefore desire neither to overrate nor underrate the value of the work. The seed work of this station has shown a very healthy increase and growing interest on the part of the farmers. It has not been extensively advertised nor the value exaggerated, as we have regarded a slow, constant growth as of more value than one of a sporadic nature. The work, however, is now becoming so important in our State that it requires the services of a seed analyst who would devote most of his time to this work. We are of the opinion that this work should be done gratuitously for farmers and citizens, for the present at any rate, as it is more or less educational in nature, and that provision should be made for an assistant and improved testing appliances. Constant experimentation should be carried on to improve upon the existing methods of germination and separation. The work should be done systematically and collections of samples obtained throughout the State from dealers and farmers, and the results of these tests published here in bulletin form. This would greatly improve the seed problem as existing in this State.

All samples of seed to be germinated or separated should be sent to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the express or freight should be prepaid.

RUST ON VINCA.

G. E. STONE.

An outbreak of rust on Vinca was recently brought to our attention by Mr. O. C. Bartlett, a graduate student at this institution. Mr. Bartlett, who is engaged in the summer in inspection work, became acquainted with this trouble through J. W. Adams & Co., of Springfield, Mass., a firm which maintains a nursery and general greenhouse establishment. The rust appears to be new in this country, and is apparently the same species as that occurring in Europe on Vinca,[1] although the specimens obtained by us do not correspond in every way to the European descriptions of this fungus. We have in our herbarium no European species with which to compare our specimens, but they were sent to Prof. W. G. Farlow, of Harvard University, and to Dr. J. C. Arthur of Purdue University, Indiana, who is a rust specialist. Professor Farlow writes that from a casual examination of material which we sent him, and which he compares with material in his own herbarium, the species differs considerably from his own type, *Puccinia Vincæ (DC) Cast.* Dr. Arthur states that there are two distinct forms in Europe, both of which are referred to as *Puccinia Berkelei, Pass.*, and *Puccinia Vincæ (DC)*, Berk., the former being a synonym of the latter, and that the specimens sent correspond with one of the European types.

The rust has apparently been present in the vicinity of Springfield and Chicopee for at least two or three years, corresponding to the period when there was more or less of an unusual epidemic of rust in this State and elsewhere. Vinca is grown out of doors during the summer from greenhouse cuttings, but we could find no evidence of the disease affecting

[1] Tubeuf & Smith, "Diseases of Plants," p. 356.

outdoor plants in the summer or early fall. It makes its appearance in the greenhouse in the late fall and persists during the winter, affecting the leaves of the young, vertical shoots more seriously than those of the older, pendant ones. We observed both the euredospore and teleutospore outbreaks, which occurred on the underside of the leaves on our material. In the spring it appears to affect the plants less seriously, probably owing to the practice of frequently cutting off the affected parts and destroying them, and to the vigorous growth of the plants in the spring. When starting new plants care has been taken to use only healthy cuttings from year to year, and in this way the rust has, perhaps, been held in check to some extent.

The disease affects both the green and variegated varieties, although the latter are usually more severely affected. It has been found on a large number of plants, but the loss has not been serious owing to a tendency on the part of the plants to outgrow the trouble.

We have not been able to learn whether the mycelium is perennial in the stem or not, or whether infection comes from the field, but the rust does not seem to be so serious this year as the past two years, agreeing in this respect with other rusts which have been more or less epidemic. If the infection occurs on outdoor plants, as in the case of chrysanthemum rust, it can easily be controlled by indoor or tent-cloth culture, or by any other means which would keep the dews off the plants, and even if the mycelium is present in the stem to some extent the disease can no doubt be practically controlled by careful selection of cuttings. We have been unable to trace the disease beyond the points mentioned. The stock in use was obtained from the immediate neighborhood where the infection occurred, although no doubt the rust at some time or other came in on stock imported from Europe.

FROST CRACKS.

G. E. STONE.

Many trees of different varieties are subject to frost cracks. These often remain open for several years, and so far as our observations go are almost always to be found on the sunny side of the tree, generally towards the south. They occur in winter, and it is generally believed that they are caused by sudden changes in temperature, and especially by very severe cold. They were very common in this section during the remarkably cold winter of 1903–04, when some fruit trees, 8 or 10 inches in diameter, had frost cracks which opened 4 or 5 inches wide.

In this section the elm tree is more liable to cracks from the action of frost than other varieties. These are often 12 or 15 feet long, and give rise to more or less serious bleeding during the summer months. Cracks in trees occur not infrequently from other causes, such as the splitting of limbs, and we have known a number of sugar maples to gradually bleed to death from the loss of sap.

Frost cracks open in winter when the temperature is low, and close in summer. When not very large they sometimes heal over and disappear through the activities of callus growths, but more often they persist for some years, and an extensive opening of the cavity prevents permanent healing, making the tree subject to bleeding in summer.

Frost cracks are difficult to treat satisfactorily by tree surgery methods, as they often extend quite deeply into the wood, and the orifice is constantly changing in width owing to changes in the temperature. For the same reason certain other cavities in trees are hard to treat, as they sometimes open in winter and allow water to enter, which often results in the displacement of the cement fillings. To obviate this difficulty we have experimented largely with elastic cement applied to the edge of the filling as a means of preventing the access of water between the cement and the wood, but have found it practically impossible so far to prevent the bleeding of frost cracks or cavities in trees. There is no substance now in use which can successfully overcome the pressure exerted by the sap, which is bound to exude under certain conditions.

During the winter of 1907 Mr. E. G. Bartlett, at that time assistant in the laboratory, at my suggestion made measurements of the opening and closing of the orifices of some large frost cracks on the south side of elm trees located on the college campus. In the following table are given the results of these measurements, together with the mean temperature for the same period. The meteorological data were taken from the local station on the college grounds, and not a great distance from the trees.

Table showing Variation in the Width of Frost Cracks in Elm Trees (Ulmus Americana).

Date.	Tree No. 1.	Tree No. 2.	Mean Temperature (Degrees F.).
February 4,	23	20	16.5
5,	24	21	11.0
6,	26	24	5.3
7,	32	28	2.5
8,	28	24	16.0
9,	26	23	13.0
11,	22	18	17.0
12,	36	32	1.3
13,	38	35	2.5
14,	24	20	31.7
15,	26	22	28.5
16,	21	17	26.7
18,	22	20	21.5
19,	22	18	14.5
20,	22	18	30.7
21,	25	21	20.5
22,	28	24	8.0
23,	32	28	.5
25,	22	28	20.3

Table showing Variation in the Width of Frost Cracks in Elm Trees (Ulmus Americana) — Concluded.

Date.	Tree No. 1.	Tree No. 2.	Mean Temperature (Degrees F.).
February 26,	28	24	7.7
27,	29	25	12.0
28,	28	24	7.5
March 4,	20	16	27.5
5,	20	16	21.3
6,	20	16	23.7
7,	21	17	22.5
8,	20	16	24.0
9,	20	16	23.7
10,	21	17	20.5
11,	20	16	29.7
12,	18	14	25.5
13,	18	14	37.3
15,	11	8	35.7
17,	9	9	41.7

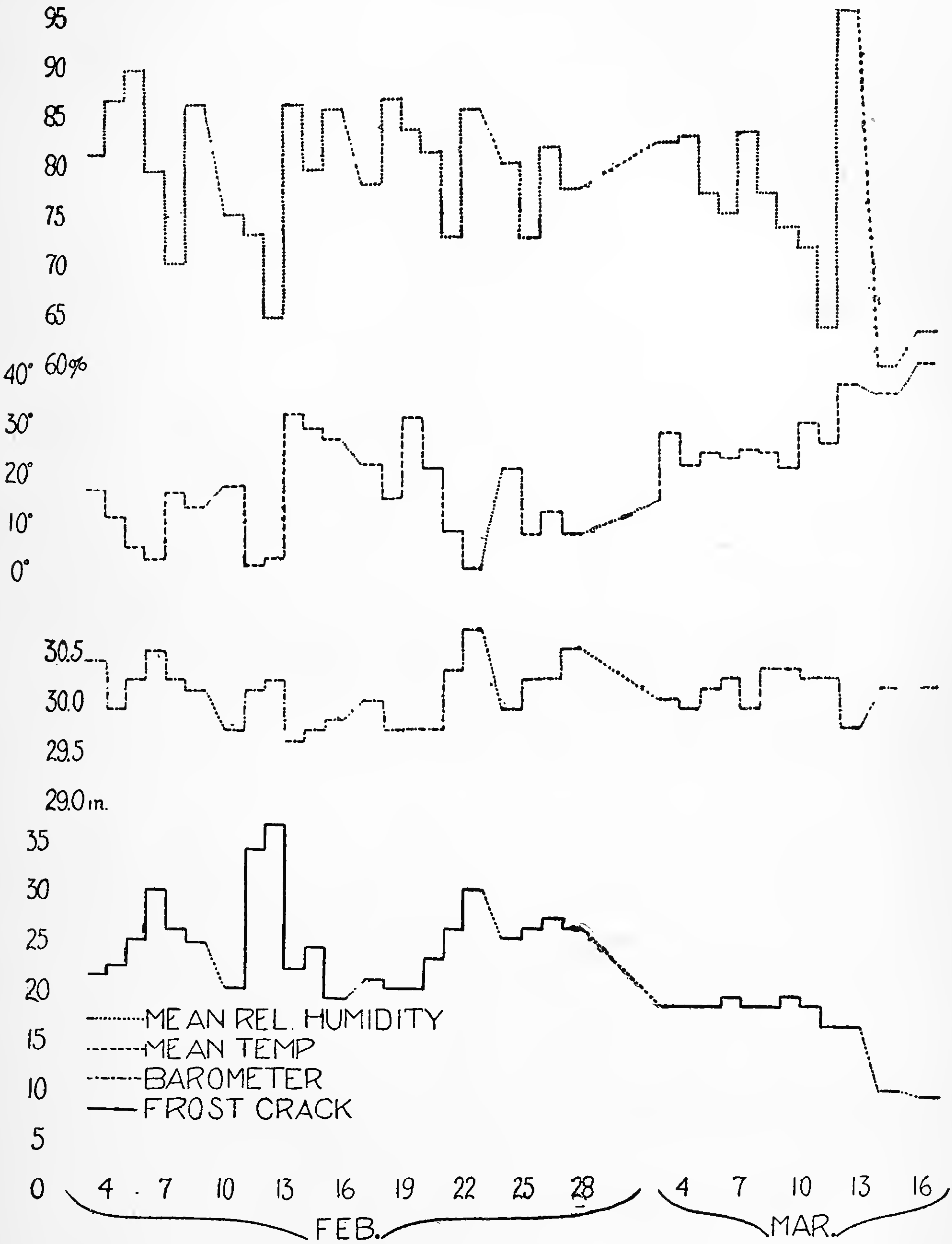
Measurements were not taken on February 10, 17 and 24 (Sunday). The remainder of March the cracks were too small to measure conveniently.

In the following diagram are shown graphically the variations in the opening and closing of frost cracks based upon the average measurements of tree No. 1 and No. 2; also the barometer, mean temperature and mean relative humidity curve.

It will be noticed that the barometer and temperature curves coincide closely with those given by the opening and closing of the frost cracks, and the same is true to a certain extent of the curve given by the relative humidity. The temperature curve is based upon the mean of the maximum and minimum for each day.

During the periods of low temperature the cracks opened, and closed when the temperature was higher. They open wider in February than in March, as shown by the higher readings in the table.

The relative mean humidity curve in general corresponds with that of the opening and closing of the frost cracks. When the humidity is low the cracks show a tendency to open, and to close when the humidity is great. The rise and fall of the



Showing curve of opening and closing of frost cracks in elm trees. The lower curve represents the variations in the opening and closing (scale, 1/64 of an inch); the others represent the mean relative humidity, mean temperature and barometer in the order named.

barometer curve coincides very closely with that of the frost cracks; in fact, there was such a close relationship between the temperature and barometer readings and opening and closing of frost cracks that considerable information as to the weather conditions might be obtained from observations on frost cracks. During the latter part of March, when the temperature was higher, the frost cracks did not open so wide, and it became more difficult to read them accurately. The same degree of variation in frost cracks may not occur in the summer months as in the winter; at any rate, the change was not so noticeable.

A NEW METHOD FOR THE APPROXIMATE MECHANICAL ANALYSIS OF SOILS.

G. E. STONE AND G. H. CHAPMAN.

According to the best authorities, and giving the definition used by the authors of Bulletin No. 24 of the United States Department of Agriculture, "The mechanical analysis of a soil consists in the separation of the soil particles into groups dependent upon the size of the grains, and in the determination of the percentage by weight of the particles constituting each group. The limits of these groups are arbitrarily chosen with reference to the ease in making the separation, and to the importance of the particles of any given size in determining the physical characteristics of the soil."

Many methods have been devised at different times by investigators, but the whole matter was somewhat hazy on account of each one using his own measurements for grading the soil particles, etc., until the present method of centrifugal analysis was devised by the authors of the bulletin previously noted. Since that time the methods described therein have been made use of by the United States Department of Agriculture and the experiment stations in general, where absolutely accurate results are desired for all characters of soils.

The chief objection to the methods heretofore devised has been the length of time necessary to carry through an analysis, even of the simplest soil.

In the work of this station there have arisen many occasions when it would have been of great advantage to know approximately the composition of a soil, more particularly of those used in greenhouses and market gardening. With a large amount of other routine station work always on hand it was found impossible to devote the time necessary to make an analysis of the soil samples by the ordinary centrifugal, or as we shall hereafter call it, the "long" method, so it became necessary to devise a method which would materially shorten the process and still give accurate results within a reasonable limit of error.

After considerable experimentation a satisfactory method was devised and has been used with success in our work here the past year. It is not claimed that this method is absolutely accurate, nor is any for that matter, as the limit of error, even when using the most approved centrifugal methods where the greatest care is used, is admittedly large, dependent somewhat of course on the manipulator.

A great number of comparisons have been made of the results obtained by analysis of soils by the long method and the short method and are given in the following pages. The method used by us is more or less of an adaptation of the centrifugal method in general use.

In brief, the centrifugal method in general use is as follows: the soil is carefully sampled and a part of the sample which passes through a 2-millimeter sieve is used for analysis. Five grams are usually taken and dried at 110° C. This sample is then shaken with water, to which a few drops of ammonia have been added, for six hours or more. The sample is then placed in tubes and centrifuged until all but the clay particles have subsided; these, with the water, are then decanted off and evaporated to dryness and weighed. The silts are found by allowing everything larger in size than .05 millimeter to subside, decanting the liquid, evaporating, drying and weighing. The remaining sands are dried and weighed and then sifted by four sieves into five grades. The organic matter is determined usually by the chromic acid method, but should not be confounded with the "loss on ignition" which is often erroneously termed organic matter.

This process, as can plainly be seen, takes a long time to carry through, and is not applicable where quick results are desired.

The briefer method in use at this station is as follows: the sample of soil as brought to the laboratory is first thoroughly mixed and then dried at 110° C. It is then sifted through a 2-millimeter sieve and all that passes through is classed as soil. This is again mixed and 10 grams taken for analysis. This is heated to obtain the "loss on ignition," in a platinum or porcelain crucible, and the organic matter, water, etc., is driven off. The sample is then cooled and weighed and loss of weight recorded as "loss on ignition." It is then placed in a small mortar and rubbed gently with a medium hard rubber-tipped pestle to disintegrate the soil particles as far as possible. Then the sample is sifted carefully with constant brushing with a stiff camel's hair brush through 1-millimeter, .5-millimeter, .25-millimeter and .1-millimeter sieves, the last two being bolting cloth, as in the long method. The residue remaining consists of the very fine sand, the silts and clay. This remainder is weighed and the weight recorded, and one gram or fraction thereof is weighed out and used in the remainder of the process to determine the percentage of very fine sand, silts and clay.

This determination is made in the following piece of apparatus (see Fig. 1): A is a circular test tube having a diameter of approximately 2 centimeters and a length to the contraction of about 7 centimeters; B is a flat glass tube with thin walls,

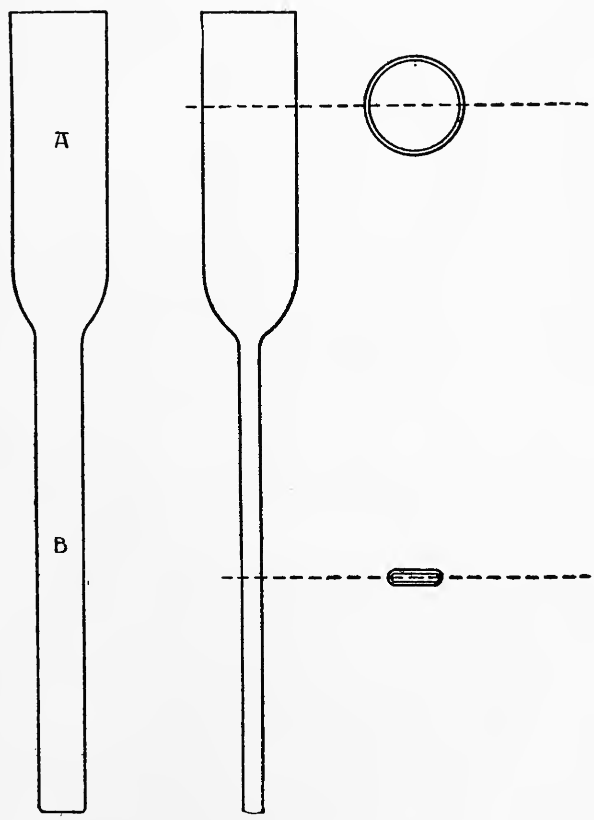


FIG. 1. — Showing special tube for mechanical analysis of soils: *A*, upper or circular part of the tube; *B*, lower or flat part of the tube. The figures to the right show cross sections, etc., of the tube.

one of which at least is perfectly flat, having an inside breadth of .8 centimeter and a width 1 to 1.5 millimeters. This tube is about 10 centimeters long. The lengths of A and B may be varied, however, but it has been found that tubes of these dimensions work well in the ordinary laboratory centrifuge. The method of procedure is as follows: the tube is filled to within about 4 centimeters of the top with distilled water and the gram of soil added. A rubber stopper is then placed in the tube and the soil thoroughly incorporated with the water by shaking for a few minutes. The tube is then placed in the centrifuge and run for a period of five minutes at a speed of about 1,200 revolutions per minute. The tube is then removed and clamped to an upright stand shown in Fig. 2, and a millimeter scale is attached so that with a horizontal microscope the size of the soil particles as shown by the eyepiece micrometer and the reading on the scale may be had at the same time or by swinging the microscope in a horizontal plane. 0 millimeter on the scale corresponds with the bottom of the soil column in the tube. The microscope is then focussed on the soil particles and raised until a majority of the particles are less than the minimum size of those of fine sand, *i.e.,* less than .05 millimeter; the scale reading is then taken and noted. The microscope is then raised until the particles are less than those of the minimum size for silts, viz., .0005 millimeter; the scale reading is again noted and the scale reading at the top of the soil column also noted. We have the readings as follows: —

	Millimeters.
Very fine sand,	3.0
Very fine sand and silts,	4.5
Very fine sand and silts and clay,	7.0

The column is divided, therefore, into volume per cents. as follows: —

	Per Cent.
Very fine sand,	42.85
Silts,	21.43
Clays,	35.72

If there were 2.34 grams of soil left after the last sifting we should have weights of very fine sand, silts and clays as follows,

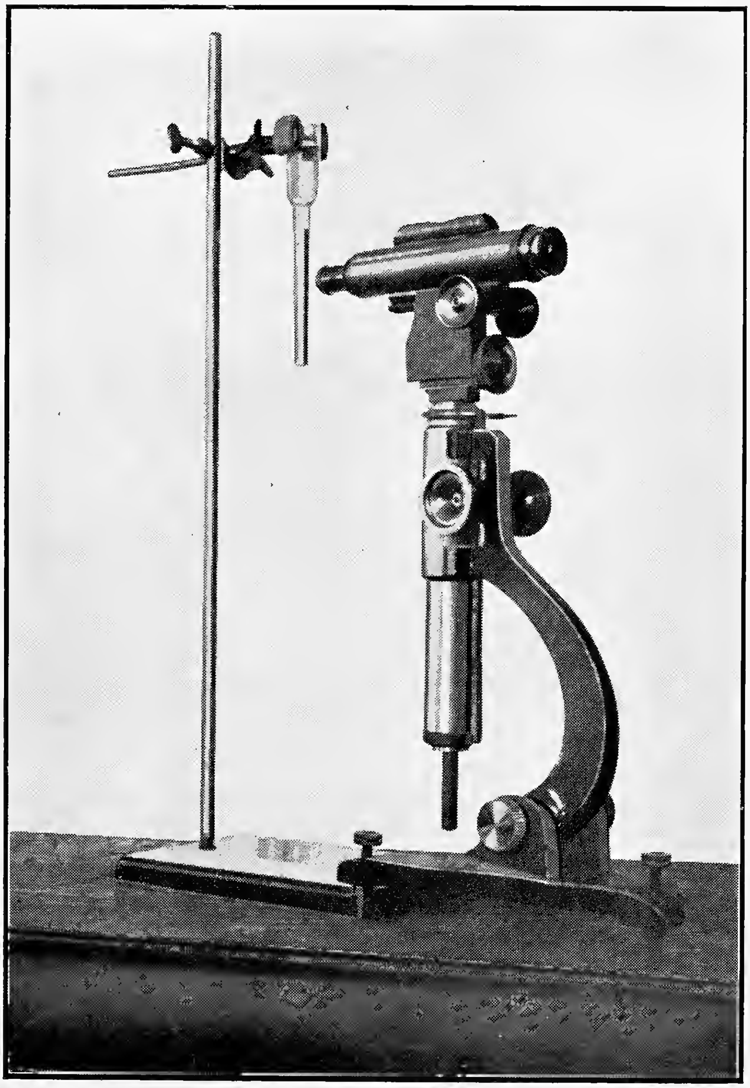


Fig. 2.—Photograph showing a horizontal microscope and methods of reading different percentages of soils in the tube.

using these volume percentages as weight percentages, which may be done, as experiment has shown that in the small tube the error is not great enough to be taken into consideration.

Very fine sand $= 2.34 \times 42.85$ per cent. $= 1.00 +$ grams.
Silts $= 2.34 \times 21.43$ per cent. $= .49 +$ grams.
Clay $= 2.34 \times 35.72$ per cent. $= .84 +$ grams.

Thus we have the weights of the very fine sand, silts and clay, and by following the same system used in calculating the percentages of the sands obtained by sifting in the whole sample we get the percentages of these constituents.

Below are given results of several typical soils which were analyzed by the long method and by the short method. It will be seen that the results vary but little and that for a close approximate analysis the results are accurate enough to warrant the use of this method where time is an important factor.

A criticism of this method may be raised, but its accuracy and ease of manipulation cannot be doubted, as it has been repeatedly proved to give as good results for general use as the long method, and in about half the time. Soils were analyzed by outside parties, and then the same soils were analyzed in the laboratory by the shorter method, and the results were well within the acknowledged limit of error, as can be seen from the following table: —

Table showing the Results obtained on Various Soils from Analyses by the "Long Method" and by the New Method.

[Per cent. of organic matter, gravel, sand, silt and clay in 20 grams of soil.]

Number.	Organic Matter.	Gravel (2–1 mm.).	Coarse Sand (1–.5 mm.).	Medium Sand (.5–.25 mm.).	Fine Sand (.25–.1 mm.).	Very Fine Sand (.1–.05 mm.).	Silt (.05–.01 mm.).	Fine Silt (.01–.005 mm.).	Clay (.005–.0001 mm.).	
55, . .	2.30	5.33	17.70	10.13	11.97	14.08	23.43	4.49	3.58	Long method.
	4.93	8.33	15.60	12.37	12.95	15.84	26.14		3.56	Short method.
49, . .	7.44	6.55	9.20	4.23	23.52	22.36	15.89	3.92	5.12	Long method.
	8.70	6.03	8.76	9.74	20.84	21.11	17.66		4.94	Short method.
54, . .	5.37	0.03	0.20	0.25	6.30	37.87	32.85	5.12	5.01	Long method.
	6.54	0.00	0.00	0.60	10.21	41.12	32.59		7.34	Short method.

There are admittedly several places where orthodox ideas have been differed from, but we have been unable to detect any bad effects as the result of these differences. The breaking up of the soil after beating in the mortar with a medium hard rubber pestle is one of these, and while error might creep in by careless or thoughtless manipulating, it is believed that with care any appreciable error can be easily obviated.

As there is a limit of error of from 2 to 5 per cent. by the long method in an analysis of the same soil, and as we came well within this limit in every case, we believe that we are justified in using this method for the breaking up of the soil particles.

In all probability it may not break up all the agglomerates, but so far in our experience the method has given perfectly satisfactory results, when reasonable care is used.

There may also be a slight loss of the finer particles in the sifting, but no more than is usual even by the long method.

In conclusion it may be said that where absolute accuracy is desired we do not recommend this short method, but for a close approximation it works very well.

THE PRESENT STATUS OF SOIL STERILIZATION.

G. E. STONE.

The term "soil sterilization" has long been applied by commercial growers to a system of heating soils, generally by the use of steam, to a temperature ranging from 180° to 212° F. for the purpose of destroying certain disease germs. In practice the heat is applied for only a short time, and as a matter of fact, only a comparatively small number of bacteria are destroyed. The process as usually employed by commercial men merely accomplishes what is termed "pasteurization."

The stimulating effects of sterilized soil on plant growth have long been recognized, and some large growers of lettuce and other crops have made extensive use of the practice largely for the effects produced on plant growth. Even as a young boy I remember observing the peculiar stimulating effects sterilized soil had on plant growth where charcoal pits had been burned. The soil and turf used in covering coal pits in the process of making charcoal are steamed and heated for many days, and become thoroughly sterilized. When the charcoal is taken out the soil is left spread out, and it often supports a vigorous and rank vegetation.

The extensive experiments which we made some years ago demonstrated that crops growing in sterilized soil are greatly stimulated; some crops, and lettuce in particular, showing the effects much more than others, however. This stimulation makes a different handling of lettuce necessary, and lower night temperatures must be maintained so that the characteristic heads will form properly and topburn be prevented.

Our experiments showed that while sterilization gives beneficial results with certain soils rich in organic matter, other soils deficient in this respect may cause injury to the crop when sterilized.

We have maintained that the benefits resulting from soil sterilization are largely chemical in nature, as shown by experiments with seeds, etc. In two series of experiments,[1] in which a large number and several varieties of seeds were employed, we found not only a marked acceleration in germination, but considerable increase in the number of seeds that germinated in sterilized soil when compared with the same soil unsterilized. The stimulating effects produced in these tests were undoubtedly chemical in nature; that is, there were certain substances in the soil which were chemically changed by the process of steaming, and these being absorbed by the seed, increased germination followed. It is, however, not at all improbable that part of the stimulating effects on seeds grown in sterilized soils is due to the renovation of the gases contained in the soil, since the old gases are driven out by the process of steaming. Steaming, in other words, has to a certain extent the same effect as aerating the soil, which process greatly stimulates seed germination and growth. In one experiment where 3,000 lettuce seed were grown in two boxes, 1,500 in each box and one being aerated and the other not, it was found that 86 per cent. germinated in the aerated soil, while only 64 per cent. germinated in the unaerated soil. The average weight of seedlings was 46 per cent. greater in the aerated than in the unaerated soil.[2]

Our experiments [3] in germinating seeds in decoctions of sterilized soil showed that the decoctions exerted a chemical stimulation, and that even decoctions from unsterilized loam had a similar effect on germination. The soil we used had never received any commercial fertilizer, but was a typical market-garden soil, frequently enriched with decomposed horse manure. It is well known that a great variety of chemicals stimulate seed germination, and it is not surprising that decoctions of soils would do the same.

The increase in the number of bacteria in sterilized soil has

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[1] Hatch Exp. Sta., 15th Ann. Rept., 1903, p. 41; also Hatch Exp. Sta., 18th Ann. Rept., 1906, p. 126.

[2] Hatch Exp. Sta., 18th Ann. Rept., 1906, p. 124.

[3] Hatch Exp. Sta., 18th Ann. Rept., 1906, p. 129.

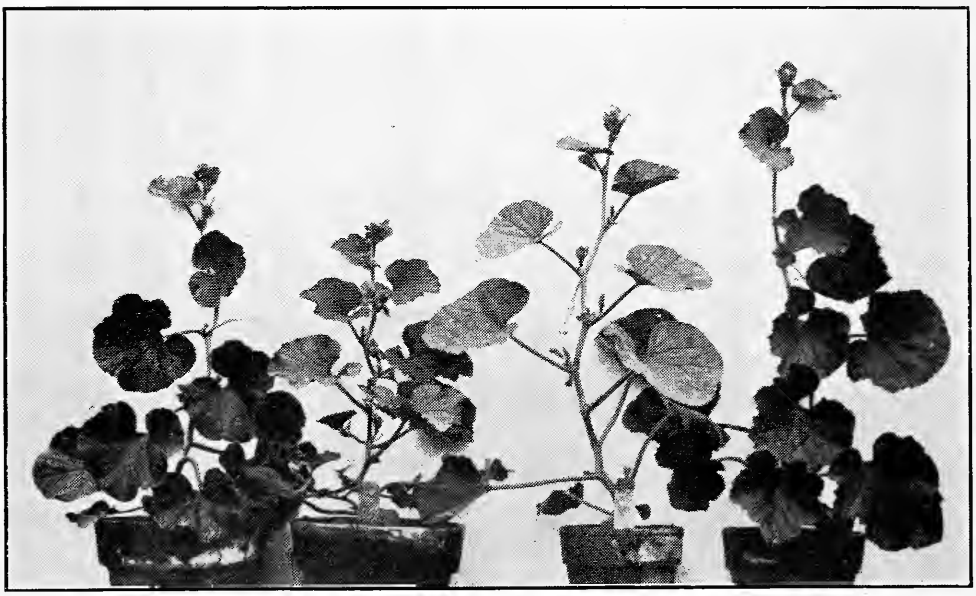

FIG. 1. — Showing the effects of soil sterilization on the growth of melons. Two plants at the left grown in unsterilized loam; those at the right in the same loam sterilized.

been demonstrated by Prof. A. Vincent Osmun [1] and others, and the interpretation of these results we believe can be found in chemical stimulation. However, it is not at all unlikely that even in this case the aeration of the soil resulting from steaming may play a small rôle in the increased number of bacteria, since it is known that cultivation gives rise to an increase in the number of bacteria in soils.

There are great differences in soils as regards the stimulating effects of sterilization, and judgment must be exercised in drawing deductions from this fact alone. Many commercial florists and market gardeners in various parts of the United States have had some experience in growing different crops in sterilized soil, and the results of their experience in this work are not always the same. The best results which we have observed as arising from sterilization have invariably been given by lettuce.

The soils used in growing lettuce are rich in organic matter from the repeated application of horse manure year after year, and it is such soils as these, rich in humus, that sterilization affects most advantageously for plant growth. Some experiments, however, which we have made, with decomposed leaves (leaf mold) and decayed vegetable matter obtained from florists, gave results somewhat different from those obtained from soils rich in organic matter largely derived from horse manure. When seeds were soaked in decoctions of either sterilized or unsterilized leaf mold they showed little or no stimulation, and when the decoction was strong we obtained positive injury to seed. Neither did we obtain any stimulus to crops in sterilized forest humus except when the humus was first washed out and then sterilized.

The idea recently advanced by Russell and Hutchinson, that the increased bacterial flora characteristic of sterilized soil is biological rather than chemical, does not in the least appeal to us, at least for our conditions. The theory is to a certain extent an adaptation or application of the Metchinikoff phagocyte theory to the soil. Russell and Hutchinson report finding protozoa devouring bacteria in the soils, and they account for the increase of bacteria in sterilized soils by the absence of protozoa

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[1] A Comparison of the Numbers of Bacteria in Sterilized and Unsterilized Soils, by A. Vincent Osmun, Hatch Exp. Sta. Rept., 1905.

and allied forms of animal life which prey upon micro-organisms.

It would be unjust for us to affirm what might take place in the soils of England or those on the continent, and it is to be assumed that the soil and climate, as well as the biological conditions, are different from those here; nevertheless, we are convinced that the biological theory does not hold in the soils we have experimented with for years, and as far as we are able to determine it possesses no significance. The matter, however, will be discussed in the following article prepared at our suggestion by Messrs. Smith and Lodge. These investigations were made under our direction in our laboratory during 1910 and 1911, when the men were taking senior work in the college, and prove to our satisfaction that protozoa, at least in our soil, have little or no part in accounting for the increased number of bacteria in our soils, although we cannot affirm that they do not play a more important rôle in England and elsewhere.[1]

The stimulating effects which sterilized soils have upon bacteria are chemical in nature, and so far as we can determine with our soils biological factors exert no influence in this respect. Most observers, we believe, agree that ammonia is given off from sterilizing soils, owing apparently to dentrification, and in this connection we might relate that in some cases where horse manure was applied freely and sterilization followed we noted that if certain plants, such as tomatoes, were transplanted in the soil too soon after the sterilizing had been done, their leaves would present symptoms of ammoniacal burning.

The sterilizing of soils has been carried on very extensively for some years in this country, particularly in greenhouses, and we have had opportunities to observe various crops growing in many acres of treated soil. In practically all cases moist heat, that is, steam, is employed for this purpose, although hot water has been used with practically the same results. There are, as might be expected, a variety of opinions as to the effects which stimulation has upon plants, since a large variety of soils have been treated, and the crops have been grown under very variable conditions. Moreover, as has already been stated, some crops

[1] Mr. David Larsen, who is associated with the Hawaiian Sugar Planters' Experiment Station in Honolulu, informs me that protozoa are quite abundant in Hawaiian soils, and that carbon bisulfid applied to the soils there acts as a great stimulus to crop production.

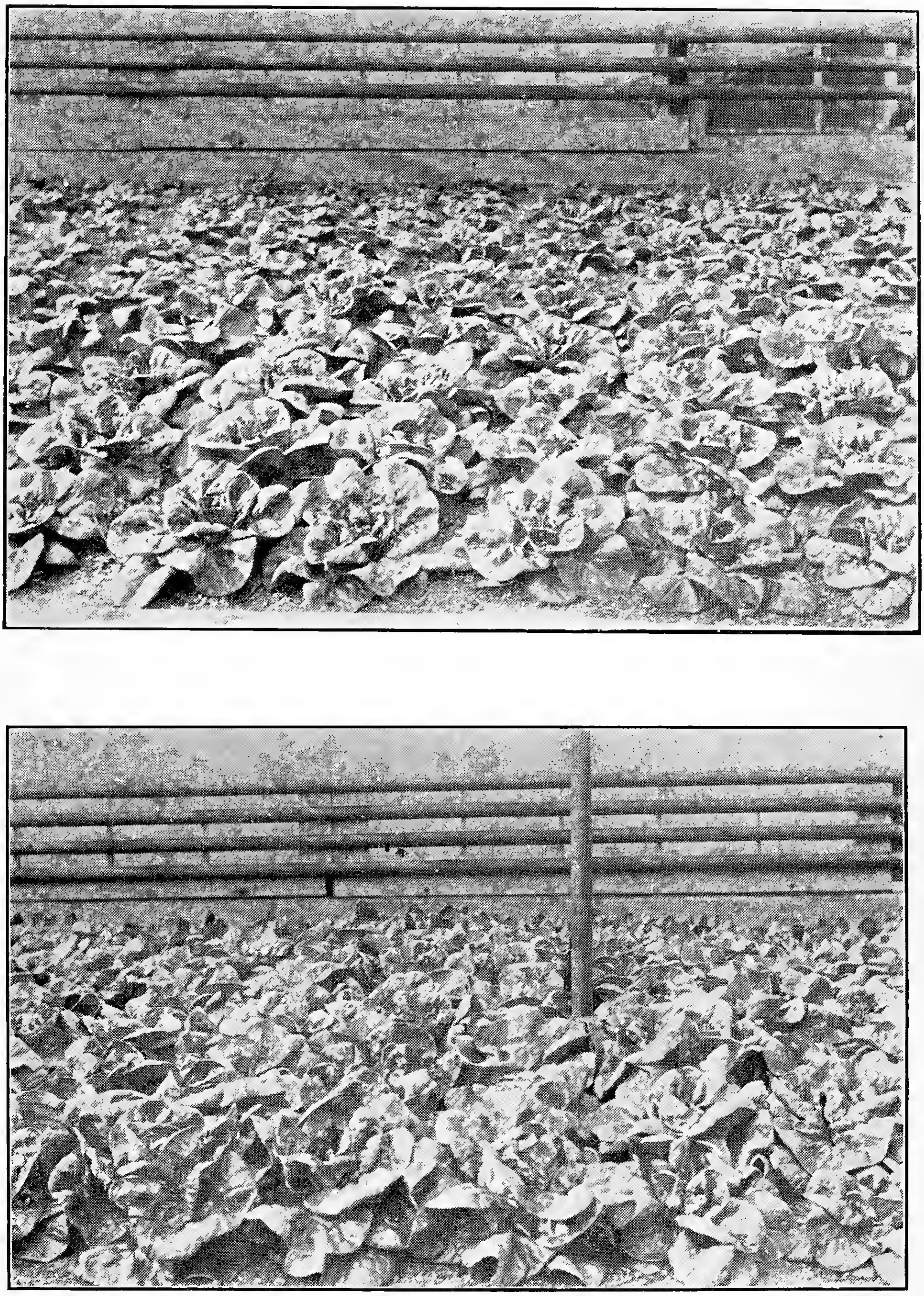

Fig. 2.—Showing the effects of sterilized loam on the growth of lettuce. In the upper figure are shown lettuce plants growing in unsterilized loam; in the lower, growing in the same loam sterilized. The difference in the average weight of these two crops, growing in the same house and the same soil, was 35 to 40 per cent.

are stimulated much more than others by this treatment. Most crops require special handling in sterilized soils, otherwise trouble is likely to follow.

Many different methods of sterilizing soils have been developed, and the writer has experimented with practically everything there is in this line. There is no doubt that many soils can be greatly improved by sterilization, and in the future it will be more extensively employed not only for the destruction of pathogenic organisms, but, like electricity and other stimuli, as a means of hastening crop production.

The writer at one time had experience with a soil which would not grow lettuce. When it was sterilized, however, no further difficulty was experienced with it. Even muck soils, which are rich in organic matter and generally injurious to plant growth, can be greatly improved by leaching and sterilizing.

In the south there are many acres of soil seriously affected with Sclerotinia which can be treated effectively at no great cost, and in the future soil sterilization is bound to become of practical use for field work. There is no reason why methods cannot be adapted for cheap and effective sterilizing of outdoor soils if the land be fairly level and free from stone.

INFLUENCE OF SOIL DECOCTIONS FROM STERILIZED AND UNSTERILIZED SOILS UPON BACTERIAL GROWTH.

C. A. LODGE AND R. G. SMITH.[1]

An attempt has been made in the following experiments to ascertain the cause underlying the effects which sterilized and unsterilized soil decoctions have upon bacterial development. These questions have often arisen: In what manner does soil sterilization affect bacterial development? Is the cause underlying the development of bacteria in soils of a chemical or biological nature? Some investigators maintain that the increase of bacteria in sterilized soils is due to a chemical stimulus, while others insist that it is biological; *i.e.*, that minute animal organisms known as protozoa affect the bacterial flora of soils. In all probability the chemical factor is the important one, the biological factor playing little or no part in either increasing or retarding bacterial growth, at least in any of our soils.

We selected for use in our experiments two types of soils, — one an Amherst greenhouse soil or loam, somewhat modified by the addition of coarse sand and quite rich in organic matter, and which will be designated as loam; and the other a yellow loam or a typical Amherst subsoil, deficient in nitrogen and containing only a slight amount of organic matter, which will be designated as subsoil.

TABLE I. — *Showing Mechanical Analysis of Two Types of Soils used in these Experiments.*

[Per cent. of organic matter, gravel, sand, silt and clay in 20 grams of soil.]

	Organic Matter.	Gravel (2-1 mm.).	Coarse Sand (1-.5 mm.).	Medium Sand (.5-.25 mm.).	Fine Sand (.25-.1 mm.).	Very Fine Sand (.1-.05 mm.).	Silt (.05-.01 mm.).	Fine Silt (.01-.005 mm.).	Clay (.005-.0001 mm.).
Loam, . . .	10.45	13.97	24.48	17.33	21.60	20.00	5.00	1.50	.12
Subsoil, . .	3.60	1.75	4.45	6.95	23.85	35.95	11.10	5.20	5.25

[1] This work was done at the instigation and under the direction of Dr. G. E. Stone when Messrs. Smith and Lodge were seniors in the college.

The soil decoctions used in our experiments were made as follows: four hundred grams of soil were placed in a percolation tube and lukewarm distilled water was allowed to percolate several times through the soil. This method was followed in each instance. The decoctions thus made (the percolated water) were then placed in flasks, each flask containing 100 cubic centimeters of percolate. Then these decoctions, composed of percolates from sterilized and unsterilized soils, were placed in the autoclave and subjected to steam pressure of 15 pounds for forty-five minutes at a temperature of 250° F.

Three series of experiments were carried on with each soil. In series No. 1 a sterilized and unsterilized loam were used, and the sterilized decoctions inoculated with ordinary soil bacteria. In the second series of experiments a sterilized and unsterilized loam, and in addition a sterilized and unsterilized subsoil, were used, and the sterilized decoctions inoculated with ordinary soil bacteria. In our third series of experiments a sterilized and unsterilized loam and subsoil were used, as in our second series of experiments, but with this difference, — inoculations were made from a pure culture of Bacillus subtilis. In the above series of experiments, where a sterilized loam or subsoil was used, sterilization was done as follows: about 1 liter of soil was placed in the autoclave and subjected to steam pressure of 15 pounds for forty-five minutes at a temperature of 250° F.

The following method of inoculation was used in our first two series of experiments, where ordinary soil bacteria were used. Ten grams of loam were placed in 100 cubic centimeters of sterilized water,[1] and this decoction placed in an incubator for three days, where a large number of bacteria developed. We used these decoctions to inoculate our sterilized percolates of sterilized and unsterilized soil in the two series of experiments, these percolates being inoculated with 1 cubic centimeter of the above culture and then incubated for twenty-four hours. The decoctions were removed from the incubator and plated, and the ordinary dilution methods followed. Cultures were made by adding ½ cubic centimeter of the dilution to agar-agar in Petri-dishes, and these were incubated for twenty-four hours, after which the colonies were counted. The agar-agar was .5 per cent.

[1] Distilled water was used in all cases in all the experiments.

normal acid in all the experiments. In the third series of experiments, where inoculation was made with Bacillus subtilis, the following method was used. A pure tube culture of Bacillus subtilis was made; from this pure culture a number of bacteria were transferred with a platinum loop to 100 cubic centimeters of sterilized water. From here on the method was followed as above indicated.

Experimental.

Table II. — *Showing Comparison of the Number of Bacteria in Decoctions of Sterilized and Unsterilized Loam. (Inoculations made with Ordinary Soil Bacteria.)*

Soil.	Number of Bacteria in 1 Cubic Centimeter of Decoction.			
	Experiment 1.	Experiment 2.	Experiment 3.	Average.
Sterilized loam, . . .	5,680,000	3,842,000	5,218,800	4,913,600
Unsterilized loam, . . .	276,000	402,000	391,240	343,746

The results shown in Table II. are of special interest for the following reason: in the three experiments recorded in this table the sterilized loam decoctions were found to contain a far greater number of bacteria per cubic centimeter of contents than the unsterilized loam decoction.

Table III. — *Showing Comparison between the Number of Bacteria in Decoctions of Sterilized and Unsterilized Loam and Subsoil. (Inoculations made with Ordinary Soil Bacteria.)*

Soil.	Number of Bacteria in 1 Cubic Centimeter of Decoction.		
	Experiment 1.	Experiment 2.	Average.
Sterilized loam, ...	5,724,000	4,693,060	5,208,530
Unsterilized loam, ...	203,520	199,308	201,414
Sterilized subsoil, ...	76,320	81,134	78,726
Unsterilized subsoil, ...	178,080	185,138	181,608

The results given in Table III. are important since they show that decoctions made from different soils affect the growth of bacteria in them in a decidedly different manner. When a sterilized loam is used we find a greater number of bacteria present as compared with the number in the unsterilized loam decoction; thus the experiments with loam soil in Table III. bear out the results recorded in Table II., where the same kind of loam soil was used in the decoctions. When a sterilized and unsterilized subsoil were used in the decoctions we found that a greater number of bacteria were present in the unsterilized decoction. This fact proves that the sterilizing of this particular soil resulted in adverse conditions for bacterial increase.

At this point it might be of interest to insert a table taken from a previous report of the Hatch Experiment Station,[1] showing the growth of soy bean in sterilized and unsterilized loam and subsoil. A glance at this will show that the greatest gain in plant growth was made in the loam soil, and the least in the subsoil. These results coincide with the relative growth of bacteria in the two soils, as shown in Table III.

TABLE IV. — *Showing Growth of Soy Bean in Sterilized and Unsterilized Loam and Subsoil (from Hatch Experiment Station Annual Report, 1906).*

	Total Number of Pots used.	Average Length (Centimeters) of Stems in —		Gain or Loss in Sterilized Soil (Per Cent.).
		Unsterilized Soil.	Sterilized Soil.	
Loam, ...	4	9.53	10.87	+14.05
Subsoil, ...	4	9.79	4.14	—57.70

Glancing over this table one can readily see that there is a connection between the development of bacteria and the growth of soy beans in sterilized and unsterilized soils. The soy beans showed an increase of growth in the sterilized loam over that given in the unsterilized loam. In the subsoil the unsterilized soil produced a greater growth than the sterilized. The same held true in regard to the development of bacteria. Decoctions of the sterilized loam produced about twenty times the number of bacteria as the unsterilized. In the sterilized subsoil there is a decrease in numbers as compared with the unsterilized, or in other words, the unsterilized subsoil produced twice as many bacteria as the sterilized.

[1] Comparison of Sterilized Loam and Subsoil, by G. E. Stone, 18th Ann. Rept. of the Hatch Exp. Sta., pp. 125, 126, 1906.

That sterilization of soils produces different effects on crops according to the nature of the soil cannot be disputed. In this experiment we used two distinct types of soil, and found that sterilization affects both soils differently. In loams well supplied with organic matter the effect is a stimulation from the beginning on certain crops. In other soils, notably deficient in organic matter (like the subsoil used in this experiment), the effect may be a detrimental one.

Lyon and Bizzell [1] have shown us that steaming reduces the nitrates of the soil to nitrites and to ammonia, but most of the ammonia comes from the organic nitrogen. Russell and Hutchinson [2] claim that the increased productiveness of sterilized soils is due to an increase in the amount of ammonia present, and that the excess of ammonia is the result of the increased decomposition of soil substances by bacteria.

TABLE V. — *Showing Comparison of the Amounts of Ammonia in Decoctions of Sterilized and Unsterilized Loam. (Inoculations made with Ordinary Soil Bacteria.)*

Soil.	Amount of Ammonia in Decoction of 100 Cubic Centimeters (Grams).			
	Experiment 1.	Experiment 2.	Experiment 3.	Average.
Sterilized loam, . . .	.0051	.0052	.0051	.0051
Unsterilized loam, . .	.0032	.0031	.0030	.0030

Analysis of the soil decoctions from soils similar to those used in the experiments given in Table IV. show an increase of ammonia in the sterilized loam as compared with the unsterilized. In the subsoil we find just the reverse condition, the unsterilized subsoil containing more ammonia than the sterilized.

Analyses of the soil decoctions used in the experiments shown in Tables II. and III. give the same results as regards the ammonia content of the decoction as those enumerated above, but in our experiments (Tables II. and III.) we have sterilized decoctions of the various soils inoculated with soil bacteria. The increase and decrease in the number of bacteria found in these

[1] Effects of Steam Sterilization on the Soluble Matter in Soils, Lyttleton Lyon and J. A. Bizzell, Cornell Agr. Exp. Sta., Bul. No. 275, April, 1910.

[2] Effects of Partial Sterilization of Soil upon the Production of Plant Food, by E. J. Russell and H. B. Hutchinson, Journal of Agricultural Science, Vol. III., Part II., October, 1909.

decoctions correspond with the increase and decrease of ammonia content in each case, more ammonia being found in the decoctions which possessed the largest number of bacteria. This fact is not new, as it has been shown by Russell and Hutchinson in recent years.

TABLE VI. — *Showing Comparison between the Amounts of Ammonia in Decoctions of Sterilized and Unsterilized Loam and Subsoil.* (*Inoculations made with Ordinary Soil Bacteria.*)

SOIL.	AMOUNT OF AMMONIA IN DECOCTION OF 100 CUBIC CENTIMETERS (GRAMS).		
	Experiment 1.	Experiment 2.	Average.
Sterilized loam,	.0050	.0050	.0050
Unsterilized loam,	.0031	.0032	.0031
Sterilized subsoil,	.0020	.0021	.0020
Unsterilized subsoil,	.0030	.0032	.0031

TABLE VII. — *Showing Comparison between the Amount of Ammonia in Decoctions of Sterilized and Unsterilized Loam and Subsoils.* (*Inoculations made with Water Cultures of B. subtilis.*)

Experiment 1.

SOIL.	Amount of Ammonia in Decoctions of 100 Cubic Centimeters (Grams).	SOIL.	Amount of Ammonia in Decoctions of 100 Cubic Centimeters (Grams).
Sterilized loam,	.0031	Sterilized subsoil,	.0010
Unsterilized loam,	.0020	Unsterilized subsoil,	.0020

This increase in the amount of ammonia in each case is certainly brought about by the action of the bacteria upon the organic matter in the soil. Now the question arises: What change takes place within the soil, when sterilized, in order to produce this increase in the number of bacteria? In the case of the subsoil, where the increase takes place in the unsterilized soil, it is a question as to what change takes place upon sterilizing that has a detrimental effect on bacteria.

Russell and Hutchinson [1] tried the effect of untreated soil

[1] The Effects of Partial Sterilization of Soil on the Production of Plant Food, by E. J. Russell and H. B. Hutchinson, Journal of Agricultural Science, Vol. III., Part II., October, 1909, p. 117.

upon sterilized soil and found a decrease in the number of bacteria and in the amount of ammonia present. This would show that there is some limiting factor in the original soil that limits bacterial action. They claim that this limiting factor is not chemical but biological.

In the experiments which we have described and in those which follow we are unable to comprehend how protozoan forms play any rôle whatsoever in the decrease of bacteria. If this is true this limiting factor must be a chemical or physical property of the soil, and one on which sterilization has a marked effect.

Protozoa as a Factor in the Bacterial Flora of Soils.

The remaining contents of the soil culture used in inoculating decoctions in the experiments of Tables II. and III. were subjected to a careful microscopic examination for various forms of protozoa. Our labors were without results, however, no protozoa being found; but it is quite possible that a few might have been introduced at the time of inoculation of the decoctions. To avoid any possibility of introducing protozoa into decoctions the experiments shown in Table VIII. were made.

Table VIII. — *Showing Comparison of Number of Bacteria in Decoctions of Sterilized and Unsterilized Loam and Subsoils.* (*Inoculations made with Water Culture of B. subtilis.*)

Soil.	Number of Bacteria in 1 Cubic Centimeter of Decoction.		
	Experiment 1.	Experiment 2.	Average.
Sterilized loam,	5,952,960	4,913,800	5,423,300
Unsterilized loam,	127,484	111,964	117,324
Sterilized subsoil,	279,840	283,380	281,610
Unsterilized subsoil,	2,060,640	2,901,244	2,480,942

The data given in the above table show that Bacillus subtilis multiply in great numbers in all the decoctions. About the same relative number of bacteria were found here as in the decoctions shown in the experiments given in Tables II. and III. A greater number of Bacillus subtilis were found in the sterilized loam decoctions as compared with the unsterilized; also a greater number of Bacillus subtilis were found in the unsterilized subsoil decoctions as compared with the sterilized decoctions.

A careful consideration of our work leads us to believe that protozoa were absent in all our decoctions, and the experiments shown in Table VIII. seem to substantiate this belief; moreover, protozoa were uncommon in the soils used. A number of samples of the loam and subsoil were subjected to examination, but very few protozoan forms [1] were found. In this vicinity great numbers of protozoa are found in pools of standing water, while few are observed in garden soils. In other localities protozoa may be more abundant in soil; however, no data are available. For protozoa to reduce the bacterial flora of the soil to an appreciable degree by devouring the bacteria, it is certain that the number of protozoa present in the soils of Amherst would have to be increased manyfold; besides, all protozoa do not consume bacteria. G. N. Calkins, professor of protozoölogy at Columbia University of New York, is the authority for the following: "All classes of protozoa except Sporozoa are bacteria eaters except the carnivorous forms." The same authority in a recent work [2] says: "Two of the most striking phenomena among the protozoa are the apparent choice of food and the selection of certain materials for building shell." The author notes that certain protozoa will live almost exclusively on other protozoa and such vegetable forms as Oscillaria, Spirogyra and diatoms. "Each protozoan will eat only its favorite food, although other food is abundant." If the above is true it means that hundreds of protozoan forms of the soil do not feed on bacteria, therefore it is impossible to credit the difference in the numbers of bacteria in a gram of soil [3] — 7,000,000, and a gram of treated soil (sterilized) 37,000,000 — to the elimination of the protozoa. This remarkable increase in the number of bacteria of over fivefold of the original number in the untreated soil can only be explained by an increased food supply. In our experiments with soil decoctions, where the protozoa were entirely eliminated, we obtained a difference in numbers of bacteria present in the decoctions of sterilized and unsterilized soils ranging from fifteen to twenty

[1] The following species were observed: Halteria, Enchelys, Paramœcum, Amœba, Euglena, Euplotes, Dileptus, Strombidium and Oxytridia.

[2] The Protozoa, Columbia Biol. Ser., VI., p. 305.

[3] Hall, Harper's Magazine, October, 1910, p. 681.

times as many in the sterilized as compared with the unsterilized decoctions. However, in the experiments where sterilized and unsterilized subsoil were used we found more bacteria in the unsterilized decoctions as compared with the sterilized decoctions. This fact proves that sterilization does not in every case result in an increased number of bacteria in the soil thus treated.

Conclusions.

1. The development of bacteria may be retarded or accelerated in soil decoctions by the use of sterilization.

2. In decoctions of soil rich in organic matter the development of bacteria is greatly increased, while in soils deficient in organic matter the development of these organisms is retarded by sterilization.

3. The stimulating or retarding effects on the development of bacteria of the two types of sterilized soil used by us are similar to those produced upon the growth of crops in these soils. (*Cf.* Table IV.)

4. From numerous microscopic examinations made of Amherst soils we do not find that protozoa are abundant; neither were they observable in our soil decoctions.

5. The question of protozoa as a biological factor was eliminated in the experiments. The stimulating or retarding effect on the development of bacteria was due to other causes.

6. Our experiments therefore, made with Amherst soils, do not confirm those of Russell and Hutchinson, who maintain that protozoa influence the number of bacteria in soils, since the development of bacteria differs in soil decoctions according to the composition of the soil used; that is, the number of bacteria which develop in a soil depends upon the chemical and physical condition of the soil rather than upon the number of protozoa.

7. These experiments do not necessarily preclude the idea that protozoa might play a much more important rôle in soils other than those with which we experimented.

THE EFFECTS OF POSITIVE AND NEGATIVE ELECTRICAL CHARGES ON SEEDS AND SEEDLINGS.

G. E. STONE.

Considerable interest is now being manifested in the effects of electricity on plant growth, and experiments are being made in this country and abroad to study this influence. Most of the experimenters at the present day are making use of high tension wires, the aim being to charge the atmosphere rather than the soil.

For many years we have been carrying on experiments along this line, and many of the results have been published from time to time.[1] However, we still have considerable data on the various phases of the subject of electrical stimulation which have not been published, as in many cases the experiments have not been completed.

The experiments given here were made under my direction in 1904 by Mr. N. F. Monahan, a former assistant in the laboratory, who while with us paid quite a little attention to the subject of electrical stimulation and plant reaction. They were made to determine the relative stimulating effect of positive and negative charges on seed germination and growth of seedlings. The seeds of lettuce and radish which we used were first moistened by soaking in water for a few hours and were then charged from a small friction machine, Töpler-Holtz model. They were then placed in electro-germinators, which consisted of a modified Leyden jar and Zurich germinator, and 10 small sparks from a Töpler-Holtz machine were applied to each germinator, which

[1] Electro-Germination, Hatch Exp. Sta., Bul. No. 43, 1897; The Influence of Current Electricity upon Plant Growth, Hatch Exp. Sta., 16th Ann. Rept., 1904; The Influence of Atmospheric Potential on Plants, Hatch Exp. Sta., 16th Ann. Rept., 1904; The Influence of Electrical Potential on the Growth of Plants, Hatch Exp. Sta., 17th Ann. Rept., 1905; Comparisons of Electrical Potential in Trees and in the Free Air, Hatch Exp. Sta., 17th Ann. Rept., 1905; Injuries to Shade Trees from Electricity, Hatch Exp. Sta., Bul. No. 91, 1903; Influence of Electricity on Micro-organisms, Bot. Gazette, 48; No. 5, November, 1909; Effects of Electricity on Plants, Bailey's Cyclopedia of American Agriculture, Vol. II., p. 30.

resulted in stimulation of the seed. The germinator was then placed in an autoclave and kept at a temperature of about 25° C. The results of the experiments follow: —

TABLE I. — *Showing the Results of the Stimulating Effect of Positive and Negative Electrical Charges on Radish Seeds and Seedlings (Raphanus sativus, L.).*

[Average of two experiments in each of which 60 seeds were used. Moist treated seed charged with 10 small sparks from a Töpler-Holtz machine. Measurements in millimeters, temperature 25° C.]

Treatment.	Average Length of —		Per Cent. gained in Length of —	
	Hypocotyl (Centimeters).	Radicle (Centimeters).	Hypocotyl.	Radicle.
Normal,	1.13	1.07	-	-
Negative charge,	1.39	1.24	23.00	15.88
Positive charge,	1.72	1.76	52.21	64.48

It is quite evident that the electrical treatment stimulated the seed very materially, as shown by the growth of the hypocotyls and radicles given in this table. The average increased length of the radicles and hypocotyls of the negatively charged seeds over that of the normal was 23 per cent. for the hypocotyl and 15.88 per cent. for the radicle. The positively charged seeds gave an average increase of 52.21 per cent. for the hypocotyl and 64.48 per cent. for the radicle over that of the normal; showing that the positive charges induced the greater growth. No attention was given to accelerated germination in this experiment.

TABLE II. — *Showing the Results of the Stimulating Effect of Positive and Negative Electrical Charges on Lettuce Seeds and Seedlings (Lactuca sativa, L.).*

[Average of two experiments in each of which 60 seeds were used. Moist treated seed charged with 10 small sparks from a Töpler-Holtz machine. Measurements in millimeters, temperature 25° C.]

Treatment.	Average Length of —		Per Cent. gained in Length of —	
	Hypocotyl (Centimeters).	Radicle (Centimeters).	Hypocotyl.	Radicle.
Normal,	0.96	1.52	-	-
Negative charge,	1.08	1.77	12.50	16.40
Positive charge,	1.21	2.18	26.00	43.42

In the experiments shown in Table II. the accelerated growth of the hypocotyl and radicle is somewhat similar to that shown in Table I., namely, the negative charges gave for the hypocotyl 12.5 per cent. increase, for the radicle 16.4 per cent., while the positively charged seeds gave 26 per cent. for the hypocotyl and 43.42 per cent. for the radicle. Here, too, the positively charged seeds gave the largest average increased growth for both hypocotyl and radicle.

The experiments shown in Tables I. and II. are typical of others made along the same line, although we have repeatedly found that it is quite an easy matter to charge the seed too strongly and obtain retardation in growth. Instead of using ten-minute sparks to stimulate the seeds in the electro-germinator we have found by subsequent experiments that it is better to use only two or three, and these should be very slight charges. The stimulating effect of positive and negative charges on germination is similar to that on growth, but there is no evidence to show that the treatment affects the germinating capacity of seeds, and we have stimulated many thousands. The following table gives an average of four experiments with seed germination.

TABLE III. — *Showing Results of the Stimulating Effects of Positive and Negative Electrical Charges on Germination of Lettuce Seed (Lactuca sativa, L.).*

[Average of four experiments, 20 seeds being used in each treatment; otherwise the same experiments as shown in Tables I. and II.]

Treatment.	Total Number of Seeds.	Number of Seeds germinated in —		
		24 Hours.	48 Hours.	72 Hours.
Normal,	80	19	35	64
Negative charge,	80	24	51	64
Positive charge,	80	48	69	72

From the experiments in Table III. it will be observed that germination is accelerated to a considerable degree by electrical stimulation, and that the positive caused greater acceleration than the negative charges, corresponding to the effects produced on the growth of the hypocotyl and radicle. In Fig. 1 is shown a diagrammatic representation of seedlings based upon an average of all the data given in Tables I. and II. It will be noticed that the radicles are stimulated more in all cases than the hypocotyls, this difference being more pronounced in the positively than in the negatively charged seedlings. In Fig. 2 are shown

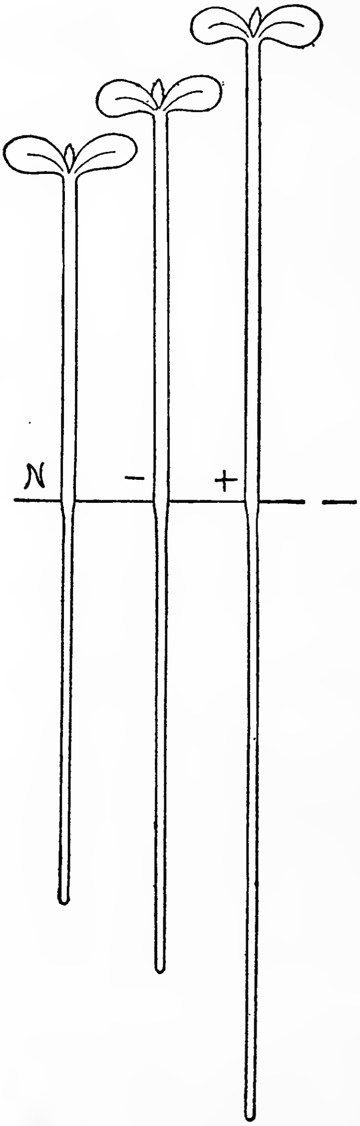

FIG. 1.—Showing the effects of positive and negative electrical charges on the growth of lettuce and radish seedlings. Average of the results in Tables I. and II.

the effects of positive and negative charges on the growth of radish seedlings, being an average of two experiments. Fig. 3 shows the effects of positive and negative electrical charges on the growth of lettuce seedlings, being an average of three experiments.

It is not surprising that the radicles show greater development than the hypocotyls since the former develop first, and for this reason electrical stimulation would show itself more prominently in the radicle than the hypocotyl. Accelerated germination is

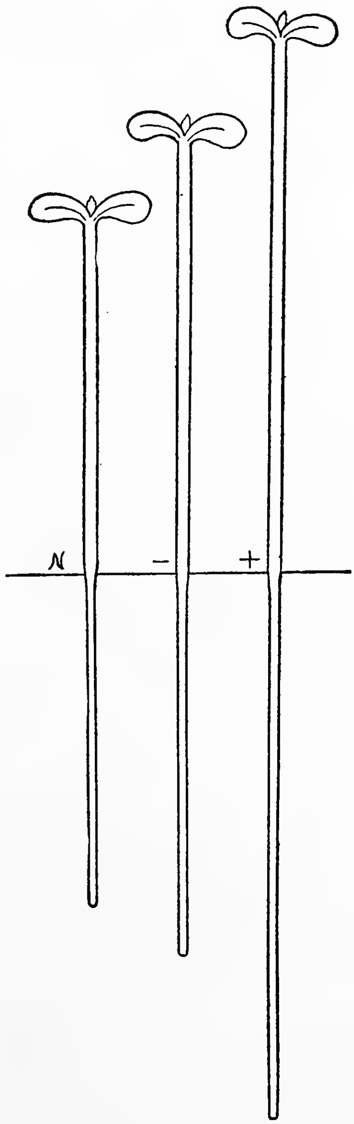

Fig. 2. — Showing the effects of positive and negative electrical charges on the growth of radish seedlings. Average of two experiments.

shown more prominently in the positively than the negatively charged seeds. The positive charges stimulated both the hypocotyl and radicle more than the negative charges, and if the difference in the time of the development of the hypocotyl and radicle is taken into consideration it will be seen that there is little or no difference in the effects of the stimulation on the radicle and hypocotyl.

The effects of a series of charges from a static machine last only two or three days, the maximum effect of the stimulus showing itself shortly after stimulating.

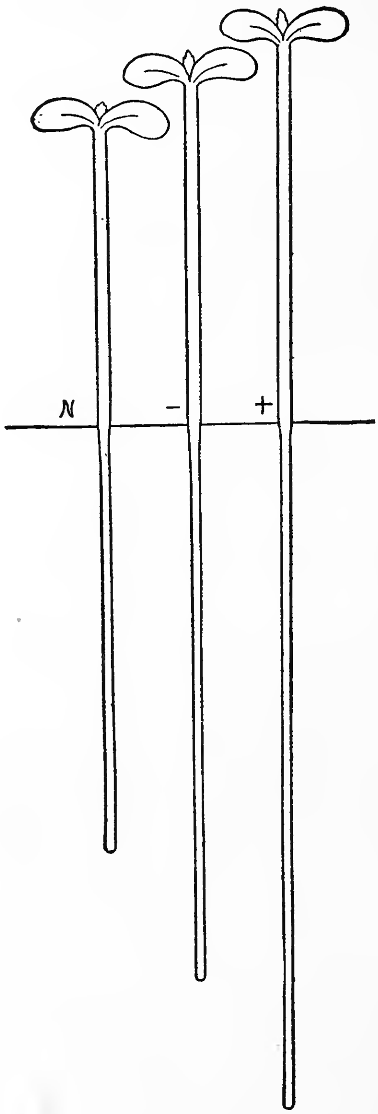

FIG. 3. — Showing the effects of positive and negative electrical charges on the growth of lettuce seedlings. Average of three experiments.

The roots and stems of plants react positively and negatively to various stimuli such as are afforded by gravity, light, moisture, chemical substances, etc. It is also well known that the same stimuli will induce reactions of an exactly opposite character in the same organism, or even in the same organ. Usually, however, the stem reacts one way and the root another; for example, roots are positively and stems negatively geotropic. It is well known that the anode and cathode behave quite differently and characteristically when acting on metals, etc. Similar characteristic differences might be expected in the reaction of plants. Where trees have been injured by burning from direct current wires the extent of the injury is about 90 per cent. greater near the positive than near the negative point of contact, showing that the positive electrode is more disastrous to plant tissue.

In our various experiments, where we have employed electricity as a stimulus, we have never observed any difference in the behavior of plants in close proximity to either positive or negative electrodes, although in some of our previous experiments with radish plants, made some years ago, in which the plants were grown in soil, we found that the tops responded much more freely to electrical stimulation than the roots when acted on by galvanic currents. We found, however, that by substituting lettuce, which is cultivated exclusively for the leaves, the leafy part responded more freely to electrical stimulation than did the underground part or fleshy roots of radish.

On the other hand we found in our experiments in growing radishes in tightly closed, insulated glass cases, the atmosphere of which was charged each day positively to an electrical potential averaging 150 volts, that the reverse was true, viz., the roots or underground parts were stimulated more than the leaves or tops. The soil itself is generally negative, and the atmosphere positive; the roots therefore are accustomed to a negatively charged, and the aerial parts to a positively charged, environment.

In the decomposition of water by electrolysis it is assumed that the oxygen is in a negatively electrical condition and is attracted by the positive pole, while the hydrogen is in a positively electrical condition and is attracted by the negative pole. Metals are described as electro-positive elements, and are usually attracted to the negative pole, while the nonmetals are spoken of as electro-negative elements and are attracted to the positive pole. In the experiments just cited with radishes, which were grown in insulated glass cases where the atmosphere was charged positively, the leaves were stimulated least and the roots most; that is, the roots, which are normal to an environment negatively charged, were stimulated most by the positive charges. In the case of galvanic stimulation of roots it is known that weak currents induce negative bendings; that is, towards the cathode, while strong currents induce positive bendings, or towards the anode. In the negative reactions, which are induced by weak currents, there is a greater growth on the side of the root towards the positive pole or anode than towards the negative pole or cathode, but there is some doubt as to whether the reverse holds true for positive galvanotropic bendings. In the case of positive galvanotropic bendings Brunchorst has pointed out that the reaction is the result of pathological conditions, and it is maintained that bendings towards the anode are due to injury of the delicate root tip by the strong currents employed. This interpretation of the phenomena appears to harmonize with the results which we have obtained with positive and negative electrical charges on plants. The positive charges give the greatest and the negative the least accelerated growth. Since the positive charges stimulate mostly those cells on the surface of the root nearest to the anode, those cells would grow more rapidly and the normal downward direction of the root would be directed towards the negative pole or cathode. The burning effect on trees from positive and negative electrodes is similar, the positive producing the greater injury, and this coincides with our results obtained by using strong positive static charges on plants, viz., strong positive static charges cause a greater degree of retardation and injury than negative charges. The use of strong positive currents would result in the cells on the anode side of the root being retarded, hence bendings towards the anode would result.

To summarize we might state that the effect of positive and negative stimulation on plants offers a mechanical explanation of the positive and negative galvanotropism in roots. When plants are grown between positive and negative electrodes, each electrode exerts a characteristic influence on the root, and that surface of the root nearest to the anode will be affected according to the nature of the stimulus on that side; and conversely, that part of the root adjacent to the cathode will be affected according to the nature of the stimulus characteristic of that pole. When weak currents are employed the positive current or anode gives the greatest stimulation to those cells on the anode side of the root, and induces bendings in the root towards the negative pole or cathode. On the other hand, when strong currents are employed the positive current induces bendings towards the anode due to a retardation or injury to the cells on the side of the root towards the anode.

From our various experiments in electrical stimulation we are of the opinion that increasing the electrical tension or potential of the atmosphere, either by the use of static charges or from high tension wires, gives rise to a greater degree of stimulation than passing the current through the soil. Alternating currents appear to be superior to direct currents in stimulating plants. There is, however, the question of increasing the number of micro-organisms in the soil by electrical stimulation as well as the importance of nitrification and nitrogen fixation resulting from electrical stimulation, a line of research on which we are now engaged and on which we hope to report later.

ELECTRICAL RESISTANCE OF TREES.

G. E. STONE AND G. H. CHAPMAN.

It has long been known that trees offer considerable resistance to electric currents, but at the time our experiments were undertaken we were not aware that much attention had been given to this subject, especially regarding the influence of certain factors on resistance. The effect of lightning strokes indicates that trees possess relatively high resistances, and that there is a difference in the resistance of their various tissues. Little or no data appear to be available concerning this subject, nor so far as we know concerning the resistance of different trees at different seasons of the year.

In a former publication [1] we have given the results of some observations on the electrical resistance of trees, and the numerous data which we obtained by passing electrical currents through trees and various plants helped to give us some idea of their electrical resistance. Our object in carrying on these experiments was to determine whether there were any variations in the electrical resistance of different sides of a tree trunk as regards points of the compass. Originally it was our purpose to learn whether the electrical resistance varied greatly from month to month during the year, and if so, what causes led to this variation; in fact, to study the effects of various influences on electrical resistance. But the temporary suspension of our work, made necessary by moving from one laboratory to another, and the change of assistants interrupted our plans somewhat, and the original idea of our investigation was not followed.

It might be supposed that since the several sides of a tree are exposed differently to light and heat they would show slight

[1] Injuries to Shade Trees from Electricity, by G. E. Stone, Mass. Agr. Exp. Sta., Bul. No. 91. 1903.

variations in temperature, and that there would also be differences in the flow of sap and the translocation of plastic substances. That this is true is shown by the fact that trees make more growth on one side than on another, the more or less localized photosynthesis causing a greater transmission of plastic substances on that side.

Some of these experiments were begun in 1907, a part of the observations being made by Mr. N. F. Monahan, our former assistant, while others were obtained in 1909 and later by Mr. G. H. Chapman.

These resistances were determined by a Weston Electric Company combination bridge, rheostat and galvanometer, provided with a battery of 6 or 8 large Samson cells.

TABLE I. — *Showing Daily Records of Electrical Resistance (in Ohms) of Maple (Acer saccharum, Marsh), April 7–26, 1907. Resistances taken on the North, South, East and West Sides of the Tree at Midday.*

[Electrodes 10 feet apart. Mean daily temperatures given in degrees F.]

DATE.	Temperature.	East.	South.	West.	North.
April 7,	35	19,000	18,840	22,000	22,000
8,	33	19,500	19,000	23,400	23,000
9,	31	23,000	23,000	23,000	24,000
10,	35	23,000	23,000	23,000	23,500
11,	39	22,000	21,500	23,000	23,500
12,	38	21,000	21,000	22,500	23,000
13,	37	21,500	21,000	22,900	23,000
14,	42	20,000	19,400	22,000	22,000
15,	39	19,100	18,900	21,200	20,800
16,	40	19,500	19,000	20,000	21,500
17,	40	20,500	20,500	21,500	21,000
18,	39	21,500	23,000	21,000	17,000
19,	34	21,000	20,000	19,000	21,000
20,	37	18,000	18,300	21,300	20,800
21,	36	19,500	19,500	22,000	21,000
23,	52	15,000	14,600	16,300	16,000
24,	49	16,000	17,300	17,000	16,500
25,	52	16,900	17,200	17,400	19,100
26,	56	15,700	15,000	16,000	18,200
Average,	–	19,857	19,055	19,310	20,890

TABLE II. — *Showing Daily Records of Electrical Resistance (in Ohms) of Elm (Ulmus Americana, L.), April 7–26, 1907. Resistances taken on the North, South, East and West Sides of the Tree at Midday.*

[Electrodes 10 feet apart. Mean daily temperatures given in degrees F.]

DATE.	Temperature.	East.	South.	West.	North.
April 6,	35	29,000	29,000	29,500	29,000
7,	35	28,200	28,000	29,000	29,400
8,	33	29,000	28,500	29,500	29,500
14,	42	.25,000	25,000	26,500	23,000
15,	39	25,500	26,500	26,000	26,000
16,	40	26,000	23,500	26,500	27,000
17,	40	26,000	29,000	25,000	23,000
18,	39	25,000	30,000	27,000	25,000
19,	34	25,600	32,000	24,900	24,200
20,	37	25,000	29,000	27,800	24,000
21,	36	25,000	29,900	28,000	25,000
23,	52	23,200	26,200	22,500	21,000[1]
24,	49	19,600	26,000	22,100	18,000
25,	52	22,000	26,000	23,000	20,000
26,	56	19,000	21,400	19,300	19,700
Average,	–	24,666	27,466	25,777	25,253

The data shown in Tables I. and II. give the electrical resistance of a maple and elm tree covering a period of nearly one month in the spring, when there was an occasional flow of sap. The elm was a large tree, over 2 feet in diameter, and the maple was nearly as large. In both cases the electrodes, which were about 3 inches long and made of galvanized iron nails, were driven through the bark and into the wood. These were connected by solder with insulated copper wires leading to a combination bridge, from which the readings were made. The batteries consisted of half a dozen cells employed to take the readings. In these experiments the electrodes were 10 feet apart on the north, south, east and west sides of the trees. The lowest electrodes were placed about 2 feet above the ground, and the highest about 12 feet.

[1] Warm.

By comparing the results given in these tables it will be seen that the resistances obtained from the north, south, east and west sides of the tree showed some variation from day to day, and also on different sides of the tree. In the maple a slightly higher average resistance was shown on the north side of the tree than on any other side, followed by the east, west and south sides.

In the case of the elm (Table II.), however, the highest average resistance was shown on the south side for the same period, this being followed by the west side, while the east side showed the least resistance. The resistance in both cases showed a tendency to decrease towards the latter part of April, when the temperature increased, as is shown by a comparison of the mean daily minimum and maximum temperature records which were taken from the station's meteorological observatory located nearby, and which are given in both tables. The highest average resistance for the maple was given on the 9th of April, when there was the lowest mean temperature. The highest average resistance given by the elm occurred on April 6 and April 8 (the records were not taken on the 9th), while the lowest average resistance for the maple occurred April 23, during one of the highest mean temperature days. The lowest average resistance for the elm occurred April 26, which date gave the highest mean temperature.

TABLE III. — *Showing Electrical Resistance (in Ohms) of Maple (Acer saccharum, Marsh), covering a Period of Nearly Three Months. Resistances taken on the North, South, East and West Sides of the Tree about Midday.*

[Electrodes 10 feet apart. Mean daily temperatures given in degrees F.]

DATE.	Temperature.	East.	South.	West.	North.
April 7,	35	19,000	18,840	22,000	22,000
14,	42	20,000	19,400	22,000	22,000
21,	36	19,500	19,500	22,000	21,000
26,	56	15,700	15,000	16,000	18,200
Average for month,	-	18,550	18,185	20,500	20,800

TABLE III. — *Concluded.*

DATE.	Temperature.	East.	South.	West.	North.
May 8,	58	18,500	21,000	19,000	23,000
14,	68	14,000	14,600	15,000	16,000
21,	46	24,000	23,600	23,000	33,000
28,	45	27,800	23,000	29,600	26,000
Average for month,	–	21,075	20,550	21,650	24,500
June 4,	55	18,600	19,100	23,600	21,700
12,	59	21,000	22,000	23,900	23,000
Average for month,	–	19,800	20,550	23,750	22,350
Average for three months,	–	19,775	19,761	21,883	22,550

TABLE IV. — *Showing Electrical Resistance (in Ohms) of Elm (Ulmus Americana, L.), made Weekly and covering a Period of Nearly Three Months. Resistances taken on the North, South, East and West Sides of the Tree.*

[Electrodes 10 feet apart. Mean daily temperatures given in degrees F.]

DATE.	Temperature.	East.	South.	West.	North.
April 7,	35	28,200	28,000	29,000	29,400
14,	42	25,000	25,000	26,500	23,000
21,	36	25,000	29,900	28,000	25,000
26,	56	19,000	21,400	19,300	19,700
Average for month,	–	24,300	26,075	25,700	24,275
May 8,	58	17,200	18,000	16,400	19,000
14,	68	10,800	11,200	11,000	12,600
21,	46	13,000	16,300	16,000	18,900
28,	45	11,100	17,500	15,900	19,000
Average for month,	–	13,025	15,750	14,825	17,375
June 4,	55	9,000	13,000	12,000	12,300
12,	59	6,300	15,000	12,000	11,700
Average for month,	–	7,650	14,000	12,000	12,000
Average for three months,	–	14,992	18,608	17,508	17,883

The data in Tables III. and IV. cover weekly observations extending over a part of three different months, the same trees being used as in the preceding experiments. The results shown in these tables present similar features to those in the preceding ones.

The lowest average resistance during any single day for the maple occurred May 14, when the temperature was highest, while the highest average resistance was on May 28, when the temperature was low, but not the lowest. The average resistance for the different sides of the tree for the whole period was the highest on the north side, followed by the west, east and south sides. For the elm the lowest average resistance for a single day was shown on May 14 and June 12, days when the temperature was highest. The highest average resistance shown corresponds to the lowest temperature, which was recorded on April 7. The average resistance for the different sides of the elm during the whole period was the highest on the south, followed by the north, west and east sides.

The experiments shown in Table V. were supervised by Mr. Chapman during the spring of 1909. The resistances were obtained from a large maple tree located near our laboratory which was a different specimen from the one used in the preceding experiments. The tree was a typical rock maple of this region, in fairly vigorous condition, slightly over 2 feet in diameter at the base. The resistance readings were obtained from a combination bridge, as in previous experiments, and a battery of 8 Samson cells was used. The electrodes consisted of galvanized iron nails about 3 inches long, which were driven through the bark into the wood for about 1½ inches. The part of the electrodes extending beyond the surface of the wood was enclosed within porcelain insulators. Before the electrodes were inserted into the tree at the various points a part of the bark extending to the wood was removed with a chisel for a space of 2 inches. The electrodes were 8 feet apart in each case, the lower ones being placed about 2½ feet from the ground, and the highest about 10½ feet, hence the resistances were taken from that part of the tree between 2½ and 10½ feet of the trunk. The wires, 8 in all, were connected with the electrodes by means of solder and were run into the laboratory about 50 feet away, all the readings being taken under cover. The resistances were read three times each day, viz., at 8 A.M., 12 M. and 4 P.M. from March 18 to March 30, inclusive.

TABLE V. — *Showing Daily Records of Electrical Resistance (in Ohms) of Maple (Acer saccharum, Marsh), March 18–31, 1909. Resistances taken Three Times Daily on the North, South, East and West Sides of the Tree.*

[Electrodes 8 feet apart.]

DATE.	8 A.M.				12 M.				4 P.M.			
	North.	West.	South.	East.	North.	West.	South.	East.	North.	West.	South.	East.
March 18,	138,500	147,500	157,700	136,300	79,980	82,670	105,900	33,980	73,100	84,540	93,200	74,200
19,	56,460	63,500	76,500	62,000	37,900	38,760	44,140	36,470	35,900	34,100	36,500	35,600
20,	121,000	126,400	86,870	68,850	99,700	85,400	62,000	68,200	77,988	54,360	46,530	62,120
21,	182,000	170,000	86,200	58,180	78,500	53,100	42,000	35,900	43,100	30,000	32,750	33,800
22,	52,100	45,800	45,700	38,360	38,640	33,650	34,750	31,100	34,350	30,000	31,050	29,950
23,	32,100	32,100	31,680	28,990	28,890	28,870	28,600	26,980	29,910	29,800	30,000	27,950
24,	31,580	30,000	30,070	25,850	26,680	26,250	26,500	23,990	33,800	22,050	23,700	22,800
25,	69,860	73,700	58,960	52,870	66,400	49,980	37,650	35,600	37,100	26,000	32,100	31,000
26,	38,700	38,600	50,100	40,000	30,390	30,320	37,000	30,200	29,110	29,100	33,100	25,000
27,	29,100	32,080	37,000	26,400	23,100	27,500	29,600	23,000	28,000	29,760	32,100	27,900
28,	40,100	46,300	48,400	38,500	40,000	44,000	47,050	37,500	29,910	31,000	39,100	29,000
29,	37,000	-	38,500	34,700	35,400	-	37,750	29,400	32,000	-	31,400	28,700
30,	51,000	56,000	60,000	41,000	39,000	43,050	47,000	36,050	38,000	38,000	47,000	38,000
Averages,	67,654	71,832	62,130	50,155	48,044	45,300	44,610	37,567	40,174	36,560	39,580	35,847

TABLE VI. — *Showing Temperature Conditions, etc., during the Month of March.*

Date.	8 A.M.			12 M.			4 P.M.		
	Weather.	Sap.	Temperature.	Weather.	Sap.	Temperature.	Weather.	Sap.	Temperature.
March 18,	Overcast, cool, no wind.	No flow.	37.0	Overcast, snow, no wind, cold.	No flow.	35.0	Overcast, sleet, no wind, cold.	No flow.	30.0
19,	Overcast, cool, no wind.	No flow.	34.0	Fair, cold, no wind.	No flow.	39.0	Fair, sunshine, windy, cold.	No flow.	35.5
20,	Fair, sun, wind.	No flow.	41.0	Fair, cool, no wind.	No flow.	37.5	Overcast, cold, no wind.	No flow.	32.0
21,	Clear, sun, slight wind.	Slow flow.	36.5	Clear, sunshine, no wind.	Flow.	46.5	Fair, cool, no wind.	No flow.	35.5
22,	Clear, sun, wind west.	Flow.	46.5	Clear, sunshine, wind west.	Flow.	48.5	Clear, cool, wind west.	Flow.	45.5
23,	Clear, sun, wind southwest.	Great flow.	45.5	Overcast, warm, no wind.	Great flow.	53.5	Overcast, rain, no wind.	Flow.	47.0
24,	Clear, sun, wind southwest.	Great flow.	50.0	Fair, sun, wind southwest.	Great flow.	55.5	Fair, warm, wind southwest.	Flow.	52.0
25,	Clear, sun, wind.	No flow.	35.0	Clear, sun, wind.	Flow.	35.5	Clear, cool, wind.	Great flow.	35.0
26,	Overcast, cold, windy.	Slow flow.	41.0	Clear, cold, high wind.	Flow.	53.5	Fair, cool, wind.	Great flow.	58.0
27,	Cloudy, warm, no wind.	Slow flow.	53.0	Fair, warm, no wind.	Flow.	64.5	Fair, warm, no wind.	Flow.	54.5
28,	Cloudy, warm, no wind.	No flow.	44.0	Rain, cool, no wind.	Flow.	46.5	Clear, warm, wind.	Flow.	61.0
29,	Rain, cool, no wind.	No flow.	47.5	Rain, cool, no wind.	No flow.	48.5	Rain, cool, no wind.	Flow.	46.5
30,	Clear, cool, moderate wind.	Flow.	42.0	Clear, cool, moderate wind.	Flow.	45.0	Clear, cool, moderate wind.	Flow.	44.0

The resistances in Table V. were taken in March and represent considerably higher readings than those given in the preceding tables, although there the distance between the electrodes was 10 feet, while in the readings shown in Table V. the distance was only 8 feet. The higher resistance is due, as shown in this table, to the cutting away of some of the outer tissue around the electrodes, a feature which will be discussed later; and also in part to the measuring of the resistances in March instead of in April, May and June, as was the case with the preceding observations.

The results obtained from these readings, however, are somewhat similar to those given in the preceding tables; the highest resistance occurring on cold days and the lowest on warm days. The highest resistance shown in any one observation was on March 21, at 8 A.M., on the north side of the tree. The temperature for this same period was 36.5° F., which is one of the lowest recorded. The lowest resistance was on the 24th of March, at 4 P.M., on the east side of the tree following one of the high temperature periods. The highest average resistance for any single day occurred March 18, and this coincides with the lowest average temperature. The lowest average resistance for any single day occurred March 24, followed by March 27, which were the two warmest days. The average temperature records for both days, taken at the time of the observation, was as follows: March 24, 52.5° F., the average temperature for the 27th being 57.3° F. The mean temperature (maximum and minimum) on this date was 38, and that for March 27 was 41. By referring to Table VI. it will be observed that March 24 was clear and sunshiny, with the wind southwest, and March 25 was fair and warm, and occasionally cloudy, with no wind. The average resistance for all periods was the greatest in the morning, followed by those given at 12 M. and 4 P.M. At 8 A.M. it was 62,942, at 12 M., 43,880, and at 4 P.M., 38,040 ohms.

Table VII. — *Showing Maximum and Minimum Resistances based on the Averages obtained from the North, South, East and West Sides of Maple Tree (Acer saccharum, Marsh) for Different Periods during the Day, March 18–31, 1909.*

8 a.m.	West, highest,	71,832
	North,	67,654
	South,	62,130
	East, least,	50,155
12 m.	North, highest,	48,044
	West,	45,300
	South,	44,610
	East, least,	37,567
4 p.m.	North, highest,	40,174
	South,	39,580
	West,	36,560
	East, least,	35,847

This table is adapted from Table V. It will be noticed that the highest average resistance was obtained on the west side for the 8 a.m. observations, and the north side gave the highest average resistance for the two following observation periods, viz., at 12 m. and 4 p.m. The lowest average resistance from March 18 to 31 occurred on the east side for each of the three periods. The average daily resistance for the whole period — 9 a.m. to 4 p.m. — was as follows: north side, 51,957; west side, 51,230; south side, 48,773 and east side, 41,189. These results coincide with those given in the preceding tables, that is, the north side shows in general the highest resistance.

Table VIII. — *Showing Electrical Resistance (in Ohms) of Maple (Acer saccharum, Marsh) from March 18-31, 1909. Resistances taken at 8 a.m., 12 m. and 4 p.m. on the South Side of the Tree.*

[Electrodes 8 feet apart. Temperature same as in Table VI.]

Date.	8 a.m.	12 m.	4 p.m.
March 18,	46,890	27,700	27,200
19,	23,350	20,400	20,900
20,	42,320	26,830	23,840
21,	53,900	22,510	19,300
22,	25,800	19,820	18,300
23,	18,790	16,700	16,500
24,	18,000	17,150	16,540
25,	39,690	21,000	15,600
26,	23,300	17,200	14,900
27,	18,300	15,700	15,100
28,	25,400	23,600	14,950
29,	20,200	16,800	16,000
30,	29,000	20,600	19,000
Averages,	29,610	20,462	18,318

The resistances given on the south side of the same maple tree as in Table V. are given here; in this case, however, the electrodes were attached differently, being driven through the bark into the wood, and none of the tissue around them was cut away.

The resistances given here run considerably lower than those shown in Table V. for the same tree for the same period, due to the fact that the electrodes were inserted differently into the tree. If we compare the average resistances obtained from the two experiments, those in Table VIII. and those in Table V., we obtain the following for the same period, with the same tree. The average resistances on the south side of the tree shown in Table V. are as follows for the three different periods: 8 A.M., 62,130; 12 M., 44,610; 4 P.M., 39,580, while those given in Table VIII. are 29,610, 20,462 and 18,318 ohms.

The higher resistance shown in Table V. represents not only that of the cambium, but of some of the wood as well.

The highest resistance readings were obtained at 8 A.M., while the lowest were obtained at 4 P.M. The midday temperatures were highest, as might be expected, with little difference in the morning and afternoon.

The after effects of the higher temperatures influenced the resistances taken at 4 P.M., since the tree, being generally exposed to the sun's rays for a considerable period in the day, would become warmer, and the heat would be retained for some time. It was thought desirable to make one experiment when the observations could be recorded hourly. The results of these observations are shown in Table IX.

TABLE IX. — *Showing Record of Electrical Resistance (in Ohms) of Maple (Acer saccharum, Marsh) for One Day, the Records being taken hourly, April 27, 1907.*

[Electrodes 10 feet apart.]

TIME.	East.	South.	West.	North.	Weather.	Remarks.	Temperature (Degrees F.).
6.15 A.M.,	24,700	23,100	22,400	26,000	Wind, cold.	Sap not started.	39
7.15 A.M.,	24,600	23,100	22,300	25,900	Wind, cold.	Sap not started.	40
8.15 A.M.,	24,600	23,000	22,200	26,000	Wind, cool.	Sap just started.	44
9.15 A.M.,	24,500	20,200	21,000	25,400	Wind, cool.	Sap flowing more freely.	48
10.15 A.M.,	23,500	18,600	19,000	24,700	Light wind, warm.	- - -	52
11.15 A.M.,	22,100	19,500	18,100	23,600	Light wind, warm.	- - -	55
12.15 P.M.,	21,200	18,800	17,700	22,500	Light wind, warm.	- - -	58
1.15 P.M.,	20,000	17,300	16,800	22,200	Calm, warm.	- - -	59
2.15 P.M.,	18,800	17,000	16,600	21,800	Calm, warm.	- - -	59
3.15 P.M.,	19,300	18,300	16,800	22,500	Calm, warm.	Sap flowing less freely.	60
4.15 P.M.,	19,800	18,700	16,800	22,500	Calm, warm.	- - -	60
5.15 P.M.,	20,000	19,400	16,900	22,700	Calm, cool.	Sap ceased flowing.	59
6.30 P.M.,	20,000	19,600	16,900	23,000	Calm, cool.	- - -	57
Averages,	21,769	19,738	18,576	23,753			

The data obtained from hourly readings on the north, south, east and west sides of the tree are given in Table IX. These were taken from the same tree (rock maple) as the records shown in Table I., and while they were continued only for one day, they undoubtedly show typical variations which occur. The resistances given are for 10 feet of the tree trunk, and the day selected for the readings was free from clouds, the sun being quite bright throughout the day for this period of the year (April 27).

At times, however, a slight haze was present which affected to some extent the intensity of the light. The highest resistance was shown in the early morning, when the temperature was the lowest, and as it had become warmer the resistance decreased. The lowest resistance occurred at 2.15 P.M., after which time there was a slight increase in the resistance. It will be noticed, however, that the least increase in the resistance after 2 P.M. occurred on the west side of the tree, which received at that time the benefits of the heat from the sun's rays during the afternoon. On the other hand, the north, east and south sides showed a greater increase for this period, as they were more or less shaded from the sun's rays. The north side of the tree gave the highest average resistance, followed by the east, south and west sides. The lowest average resistance occurred on the west side of the tree.

Sap commenced flowing freely at 9.15, and at 2.15, the time of the lowest resistance, it had commenced to cease flowing. As is well known, there is a relationship between the flow of sap and temperature, but there is no indication from these observations or from any of our experiments that there is any relationship between resistance and flow of sap.

Experiments with Cut Branches of Trees.

A number of resistances were obtained from cut branches of maple trees by Mr. Chapman. These were taken when the trees were in a dormant condition, and in some cases when the buds were developing.

Experiment A.

A maple branch 1½ inches in diameter and several feet long was used for this purpose. The branches showed slight bleeding at first. Heavy galvanized iron nail electrodes were driven into the branch 20 inches apart, and several half-hour readings were taken. The branches were left out of doors where the temperature varied only a few degrees, and at the time the readings were taken it was just above freezing. The results follow: —

	Ohms.
8.30 A.M.,	136,000
9.00 A.M.,	132,000
9.30 A.M.,	131,000
10.00 A.M.,	132,000
10.30 A.M.,	120,000

This experiment was repeated several times with approximately the same results, and is not conclusive as regards influences of temperature.

Experiment B.

The same branch of maple was kept in the laboratory for five days at a room temperature (about 70° F.), the only difference between this experiment and the one preceding being the fact that the electrodes were placed 1 foot apart instead of 20 inches. The readings obtained are as follows, taking half-hour periods: —

	Ohms.
8.30 A.M.,	72,000
9.00 A.M.,	72,000
9.30 A.M.,	74,000
10.00 A.M.,	75,000
10.30 A.M.,	77,000

Very little variation was shown in the resistances.

Experiment C.

A branch of another maple of about the same diameter as the preceding was cut under water and allowed to stand at room temperature for five days, when a fresh cut was made under water. During this time the leaves and flowers had started, and there was evidently some transpiration. The electrodes were 1 foot apart. The following readings were obtained: —

	Ohms.
8.30 A.M.,	64,400
9.00 A.M.,	65,000
9.30 A.M.,	68,000
10.00 A.M.,	67,000

It will be seen that these resistances were all ranged between 64,000 and 67,000, and coincide very closely with those given in Experiment B.

Experiment D.

Another experiment, using the same branch as was used in Experiment C, was undertaken, but in this case the water in which the branches stood was heated to a temperature ranging from 100 to 130° C. The readings were taken at half-hour intervals, with the following results: —

	Ohms.
9.30 A.M.,	67,000
10.00 A.M.,	68,000
10.30 A.M.,	67,500
11.00 A.M.,	67,600
11.30 A.M.,	73,000
12.00 M.,	72,000
1.00 P.M.,	72,000
1.30 P.M.,	71,000
2.00 P.M.,	69,000
2.30 P.M.,	70,000
3.00 P.M.,	73,000
3.30 P.M.,	75,000
4.00 P.M.,	76,000

The rise in temperature had little or no effect on the resistance. On the other hand, the readings in some cases were slightly higher.

Experiment E.

The same branch was used in this experiment. After standing over night and the water brought to room temperature a space of ½ inch down to the wood was removed halfway between the electrodes; in other words, the branch was girdled for this distance. The following readings were obtained: —

	Ohms.
8.30 A.M.,	122,000
9.00 A.M.,	121,000
9.30 A.M.,	124,000

all averaging not over 123,000. The results here show greatly increased resistances as the effect of girdling.

Experiment F.

The same branch was used here as in E, except the girdling was increased to 3 inches. The following readings were taken: —

	Ohms.
1.00 P.M.,	128,000
1.30 P.M.,	130,000
2.00 P.M.,	127,000
2.30 P.M.,	130,000
3.00 P.M.,	129,000

It will be noticed that these readings were slightly higher than those in Experiment E, due to girdling.

Experiment G.

The same branch under the same conditions was used for this experiment, except that the branch was completely girdled between the electrodes. The results follow: —

	Ohms.
8.30 A.M.,	150,000
9.00 A.M.,	151,000
9.30 A.M.,	150,000
10.00 A.M.,	150,000
10.30 A.M.,	149,000

It will be noticed that the readings obtained here are higher than in F or E, due to the greater girdling. These experiments demonstrate that the wood gives much higher resistance than the cambium, and shows that the resistance increased as the bark and cambium were removed. The highest resistances were given where there was the greatest amount of girdling. Even cutting away the bark for a distance of ½ an inch or more in each direction from the electrodes greatly increases the resistance. This is what occurred in the experiment shown in Table V., where the bark was cut away from the electrodes, whereas in experiments shown in Table VIII. for the same distance, and where no bark was removed, the resistances were much lower.

Experiment H.

In this experiment a freshly cut branch about 1 inch in diameter was used, and the bark cut away for a space of 1 inch around the electrodes, which were inserted 1 foot apart, as in the other experiments. The branch was placed in water at room temperature of from 68° to 70° F. The following results were obtained: —

	Ohms.
10.00 A.M.,	110,000
10.30 A.M.,	100,000
11.00 A.M.,	100,000
11.30 A.M.,	105,000

Experiment I.

The same branch was used as in Experiment H, and a fresh cut made under water, the water being heated for three hours at a temperature ranging from 149 to 150°. After three hours at this temperature the following readings were obtained: —

	Ohms.
1.30 P.M.,	140,000
2.00 P.M.,	135,000
2.30 P.M.,	138,000
3.00 P.M.,	142,000
3.30 P.M.,	150,000

It will be noted that the resistances were higher here than in the others, although the temperature of the water in the latter case was very much higher than in the former experiment.

Experiments with Small Plants.

Some experiments were made with small plants in the greenhouse in February to determine the electrical resistance. For this purpose we made use of tobacco plants in pots, the plants being 3 feet high. The results of these experiments, made by Mr. Chapman, follow: —

TABLE X. — *Showing the Electrical Resistance of a Tobacco Plant (Nicotiana tabacum, Linn.).*

[Resistance in ohms.]

TIME.	Experiment I.	Temperature (Degrees F.).	Experiment II.	Temperature (Degrees F.).	Experiment III.	Temperature (Degrees F.).	Experiment IV.	Temperature (Degrees F.).
8.00	-	-	-	-	132,000	-	-	-
8.30	-	-	-	-	130,900	68	128,000	62
9.00	131,000	-	108,000	60	136,000	73	129,000	63
9.30	116,000	-	140,000	60	134,000	78	124,000	63.5
10.00	110,000	-	137,000	61	110,000	83	127,000	63
10.30	133,000	-	146,000	62	129,000	79	-	-
11.00	117,000	-	151,000	62	136,000	73	128,000	64
11.30	117,500	87	147,000	61	133,000	77	123,000	67
12.00	125,000	84	147,000	62	116,000	82	121,000	71
12.30	-	-	-	-	-	-	-	-
1.00	137,000	81	136,000	62	-	-	-	-
1.30	126,000	80.5	147,000	63	143,000	69	-	-
2.00	129,000	80.5	-	-	144,000	65	-	-
2.30	131,000	80	139,000	63	143,000	67	-	-
3.00	125,000	81	135,000	63	151,000	67	-	-
3.30	128,000	70	144,000	63	155,000	66	-	-
4.00	153,000	67	146,000	59	161,000	64	-	-
4.30	156,000	67	143,000	61	161,000	62	-	-
5.00	156,500	66	150,000	60	164,000	60	-	-

The object of the experiment was to determine what influence other factors might have on resistance, such as temperature, etc., but more particularly whether variations in temperature were discernible in resistance. The plants were under tolerably uniform conditions, although the temperature varied, as will be seen in the tables. Platinum electrodes were used, these being driven into the plant at a distance of 14 inches apart. One was driven in at the base and the other near the apex of the stem. There were no very marked coincidences between the changes of temperature and resistance in these experiments, but it should be remarked that the lowest resistance coincides with the highest temperature in Experiments I., II. and IV., while in Experiment III. there was little variation in temperature, although variation in resistance occurred. In averaging up the temperature and resistance for those periods where all the data are present it is found that there is a relationship between the temperature and the resistance. For example, it was found that the lowest temperature occurred on the last three periods, that is, from 4 P.M. to 5 P.M., and that the highest average resistance occurred during these periods also. On the other hand, the lowest average resistance coincides in a general way with those periods which gave the highest temperature readings.

Relation of Electrical Resistance to Flow of Sap.

Some observations were made on a rock maple in regard to the relation of electrical resistance to the flow of sap, but these were not extensive and lasted only a few days. The following results were obtained by collecting sap on the north, south, east and west sides of the tree. The amount of sap represents the amount of flow between 9 A.M. and 12 M., and 12 M. and 4 P.M., but the table gives the total amount obtained as well as the average resistances for the whole period.

	North.	South.	East.	West.
Average resistance, ...	34,720	40,340	32,217	37,140
Total sap flow in cubic centimeters, .	5,945	6,180	5,820	5,150

The highest average resistance and greatest sap flow occurred on the south side of the tree. The sequence of the average resistance was as follows: north, south, east and west, and that for the sap flow, south, north, east and west. Our records, moreover, showed that sap flowed more freely in the morning than in the afternoon, also that the average resistance was higher in the morning than in the afternoon. Since these observations were not prolonged the results are not conclusive, but we do not believe that electrical resistance is affected materially by sap flow. Since our resistance readings were obtained from the trees offering the least resistance, which is no doubt in all cases the cambium layer, it is questionable whether sap flow, which is characteristic of the woody tissue, would affect our results.

The flow of sap, as is well known, is influenced by various conditions, a very important one being night temperature, as well as the conditions which prevail during the day. Temperature records were taken for the same period, but there was little or no direct relation between the temperature of this period and the sap flow. In all cases the air temperature was at freezing or below this point during the night, while in the daytime it ranges from 43 to 57°.

Jones, Edson and Morse [1] found that the maximum yield of sap occurred quite generally between the hours of 9 A.M. and 12 M. They also maintain that on a typical sap day the tree will yield more sap and sugar on a southern exposure than on any other, while on a cloudy day, when all the sides of the trees are subject to a uniform temperature, there is little or no difference in the sap flow as regards the cardinal points of the compass. It is known that the percentage of sugar varies in the tissues of a tree from day to day, and it is doubtful whether this variation in the chemical composition of the sap, or even the amount of flow, would affect resistance even if our observations were confined to the woody tissues alone. This opinion is based on laboratory experiments.

Electrical Resistance of Different Tissues.

It might be expected that there would be found considerable difference in the electrical resistance of various trees, as well as of the different tissues found in trees. The heartwood, sapwood, cambium, bark and sieve tubes possess quite different properties and functions, and their electrical resistance would naturally vary to a large extent. The living cells containing protoplasm, such as are found in the cambium, present the least resistance, as would seem from various observations on lightning discharges. The minute burned channel found in trees caused by comparatively insignificant lightning discharges follows down the cambium, indicating that this is the line of least resistance. Moreover, by driving electrodes into a tree to different depths and measuring the resistance it can be shown that the least resistance occurs in the region of the cambium.

[1] The Maple Sap Flow, by C. H. Jones, A. W. Edson and W. J. Morse, Vt. Agr. Exp. Sta., Bul. No. 103, December, 1903.

The resistance, however, may equal 25,000 ohms more or less, in 10 feet of the trunk of an elm or maple tree. This constitutes a comparatively high resistance. The resistance of the sapwood is very much greater, and probably that of the heartwood is even higher than that of the sapwood.

In determining the electrical resistance it is necessary to know the path or course of the current, and the only manner in which the electrical resistance of different tissues can be determined accurately is by isolating the tissues. By girdling a tree and scraping the trunk down to the solid wood we can get the resistance of the wood. Mr. Chapman found the resistance of a freshly cut rock maple stem, 1½ inches in diameter, to be 70,000 ohms when intact, *i.e.*, with the bark on, but 150,000 ohms when the bark was removed. The electrodes were 1 foot apart.

Some experiments which have been made indicate that next to the cambium the phloem has the least resistance, followed by the sapwood. The outer bark appears to offer the most resistance, but when this is moist, as during rain storms, the resistance may be somewhat decreased. When leakage occurs, owing to grounding of the electric currents from high tension wires in moist weather, burning results, but this is due to the presence of a film of water on the bark, and what is termed "arcing" occurs. The resistance obtained from an elm tree, with the electrodes 10 feet apart and in contact with the cambium, was 10,698 ohms, whereas when the electrodes were inserted into the middle of the cortex or phloem we obtained 11,300 ohms resistance. When driven ¼ inch into the wood the resistance was 98,700 ohms. The outer bark gave 198,800 ohms resistance, but when the electrodes were inserted slightly deeper into the bark we obtained 109,900 ohms. It must not be understood, however, that these readings gave the electrical resistance of 10 feet of the various tissues enumerated except in the case of the cambium, since if these tissues were isolated the resistance would be much greater. They show that there is much difference in the resistance of different tissues, but in all cases here we obtained merely a resistance of the cambium, together with that of a part of the other tissues, which the current had traversed from its various points of entrance to the cambium.

It is quite evident from our observations on the resistance of trees that the cambium gives the least resistance, the phloem next, and it is not at all unlikely that in some trees there may be some variation in this respect.

The resistance given by small tree trunks and woody stems, even for small distances, is quite large. About 4 feet of a young pear tree, with a maximum diameter of stem equal to 1 inch, gave a resistance of about 300,000 ohms, and the resistance given by a tobacco plant in which the distance between the electrodes was only 14 inches, was much higher (110,000 to 165,-000 ohms) than that shown by trees. In the case of the pear tree, which was in a large box, filled with soil, one of the electrodes (metal plate) was in contact with the small roots, the other being in contact with the apex of the plant.

The presence of water and various salts undoubtedly plays a rôle in resistance, and it might be expected that the various plastic substances in the plant would influence resistance.

The path of a current in a tree, as already stated, follows the line of least resistance, but this line may not necessarily be a straight one between one electrode and another. Although in many lightning strokes a straight line is generally followed, we have seen instances where the whole cambium zone was involved, and when the tissue in a tree is twisted the discharge will follow the tissue. A lightning discharge may therefore completely circle a tree trunk, passing from the apex of the tree to the ground. In earth discharges the path follows up the trunk and is generally diverted to the branches, often causing them to split. When heavy lightning discharges occur and the tissues of the tree become shattered, as is often the case, the line of least resistance seems to be an unimportant factor, and in this respect the electric discharges resemble an avalanche in their behavior. In some of our experiments, where trees were connected with wires carrying relatively high currents and the electrodes were 1 foot apart vertically, all of the injury was done by burning on one side of the tree in close proximity to the electrodes, but even here the burning of the tissue covered an area of more than 1 foot in width on the trunk. Burning under these conditions, however, occurred only when the bark of the tree was moist, and was not caused by a decrease in resistance in the tissue, but by the presence of a film of water, which is a far better conductor, on the bark, which became heated and killed the underlying tissue. In the case of some large trees which we observed and which had been killed by direct currents from trolley wires, the tissue was as a rule affected nearly equally around the entire trunk of the tree, although the point of contact was on one side of the tree. In both cases it was a heating of the film of water on the trunk caused by the escaping electric current which caused the injury.

The cambium ring is very insignificant in size, practically $\frac{1}{500}$ to $\frac{1}{1000}$ in diameter, and even on a large tree the total area is small. In all probability it is the protoplasm itself which offers the least resistance to the transmission of an electric current; and even if there were no continuity it would be necessary for the current to pass through a great many cell walls even for comparatively short distances on the trunk. In case the protoplasm was contiguous or there existed continuity, the strands would be so very small that they would undoubtedly offer some resistance. Whatever conditions prevailed trees showed relatively high electric resistances, a feature which is no doubt of some biological importance as trees are often struck by lightning. The high resistance of trees, therefore, is undoubtedly a protection in case of lightning strokes, since often the heat developed is enough to do only slight injury. On the other hand, if trees possessed tissue with relatively small electrical resistance they would be much more subject to injuries from burning from lightning strokes, and would be more seriously affected by currents from high tension wires. The electrical resistance of trees is so high that it is doubtful whether injury ever occurs to them from contact with low or even high tension wires except that produced by grounding when the bark of the tree is moist. Any escaping current which can be transmitted even through the least resistant tissue is likely to be insignificant.

The amount of current necessary to kill a plant depends upon its size, etc. A current equal to .01 amperes may be sufficient to kill a small plant, whereas a current ten times as great would cause no perceptible injury to a large tree even when passed through the tissue for months. The higher resistance shown by small branches or woody stemmed plants may possibly be due to the presence of less conductive tissue, whereas in a tree the conductive zone, if we include the phloem, is larger.

It is known that there are minute currents of electricity in plants, but we have never noticed their effects on our galvanometers nor have we detected them by the use of a milliammeter. Trees frequently become charged with electricity, and sparks are given off from the apices of the leaves. Vegetation in general responds quickly to electrical stimulation, and trees undoubtedly play an important part in equalizing the differences in electrical potential between the atmosphere and earth. In this respect conifers appear to behave differently from deciduous trees, and in our experiments we have found that the atmospheric electrical potential under thick conifers was the same as that which characterizes the earth.

Relationship of Electrical Resistance to Other Factors.

We had little or no opportunity to observe the effects of winds, if such exist, on electrical resistance. Most of our records were taken while the tree was in a dormant condition. In some cases the trees were well protected from the winds. It is known that transpiration is increased by wind, and the movements of water in the tissues of the tree are accelerated. No relationship, however, between the wind and electrical resistance has been noted by us in comparing the records of the local meteorological station with our data, neither was there any specific relationship observable between barometer pressure and electrical resistance. A careful study of the humidity conditions, also, did not seem to affect the electrical resistance so far as we could observe. Aside from the temperature effects coincident with light intensity no special changes in resistance were observable except such as would naturally follow from the variations in temperature.

Influence of Temperature on Resistance.

The most important factor which we have observed as influencing the electrical resistance of trees is temperature. The effects of temperature on various metals give rise to an increased resistance, whereas plant tissues show a greatly reduced resistance when heated.

Our numerous experiments in subjecting seeds to electric currents have shown that when they have been soaking in water for some hours and are quite moist, and a relatively strong current is passed through them, the resistance is largely decreased owing to the development of heat, and the current increases very perceptibly. This also occurs to plants when subjected to currents of electricity of sufficient intensity, as it induces heat. The injury caused to plants by electricity generally arises from decreased resistance, which is likely to follow after a more or less prolonged application of the current; in other words, the injurious effect is caused by heat, although it is possible that electricity will kill plants without generating heat sufficient to injure the protoplasm.

Experiments made some years ago by us seemed to indicate that when strong currents are applied to small plants and they become excessively heated, after a short period of time the protoplasm is destroyed, and the current, which first increases in strength very rapidly, suddenly drops to almost nothing.

A low temperature in trees gives rise to a high resistance, and a high temperature to a low resistance; in other words, the resistance of trees resembles that of moist seeds in their behavior to temperature, and the relationship between temperature and resistance is quite general. There may be, of course, other factors which influence resistance besides temperature, such as, for example, the degree of moisture in the tissue, as well as the nature of the substances in the tissue.

The relationship existing between temperatures and resistance is shown in Figs. 1, 2 and 3. Fig. 1 shows the curve given by an elm tree, and is based upon the data given in Table II., being the average daily resistance obtained from the north, south, east and west sides of the tree during April, the upper curve with broken lines being that of the mean temperatures for the days when the observations were made. In Fig. 2 A the average electrical resistance of the south side of a maple tree is shown from the data given in Table VIII. The readings are averages of three daily readings at 8 A.M., 12 M. and 4 P.M., and in B is given the average electrical resistance of a maple tree from data obtained in Table I., the curve being based on daily readings on the north, south, east and west sides of the tree. All of these figures show that there exists a marked relationship between the temperature curve and that for the electrical resistance, since as the temperature curve goes up the resistance curve goes down.

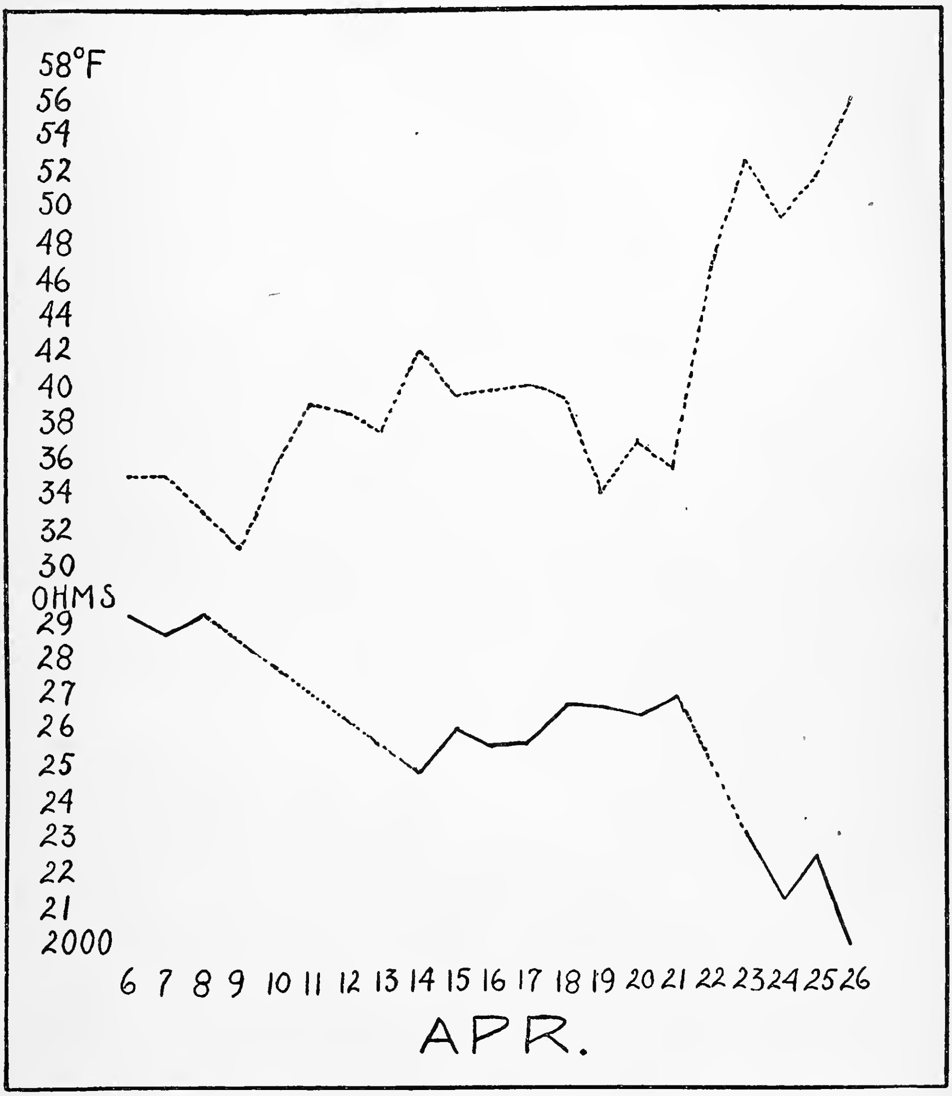

Fig. 1. — Showing curve of electrical resistance and temperature of elm, *Ulmus Americana* (Table II.). The lower curve gives the average resistance of the north, south, east and west sides of the tree from April 6 to 26; the upper curve gives the mean of the minimum and maximum temperature for the same period obtained from the local meteorological station.

In Fig. 3 is shown the hourly temperature and electrical resistance of the north side of a maple tree for a single day, the data being obtained from Table IX. In both Figs. 1 and 2 the temperature is taken from mean temperature records, while in the case of Fig. 3 they correspond with the hours of observation.

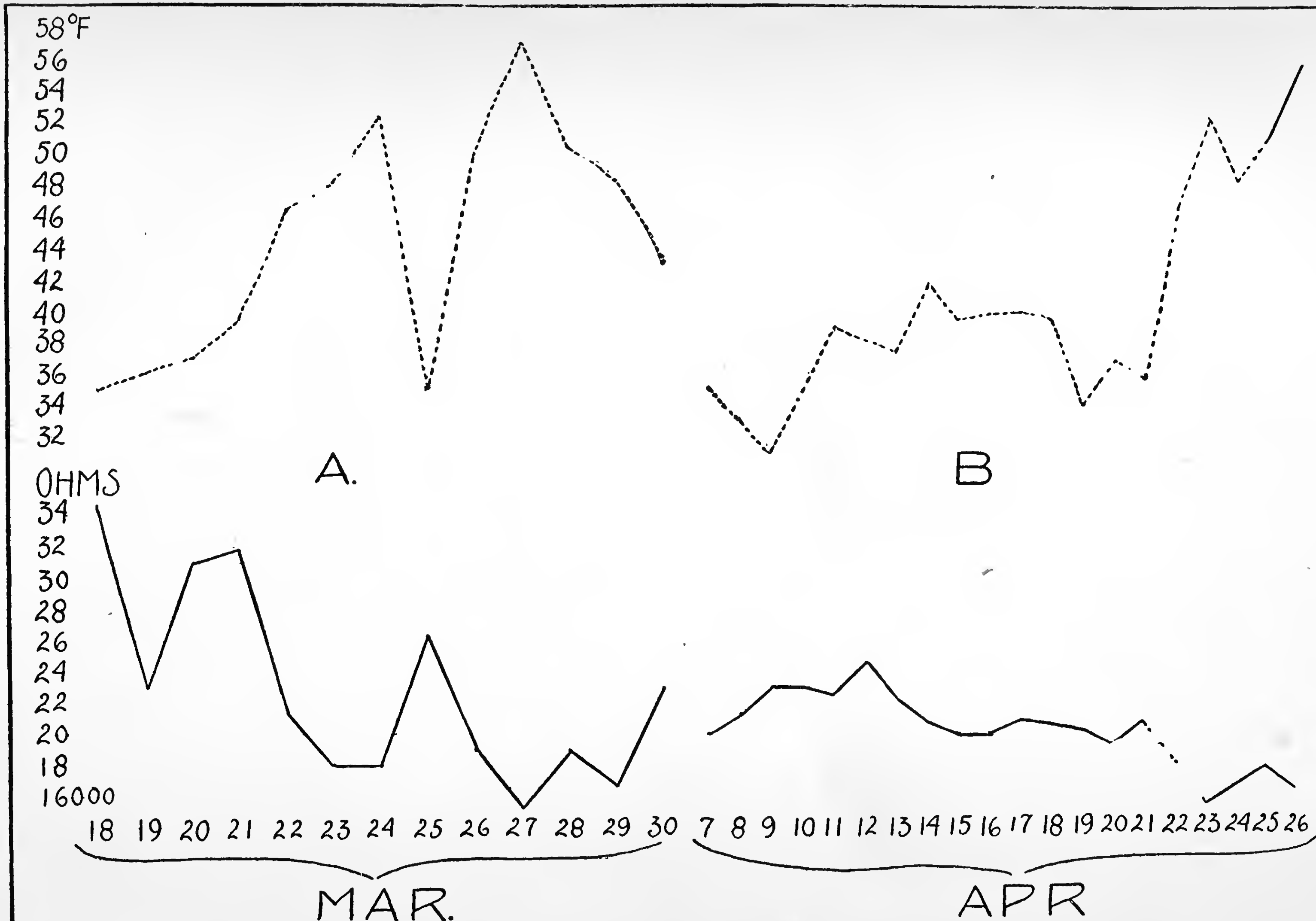

FIG. 2. —Showing electrical resistance and temperature curve of maple tree, *Acer saccharum*. The lower curves give the resistance of trees in ohms; the upper curves give corresponding mean temperatures obtained from the local meteorological station. A. Resistance given by the south side of a maple tree from March 18 to 30, inclusive, the resistance being averages of three daily observations taken at 8 A.M., 12 M. and 4 P.M. (See Table VIII.) B. Average resistance of the north, south, east and west sides of a maple tree. Observations taken daily from April 7 to 26. (See Table I.)

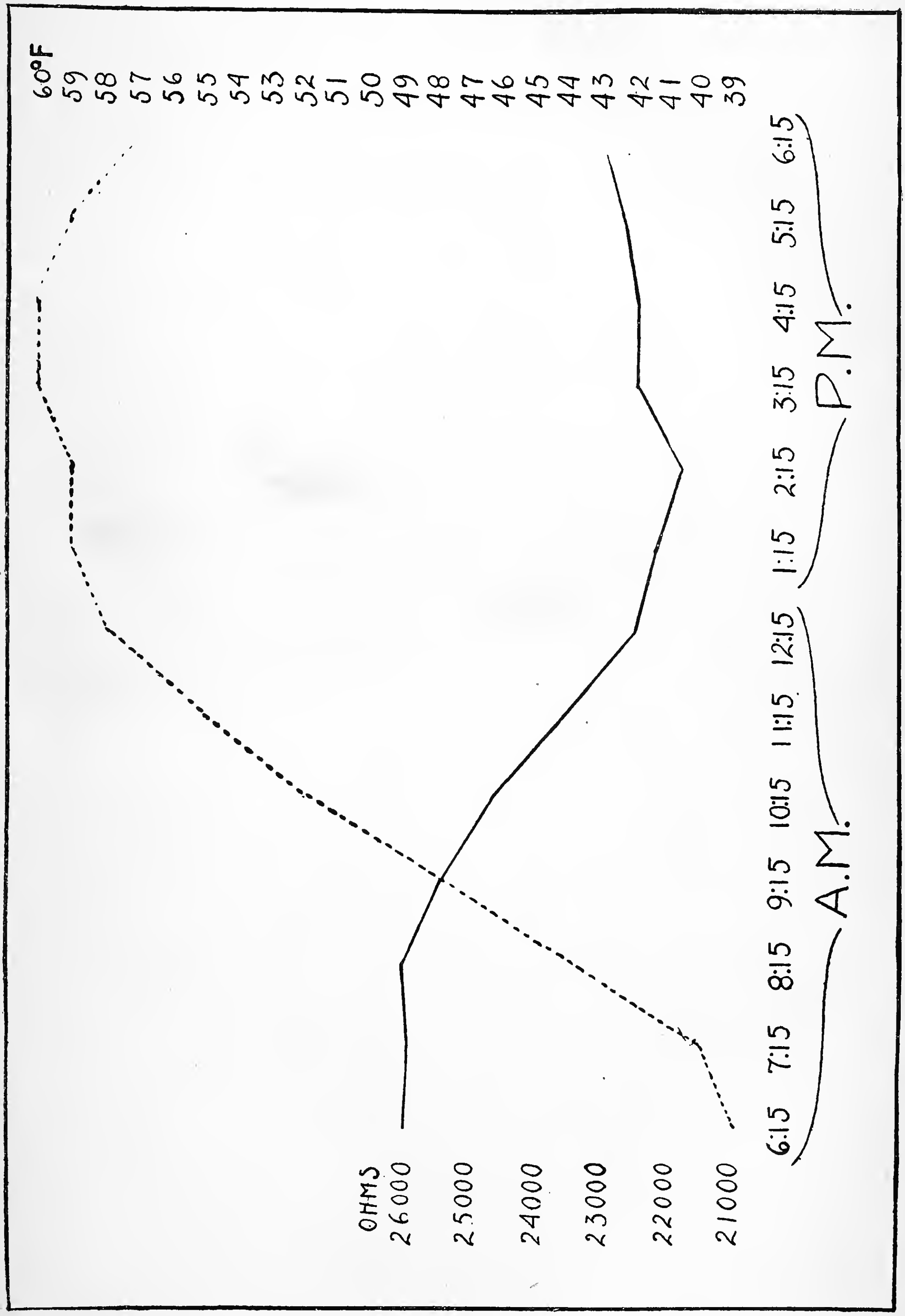

FIG. 3. — Showing electrical resistance and temperature curve of north side of maple tree, *Acer saccharum*. (See Table IX.) Observations taken hourly for one day, from 6.15 A.M. to 6.30 P.M. Lower curve represents the resistance curve, and the upper, the hourly temperature obtained from Draper records of the local meteorological station.

In the curve shown in Fig. 3 it will be observed that there is a close relationship between temperature and resistance.

Light, so far as we have observed, influences resistance only so far as it modifies temperature. The southeast side of the tree receives the most light, since the morning light is more intense than the afternoon light. Photosynthesis is more active on that side of the tree, and growth greater. Since there is a relationship between photosynthesis and light intensity, and also between growth, there occurs more activity, as a rule, on the southeast side of the tree than on any other, but whether the greater flow of plastic substances in any given tissue would affect resistance, our data do not show. So far, however, as the greater light intensity is associated with increased temperature, we should expect to find corresponding modifications in resistance.

Influence of temperature is shown in the difference existing between the resistance occurring on the north and south sides of trees. Some of our temperature records taken on the north, south, east and west sides of a rock maple were not satisfactory on account of the constant breakage of thermometers. These temperatures were taken three times daily, at 8 A.M., 12 M. and 4 P.M., for a period of five days. The records, however, gave the lowest average temperature on the north side of the tree, followed by the west, east and south sides respectively.

Other observations carried on for a brief period on a rock maple tree gave the following results. In both cases the thermometers were inserted into holes bored in the tree. The records obtained in the second series of observations, which are averages for a period of seven days, are as follows: —

The average of three observations daily, at 8 A.M., 12 M. and 4 P.M. on the north, south, east and west sides of a rock maple tree, gave the lowest temperature on the north, this being followed by the west, east and south sides respectively. These temperatures were taken in December, when the tree was in a dormant condition, and the temperature given by the north side of the tree was invariably the lowest.

Jones, Edson and Morse obtained careful temperature records from a rock maple tree. The observations were made on the north and south exposures, and extended from February 8 to March 20, and were made at 8 A.M., 12 M. and 6 P.M. each day. Corresponding air temperatures were made for the same period. These observations were made with centigrade thermometers, which were carefully protected from external influences. We transposed their readings into Fahrenheit and found that the average temperature given by the south side of the tree was 31.43° F., while that for the north side was 30.57° F. The air temperature for the same period, as might be expected, was variable, averaging slightly higher than that for the inside of the tree.

The average temperature readings obtained by Jones, Edson and Morse from the north and south sides of the tree showed that the temperature on the north side was about 3 per cent. lower than on the south side. The average obtained from all our electrical resistances and temperature readings are given below in sequence: —

	Average Electrical Resistance.	Average Temperature of Trees (Degrees F.).
North side,	27,081	30.91
West side,	25,714	32.14
South side,	25,566	33.60
East side,	23,708	32.28

It will be noticed that the highest average resistance of trees was given by the north side, followed by the west, south and east sides, and this sequence was closely followed by the temperature readings, the lowest being given by the north, followed by the west, east and south sides. The temperature readings lasted seven days only, and were too incomplete to obtain a true average. It will be noticed, however, that there was a difference of about 8 per cent. between the resistance of the east and west sides of the tree, a feature which would result from the greater intensity of the morning light. In our temperature readings, which are probably not as good averages as those obtained by the authors noted above, we find that the north side of the tree showed a temperature equal to 7 per cent. lower than the south side, as compared with 3 per cent. given by Jones, Edson and

Morse, whereas the average resistance for the north side of the tree runs about 5 per cent. more than that for the south side. The relationship of temperature to resistance manifests itself throughout; the higher temperature giving rise to a low, and conversely a low temperature giving rise to a high resistance.

The sun strikes the tree on the east, south and west sides, and each side is exposed for the same length of time; but the angle of the sun is variable as it strikes the tree's surface. In the early morning and late afternoon the sun's rays are more or less at right angles to the tree trunk, whereas at noon the angle is more oblique. The surface of a tree is not a good reflector of light and heat, and in the early morning and late afternoon, when the rays are more at right angles to the surface of the trunk, there is less loss of light and heat by reflection. Assuming that the light intensity is uniform throughout the day, and that the temperature is the same, we would expect to find fairly uniform resistances for the east, south and west sides of the tree. This, however, is not the case, as the temperature is seldom uniform, neither are the light conditions, as is shown by the flow of sap.

The north side of the tree gives the highest average resistance, followed by the west, south and east sides. From the point of view of influence of temperature this might be expected, especially during seasons when there is considerable difference between the night and day temperatures, and very likely for long periods of observations thermometers placed in trees would demonstrate this. Electrical resistances taken in the afternoon usually run lower than those taken in the morning on all sides of the tree, which results from a general increase in the temperature of the surrounding air and of the tree occurring in the daytime. The electrical resistance is less in the warm than in the cold months, and less on warm than cold days. In the morning the sun affects the east side of the tree most markedly, and in the afternoon the west side.

In experimenting with cut branches of maple trees we did not find, however, that this held true. The resistances obtained from branches placed out of doors when it was cold were in no wise different from those taken from the same branch when placed in the laboratory, where it was warm, or even when they were placed in hot water, although trees and various potted plants with an intact root system all showed the influence of temperature on resistance.

Conclusions.

1. The electrical resistance of trees shows a close relationship to temperature, their higher resistance corresponding with the low temperature, and the low resistance corresponding with the higher temperature.

2. The electrical resistance of trees is lower during warm than cold days, and less during warm than cold seasons. It is usually less during afternoons than mornings; in other words, it corresponds to changes in the temperature.

3. The average electrical resistance of trees is highest on the north side, followed by the west, south and east sides respectively.

4. The temperature of trees given by our experiments, which were of limited duration, is less on the north side, followed by the west, east and south sides, and coincides in a general way with the variation in the resistance of the different sides of the tree. Extensive observations regarding temperature and resistance would undoubtedly show very close relationship between these two factors.

5. The average electrical resistance for the east side of the tree is about 8 per cent. lower than the west side, due, undoubtedly, to differences in temperature existing between the east and west exposures. The difference, however, in the light intensity of morning and afternoon is variable from day to day and from year to year, and may range from 1 or 2 per cent. to 30 per cent. or more per month, but averages between 10 per cent. and 17 per cent. per annum.

6. The difference in the average electrical resistance of the north and south sides of the tree is about 5 per cent., the average difference in the temperature being about the same.

7. The cambium layer offers the least electrical resistance, as shown by lightning discharges and by our experiments. This is followed by the phloem and sapwood.

8. Small plants and branches of trees in general give higher electrical resistances than trees, probably due to the greater

amount of conductive tissue, possessing less resistant qualities in the trees.

9. The high resistance and consequent nonconductivity of trees serves, no doubt, as a protection for the tree against lightning stroke and other electrical discharges.

10. Sap flow did not, so far as we were able to observe, exert any influence on the electrical resistance.

11. Temperature constitutes a determinative factor in variations of electrical resistance of trees. Other meteorological factors, such as relative humidity, barometric pressure, winds, etc., exert no discernible specific influence.

THE CHEMISTRY OF ARSENICAL INSECTICIDES.

BY E. B. HOLLAND AND J. C. REED.

General Introduction.

The work on arsenical insecticides, at the chemical laboratory of this station, has advanced sufficiently to warrant a second report [1] on the subject dealing particularly in this instance with the composition, manufacture and use of Paris green, lime arsenite and lead arsenate. In this connection it may be of interest to consider briefly the monetary loss resulting from injurious insects, and note the insecticides available to check their depredations previous to the introduction of arsenicals.

The aggregate loss in the United States from insect injury to agricultural products of all kinds including live stock, forest and shade trees and ornamental plants, together with the subsequent damage to manufactured goods, is impossible to compute with any degree of accuracy. It has been estimated [2], however, at $1,000,000,000 annually, and may exceed that amount. Without question the successful production of many, if not most, crops is dependent in a large measure upon their protection from noxious insects. The rapidity with which such pests multiply and are disseminated, and the readiness with which they adapt themselves to new conditions, occasionally undergoing considerable change in character, size and appearance, demands thorough scientific treatment for their control, as eradication is practically impossible. The tendency of injurious insects to feed on a greater variety of plants and to become more destructive in a new country than where indigenous, due to more favorable climatic conditions or absence of natural enemies, renders the problem even more difficult to handle.

[1] First report in Mass. Exp. Sta. Rept., 23, p. 122 (1911), entitled The Determination of Arsenic in Insecticides.

[2] Economic entomologists allow 10 per cent. loss on all produce.

The substances formerly employed as insecticides were usually characterized by offensive or caustic rather than poisonous properties. An acrid or bitter taste and a pungent odor were evidently deemed necessary qualifications for insecticides, and the more unpleasant the greater merit they were supposed to possess. Among the more prominent, enumerated by early writers,[1] might be mentioned water, hot water, brine, urine, lye, lime water, whitewash, clay wash, soapsuds, vinegar, petroleum, tar infusion, turpentine, fish oil, whale oil, sulfur, decoctions of aloes, dwarf elder, pepper, quassia chips, rue, tobacco, walnut leaves, wormwood and dustings of wood ashes, quick lime, soot, sulfur, hellebore and tobacco. It is not surprising that the use of such repellants (as a class they could not be designated otherwise) was often ineffectual. The farmers were hampered further by a very imperfect knowledge of the life history and habits of the insects to be combated. To be sure, some of the materials had insecticidal value, largely, however, as contact[2] rather than as internal poisons, effective as an irritant, also, by penetrating the cuticle or entering the body tissue through breathing pores, and possibly in some cases by closing the tracheæ,[3] resulting in the asphyxiation of the insect. The application of these substances, singly or several together, constituted the best recognized treatment both in this country and abroad previous to 1860–70.

Several materials deserve especial notice not only because they possess merit, maintaining a place even to the present time, but more particularly on account of the part taken in the development of modern practice. These are hellebore, pyrethrum, kerosene and lime-sulfur. Hellebore, though known to possess poisonous properties, received little attention until about 1842 in England[4] and later in this country.[5] Pyrethrum has been a

[1] Wm. Speechly, A Treatise on the Culture of the Pine-Apple (1779); J. A. E. Goeze, Geschichte einiger schadlichen Insecten (Leipzig, 1787). Cited by E. G. Lodeman, The Spraying of Plants, p. 5, (1902); Samuel Deane, The Newengland Farmer or Georgical Dictionary, 2d edition (1797); Wm. Forsyth, A Treatise on the Culture and Management of Fruit Trees (1802); Jas. Thatcher, The American Orchardist (1822); Thos. G. Fessenden, The New American Gardener, 6th edition (1832); Wm. Kenrick, The New American Orchardist (1833); Thos. Bridgeman, The Young Gardener's Assistant (1857); J. C. Loudon, The Encyclopedia of Gardening (1878).

[2] How Contact Poisons Kill, Geo. D. Shafer, Mich. Exp. Sta. Tech., Bul. No. 11 (1911).

[3] No attempt was made to differentiate tracheal poisons from contact poisons in general.

[4] A. Mitchell in Gard. Chron., 1842, p. 397.

[5] J. Harris in Country Gentleman, 1865, p. 413.

commodity of southwestern Asia for a long time, but appears to have been overlooked by early European and American agriculturists, being introduced into France about 1850. The efficacy of kerosene, fish and whale oils, and turpentine was acknowledged comparatively early, though they were seldom used on account of the liability to injure the plant. The fact that such substances must be miscible with water to be applied safely was recognized long prior to an understanding of how it could be accomplished. An emulsion [1] of kerosene with soap and water was apparently not used until 1870. Soap and water has probably been more extensively employed in the past than any other substance, both for its effect and as a vehicle. Whale oil soap [2] was recommended in 1842. Lime and sulfur were almost invariably mentioned by early writers on insecticides. They jointly appeared in a number of mixtures, and where heat was employed in their preparation [3] partial combination, at least, must have taken place. This product was a forerunner of the lime-sulfur compounds which have since proved so valuable in checking the San José and other scales.

While the above summary may fail to convey a clear understanding of the subject, it will serve to show that practically no active "food" poison had been used as an insecticide previous to 1860.

The advent of the potato beetle [4] in Nebraska in 1859 and its rapid spread eastward created a demand for a more powerful insecticide than those commonly employed. In a measure this was true also of the imported currant worm which appeared in the eastern States about 1858. The poisonous nature of arsenic was well understood, and its salts would naturally be expected to possess a like property. Paris (Schweinfurt) green had long been known as a pigment under various trade names and was first applied [5] as an insecticide for the potato beetle about 1868, from which time its use was gradually extended to the cotton worm, cankerworm, codling moth and other insects. Subsequently a number of other arsenicals were recommended, of

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[1] Geo. Cruickshank in Gardener's Monthly, 1875, p. 45.

[2] David Haggerston in History of Mass. Hort. Soc., 1829–78, p. 256.

[3] Kenrick, *loc. cit.*, p. XXXVI., and for grape mildew, p. 328 (1833).

[4] C. V. Riley, Potato Pests, pp. 12–24 (1876).

[5] Geo. Liddle, Sr., in Amer. Ent. 1, p. 219 (1869).

which Scheele's green[1] in 1875, London purple[2] in 1877, lime arsenite[3] in 1891 and lead arsenate[4] in 1893 are the most important. Paris green and lead arsenate are to-day the most extensively employed food poisons for leaf-eating insects. Lime arsenite is more particularly a farm preparation. Scheele's green and London purple have been largely superseded by the other compounds.

The Investigation.

The object of the investigation, planned by Dr. H. T. Fernald of the entomological department, was "to ascertain why and under what conditions insecticides burn foliage." The principal arsenicals were to be applied "under differing known conditions of light, temperature and humidity," and where injury resulted, its character and extent carefully determined. Work of this type would naturally extend over a considerable number of growing seasons to furnish sufficient data to warrant positive deductions. The chemical department of the experiment station was required to co-operate so far as to provide the necessary amount of chemicals of known composition, suitable for the purpose intended, together with any information relative to solubility, hydrolysis and power of suspension, that would be of service in their application.

At the outset the laboratory phase of the project appeared an easy matter, — simple analytical work on a relatively small number of samples of similar nature. In February, 1908, letters were sent to several large manufacturers of high-grade chemicals stating the object of the investigation and asking if they could supply Paris green, copper arsenite, lime arsenite and lead arsenate of the necessary purity and, if not, the best method of securing such salts. The replies were rather unsatisfactory, though the order was finally placed with a firm making a specialty of guaranteed reagents. The dry salts were received, but on examination proved unfit for the purpose intended. Work on methods of analysis and study of arsenical reactions were continued, so far as other duties would permit, during the next two years.

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[1] C. V. Riley, Potato Pests, p. 67.

[2] E. G. Lodeman, Spraying of Plants, p. 65.

[3] N. Car. Exp. Sta., Bul. No. 77b, pp. 7-8, (1891).

[4] Mass. Bd. Agr. Rept., 41, p. 282 (1894).

In March, 1910, a persistent effort was made to obtain all help possible in furtherance of the work, as it was then thought that it would be necessary for us to prepare the salts in the station laboratory. A circular letter was sent to manufacturers of chemicals, particularly those firms making insecticides, asking for information relative to the general process of manufacture of the several products. A statement was inserted to the effect that the station was not in quest of trade secrets, but merely wished to secure a fairly broad knowledge of the difficulties attending the manufacture, and of the impurities likely to be present, so as to be in position to handle the problem intelligently. The replies in general contained little or no information of value. Two large concerns, however, took a more liberal view of the matter and readily furnished any data at their command. One of these companies volunteered to supply any insecticides needed free of cost. Inasmuch as a manufacturer of arsenicals with adequate facilities was unquestionably in a better position to handle the matter, the offer was gratefully accepted. In May large, dry samples of Paris green, copper arsenite, lime arsenite and neutral and acid lead arsenates were received from the factory. A laboratory examination showed that not one of these specially prepared insecticides was entirely satisfactory, the Paris green alone being set aside for actual use in spraying tests.

The matter now began to assume rather a serious aspect. Was it possible to produce arsenicals of definite molecular ratios or not? Two companies had signally failed in the attempt, presumably using all the precautions they knew. Letters somewhat similar to those sent the manufacturers had also been addressed to several eminent chemists, requesting their opinions as to the preferable precipitants and conditions of manipulation to insure the proper equilibrium for the production of compounds of theoretical composition. The substance of their replies, while general in character, was to the effect that "the difficulties are inherent in the nature of the compounds," and that arsenites (particularly) are unstable, hydrolizing in the presence of water. The latter fact had long been a matter of record [1] and might excuse slight discrepancies in composition,

[1] See p. 186 of this article.

but the gross differences noted in the several samples were evidently due to incorrect methods of production. This view was substantiated by a large number of tests in the station laboratory, the resulting compounds varying in composition with differing conditions attending their preparation. To be sure, our work was conducted in a small way (2 to 3 ounces at most), but there was no reason to doubt that it would hold equally true on a commercial scale under like circumstances.

After having failed to obtain satisfactory salts from two different companies, and realizing more than ever the lack of manufacturing facilities in the laboratory, the matter was brought to the attention of one of the largest American manufacturers of analytical chemicals with whom the problem had previously been discussed. This firm agreed to undertake the preparation of the arsenicals, following general directions furnished by the laboratory. Dry calcium metarsenite and neutral and acid lead arsenates were received from them early in August, and while all were more or less impure the results, on the whole, were encouraging though showing the necessity of further study in order to give more specific directions. Precipitations under varying conditions were continued into January, 1911, at which time the data at hand warranted placing another order with the last-mentioned firm for acid lead arsenate and calcium metarsenite in form of paste. Explicit directions were furnished by this laboratory as to the method of manufacture. The resulting lead salt proved to be approximately 97 per cent. pure and was accepted. The first lot of lime arsenite was rejected, but the next shipment, over 94 per cent. pure, was accepted and employed in spraying tests during the summer of 1911, together with the acid lead arsenate and Paris green.

The above is a brief statement of some of the difficulties encountered in securing these three insecticides. In the papers that follow will be found under the headings of Paris green, calcium arsenite and lead arsenates a somewhat detailed description of the work performed in this laboratory relative to the several insecticides. Deductions drawn from a small number of samples must be considered indicative rather than conclusive, and their accuracy can be proved only by additional work.

A. Paris Green.

Historical.

Paris green was produced by Russ and Sattler [1] in 1814. The process was kept a factory secret until revealed by the independent investigations [2] of J. Liebig and Henri Braconnot in 1822. Liebig [3] treated 4 parts of verdigris in acetic acid with 3 parts of arsenous oxide in boiling acetic acid. The acid retained the material in solution until the excess was expelled. Braconnot [4] prepared a solution of potassium arsenite by boiling 6 parts of arsenous oxide with 8 of potassium carbonate, poured it while warm into 6 parts of copper sulfate, dissolved in a small quantity of warm water, and added acetic acid until the odor was perceptible. The methods of Liebig and Braconnot have since been modified by many chemists, but substantially they typify the two distinct manufacturing processes employed to-day, *i.e.*, the *instantaneous* and the *slow*.

The instantaneous method is thus described in Watts' "Dictionary of Chemistry:" [5] "Five parts of verdigris are made up to a thin paste, and added to a boiling solution of 4 parts or rather more of arsenous acid [6] in 50 parts of water. The boiling must be well kept up, otherwise . . . acetic acid must be added."

The slow process, as given by a manufacturing company,[7] is as follows: 1,000 pounds of blue vitriol are dissolved in 480 gallons of hot water and run into a 1,200-gallon "striking vat." Four hundred and fifty pounds of sodium carbonate (Solvay) are dissolved in 480 gallons of hot water, and 795 pounds of arsenic "sprinkled" on and boiled to remove carbonic acid.

The boiling arsenic solution is "let down" into the blue vitriol solution, the temperature of which is about 140° F., well stirred, and 210 pounds of acetic acid (100 per cent.) mixed with an equal weight of cold water added. The mixture is

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[1] B. B. Ross, Ala. Exp. Sta., Bul. No. 58, p. 4 (1894).
[2] H. Sattler, Ztschr. Angew. Chem., 1888, p. 35.
[3] Repert. für die Pharm. 13, pp. 446-457 (1822).
[4] Ann. Chim. et Phys. Ser. 2, 21, pp. 53-56 (1822).
[5] 3d edition, 1, p. 10 (1893).
[6] C. L. Bloxam states equal parts by weight of arsenic and copper acetate. (See Chemistry, 9th edition, p. 271 (1907).)
[7] From correspondence on file.

allowed to stand two hours, then well stirred, after half an hour stirred again, and finally at the end of a quarter of an hour the liquid is drawn off and filtered. The resulting Paris green is dried on racks for four or five days at 185° F., or in a steam vacuum oven about 260° F. The yield is 985 pounds.

An electrolytic process for making Paris green from metallic copper, arsenous oxide and acetic acid was patented by Richard Franchot in 1902. No information relative to the character of the product is available.

Paris green is a copper aceto-arsenite for which Eugène Ehrmann's formula [1] is generally accepted.

$$Cu(C_2H_3O_2)_2 \cdot 3\,Cu(AsO_2)_2.$$

As a double salt it may be said to consist of 1 part of copper acetate to 3 of copper metarsenite, equivalent to 17.91 per cent. of the former to 82.09 per cent. of the latter. The structure of Paris green and its homologues was carefully studied by Avery, and while his results [2] most frequently approached a ratio of 1:3, there was invariably a deficiency in arsenic. As the product is not recrystallizable he recognized that purity must be assured largely by a microscopical examination, which proved a questionable guide for so unstable a compound.

Although some chemists claim that the formula is only empirical it certainly expresses the proportion of cupric oxide to combined arsenic trioxide as found in well-formed greens. Four hundred and ninety-nine samples [3] collected in the open market by the Pennsylvania department of agriculture contained on the average: —

	Per Cent.
Cupric oxide,	29.41
Total arsenic trioxide,	56.56
Water soluble arsenic,	1.41

The relation of cupric oxide to "insoluble" arsenous oxide is 1:1.875, theory 1:1.865. Similar results are reported by others.

The comparatively high specific gravity of Paris green, as

[1] Bul. Soc.: ind., Mulhausen 7, pp. 68-80 (1834).
[2] Jour. Amer. Chem. Soc., 28, p. 1155 (1906).
[3] J. W. Kellogg, Bul. No. 192, p. 37 (1910).

recorded by Miles [1] and by Fernald [2] of 3.29 and 3.42 respectively, results in a low power of suspension as shown by Colby [3] of five minutes for a coarse sample and seventeen minutes for a fine, in 1 foot column of water at the proportion ordinarily applied. Woods and Hanson [4] show as a result of a microscopical examination of 21 commercial samples of Paris green, slow process with possibly one exception, that on the average only 5.27 per cent. of the green particles exceeded a diameter of 19.2 microns (.00077 of an inch). The ammonia test for purity mentioned by Riley [5] and by Paddock [6] is now considered of little value except in determining the presence of insoluble materials such as flour and gypsum added as a filler.

The presence of free arsenic in Paris green in any appreciable amount is deemed objectionable by all investigators on account of possible injury to the foliage due to its corrosive action. While free arsenic can usually be detected by the microscope, its quantitative determination for a time proved a more difficult matter, and results by the earlier methods were of questionable value except in a comparative sense. Haywood [7] found that Paris green continued to yield arsenic to successive portions of warm water at 50° to 60° C., and also to repeated washings of cold water on a filter. He secured practically constant results by treating 1 gram of green in a flask with 500 cubic centimeters of water for twelve days, but subsequent tests [8] showed the presence of soluble copper, indicating either solution or breaking down of the green. He favored the latter view, but assumed that the decomposition was in proportion to original content and corrected the results accordingly.

Hilgard [9] acknowledged that warm water was not permissible and recommended a treatment conforming more nearly to orchard practice, 1 gram to 1,000 cubic centimeters of cold water for twenty-four hours with prolonged agitation. He questioned any dissociation of the green, but admitted that continued

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1 Va. Exp. Sta., Bul. No. 24, p. 16 (1893).
2 Mass. Bd. Agr. Rept., 45, p. 355 (1898).
3 Cal. Exp. Sta., Bul. No. 151, p. 34 (1903).
4 Me. Exp. Sta., Bul. No. 154, p. 114 (1908).
5 U. S. Ent. Com., Bul. No. 3, p. 56 (1880).
6 N. Y. Exp. Sta., Bul. No. 121, p. 219 (1897).
7 Jour. Amer. Chem. Soc., 22, p. 579 (1900).
8 Jour. Amer. Chem. Soc., 22, p. 705 (1900).
9 Jour. Amer. Chem. Soc., 22, p. 691 (1900).

percolation gave free arsenic. Avery and Beans,[1] working with a sample of perfect structure and of nearly theoretical composition, found that when treated in a stoppered flask, ½ gram to 500 cubic centimeters of water, the arsenic continued to pass into solution for sixteen weeks, the duration of the experiment. Upon breaking the granules of Paris green by grinding in a mortar the disintegration was more rapid until a state of equilibrium was reached. Carbonic acid also increased the solubility of the arsenic. The decomposition was evidently due to hydrolysis, as the arsenic dissolved in much greater proportion of the original content than did the copper. They concluded that any method based on solubility in water was merely arbitrary, as "the amount of arsenic trioxide in solution appears to depend almost entirely on the length of time of action, the concentration of the solution and the state of division of the particles of Paris green." To distinguish free arsenic from that rendered free by hydrolysis, Avery and Beans recommended boiling 1 gram of green five minutes in 25 cubic centimeters of sodium acetate solution (1 to 2). It was found that the sodium acetate solution readily dissolved the free arsenic and at the same time largely prevented hydrolysis of the green. The Hilgard method, 1 gram to 1,000 cubic centimeters of water for twenty-four hours with agitation, indicates free and loosely combined arsenic, and while such results are invariably higher than the former, the increase for greens of perfect structure, free from broken particles, is comparatively slight. These two processes are now quite generally employed. The Association of Official Agricultural Chemists[2] recognizes the acetate method and the ten days' extraction method recommended by Haywood as provisional methods.

To prevent arsenical injury to foliage, Gillette[3] and Kilgore[4] advised mixing Paris green with milk of lime to neutralize the free arsenic, and Weed[5] suggested combining the green with Bordeaux mixture.

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1 Jour. Amer. Chem. Soc., 23, p. 111 (1901).
2 Methods of Analysis Bur. Chem. Bul. No. 107 (revised), p. 27 (1908).
3 Iowa. Exp Sta., Bul. No. 10, pp. 410–413 (1890).
4 N. Car. Exp. Sta., Bul. No. 77b, pp. 4–7 (1891).
5 Ohio Exp. Sta., Bul. (Vol. 2) No. 7, p. 186 (1889); *Ibid.*, (Vol. 4) No. 2, pp. 39–42 (1891).

Experimental Results.

The terms "instantaneous" and "slow process" are used to designate Paris greens of different physical structure. While this classification may not be in strict conformity with some writers it appears, nevertheless, the most desirable for the purpose intended.

Instantaneous green is the result of a quick boiling process as previously shown. The ultimate reaction is illustrated by the following equation: —

$$3\ As_2O_3 + 4\ Cu(C_2H_3O_2)_2H_2O = Cu(C_2H_3O_2)_2 \cdot 3\ Cu(AsO_2)_2 + 6\ C_2H_4O_2 + H_2O.$$

If the process could be carried out with the ingredients in the proportion given there would be very little waste. In practice, however, instead of 1 part by weight of arsenous acid to 1.34 parts of copper acetate, an equal amount appears necessary to insure the desired change. This is probably due to the weak acid properties of the arsenic.

Slow process green is generally formed less rapidly and at a lower temperature than the instantaneous. From what could be learned the slow process seems to be the one employed by most of the large manufacturers. Blue vitriol is used as the source of copper, and sodium arsenite ($NaAsO_2$) in place of arsenous oxide, on account of its greater solubility and the necessity for a base to neutralize the sulfuric acid. Sodium arsenite is easily prepared by adding a thin paste of arsenous oxide in slight excess to a boiling solution of caustic soda or of a carbonate.

$$Na_2CO_3 + As_2O_3 = 2\ NaAsO_2 + CO_2.$$

The soda and arsenic readily combine with volatilization of carbonic acid. As commercial salts were often employed in our work the analyses of two are given: —

Sodium Arsenite.

	Baker and Adamson (Per Cent.).	Kahlbaum (Per Cent.).	Theoretical (Per Cent.).
Arsenic trioxide,	78.68	74.71	76.15
Sodium oxide,	18.45	22.63	23.85
	97.13	97.34	100.00

The sodium oxide was calculated from the alkalinity, determined by direct titration with methyl orange as indicator, a process sufficiently accurate for the purpose of checking quality.

The several reactions taking place in the manufacture of slow process green may be summarized in a single equation: —

$$4\,CuSO_4 5\,H_2O + 8\,NaAsO_2 + 2\,C_2H_4O_2 \\ = Cu(C_2H_3O_2)_2 \cdot 3\,Cu(AsO_2)_2 + As_2O_3 + 4\,Na_2SO_4 + 6\,H_2O.$$

Sodium arsenite reacts upon the blue vitriol with the production of a bulky, yellowish-green precipitate of copper arsenite (Scheele's green), which in turn is acted upon by the acetic acid with the formation of a greatly reduced volume of Paris green. Experience has shown, as indicated by the above formula, that about ⅓ more arsenic is required for the production of the green than actually enters combination, as was the case with the instantaneous process. Acetic acid in excess of the 2 molecules stated (by nearly 66 per cent.) is needed for the reaction. It is evident from what has been said that the manufacture of slow process green requires considerable equipment, expensive reagents and expert control which, together with the unavoidable waste of chemicals, insures a costly product.

The two general processes for making Paris green and their several reactions were carefully studied in the station laboratory to ascertain the character of the product that might reasonably be expected. As a result of numerous experiments a combination process, using copper acetate and sodium arsenite, together with sufficient acetic acid to offset the alkalinity of the arsenite, was found the most acceptable.

$$4\,Cu(C_2H_3O_2)_2H_2O + 6\,NaAsO_2 + 6\,C_2H_4O_2 \\ = Cu(C_2H_3O_2)_2 \cdot 3\,Cu(AsO_2)_2 + 6\,NaC_2H_3O_2.$$

The reaction was easy to control, could be carried out at any temperature from that of the laboratory to boiling and gave a product of variable physical structure and of fine color. Solutions of different concentrations were tried, of which ⅕ molecular (M/5) for the acetate and ½ molecular (M/2) for the arsenite proved satisfactory. This process appeared to require less arsenic in *excess* than the ordinary method, although the work was performed on too small a scale to warrant positive statements to that effect.

Attention has already been called, on pages 180 and 181 to two samples of Paris green supplied by different manufacturers for the investigation, of which the second was employed in actual spraying tests. The sample of instantaneous green was made according to the method described, with the exception that crystallized copper acetate was substituted for verdigris. The slow process sample was selected from a factory run of commercial green manufactured substantially as has been stated.

Paris Green from Chemical Manufacturers.

	Instantaneous Green.	Slow Process Green.	Theoretical.
Manufacturer,	A	B	-
Character of product,	Dry powder.	Dry powder.	-
Color,	Pale green.	Bright green.	-
Shape of green particles,[1]	Irregular, angular.	Mostly perfect spheres.	-
Size of green particles,[1]	Average 10 μ.	12–30 μ, average 17.39 μ.	-
Uniformity,[1]	Very little variation.	Considerable variation.	-
Nature of impurities,[1]	Crystalline matter.	Crystalline matter.	-
Amount of impurities,[1]	Large amount.	Small amount, less than 5 per cent.	-
Flow,	Poor.	Excellent.	-
Film test,	Whitish.	Green.	-
Water (per cent.),	.78	1.46	-
Cupric oxide (CuO) (per cent.),	31.74	30.94	31.39
Arsenic trioxide (As_2O_3) (per cent.),	56.94	56.34	58.55
Acetic anhydride ($C_4H_6O_3$) (per cent.),	10.37	9.94	10.06
Ferric (Fe_2O_3) and aluminum oxides (Al_2O_3) (per cent.).	-	.53	-
Sulfuric acid (SO_3) (per cent.),	-	.29	-
Insoluble matter (per cent.),	.00	.05	-
	99.83	99.55	100.00
Arsenic (As) (per cent.),	43.13	42.68	44.35
Suspension in water,	-	17 minutes.	-
Suspension in filtered lime water,	-	48 minutes.	-

Both greens contained an excess of cupric oxide and acetic acid, and may have been hydrolyzed somewhat by washing with

[1] Determined by the entomological department of this station.

the formation of a basic acetate. Sample B showed a considerable amount of impurities. Any hypothetical combination of the various constituents that might be offered would be decidedly arbitrary, and a discussion seems inadvisable at this time. A careful study of the results would indicate that the slow process green, exclusive of moisture, was at least 96 per cent. pure. To be of standard quality Paris green should contain not less than 50 per cent. of arsenous oxide combined with copper, and not more than 3.50 per cent. of arsenous oxide soluble in water. The poisonous character of Paris green is dependent on the arsenic content, but the form in which the arsenic exists largely fixes its value as an insecticide. Adulteration is seldom practiced under the inspection laws now in force.

Paris green is a dry, impalpable powder that readily passes a 100-mesh sieve, and to the touch resembles flour. A microscopical examination is required to determine the size, shape and uniformity of particles as well as the general character and amount of impurities. The latter may consist of Scheele's green that was not transformed or by-products such as arsenic, sodium sulfate, sodium acetate and possibly other compounds not intentionally added but present in the original chemicals. The sample of instantaneous green under examination was of a pale green color, and consisted of very small, irregular, angular particles with considerable impurity. It was cohesive, had a poor "flow," and the film test [1] on glass appeared whitish. The slow process green, on the other hand, had a brilliant green color of metallic luster, and was composed of minute green spheres of various sizes, together with a small amount of crystalline and fragmentary matter. It had an excellent "flow," and the film test on glass was green. The size of the particles is affected by the concentration, temperature and amount of agitation at the time of formation. The smaller the globules with retention of perfect form and similar size, the more desirable the product.

Paris green has a high specific gravity and a low power of suspension. In the station laboratory suspension was determined [2] in a foot column containing the insecticide at the proportion of 1 gram of dry salt to 1,000 cubic centimeters of

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[1] C. W. Woodworth, Cal. Exp. Sta., Bul. No. 126, p. 13 (1899).

[2] Modification of the California method. G. E. Colby, Cal. Exp. Sta., Bul. No. 151, pp. 33-35 (1903).

water. The mixture in a closed cylinder was thoroughly agitated, and the reading, in minutes, taken with a horizontal microscope, using a 1-inch eyepiece and ½-inch objective, when movement of the particles midway of the column (6 inches down) was no longer apparent. The slow process green gave a reading of seventeen minutes in water and forty-eight minutes in filtered lime water. As lime tends to flocculate the particles of Paris green, the test should be performed immediately after mixing.

Although copper aceto-arsenite is termed insoluble in water, decomposition readily takes place under certain conditions; therefore, the determination of so-called "free" and "loosely combined" arsenic is closely related to stability of product and should be considered in that connection.

Solubility.

	Instantaneous Green.	Slow Process Green.
Manufacturer,	A	B
Water (per cent.),	.78	1.46
Sodium acetate soluble "free arsenic" (Avery and Beans Method): —		
Cupric oxide,	Trace.	Trace.
Arsenic trioxide (per cent.),	1.45	.74
Copper acetate soluble: —		
Arsenic trioxide (per cent.),	1.09	.45
Water soluble "free and loosely combined arsenic" (Hilgard Method):—		
Cupric oxide,	None.	Trace.
Arsenic trioxide, (per cent.)	2.06	.86
Solids (per cent.),	3.08	1.96
Lime water soluble: —		
Cupric oxide,	None.	-
Arsenic trioxide (per cent.),	.97	1.52
Ammonia insoluble (per cent.),	-	.11

Neither of the greens contained an excessive amount of free or of free and loosely combined arsenic, judging by the standard, although the slow process was decidedly the better in that respect. This was to be expected, as the finely divided angular particles of the instantaneous green offered greater surface and apparently less resistance to a solvent than the nearly perfect spheres of the slow process. The copper acetate soluble results are of uncertain value. Filtered lime water, with .12 per cent. calcium oxide, contained insufficient lime to prevent solution of the arsenic. Ammonia dissolves Paris green and the normal by-products concomitant with its manufacture, such as copper arsenite, arsenous oxide, sodium sulfate and sodium acetate; the residue, .11 per cent. in case of the slow process green, was organic and other insoluble materials.

To ascertain the solvent action of various substances in solution on Paris green, a series of tests were conducted with the slow process sample. The green in stoppered flasks was treated with water and with solutions of the respective compounds at the rate of 1 gram to 1,000 cubic centimeters for twenty-four hours at laboratory temperature, with occasional agitation during the working day.

Solubility Tests, Slow Process Green.

SOLVENT.	Amount of Solvent in a Liter of Water (Grams).	Soluble As_2O_3 (Per Cent.).	Copper.	Remarks.
Distilled water,	-	.84	None.	- -
Water saturated with CO_2,	-[1]	6.16	Much.	- -
Ammonium hydroxide (concentrated).	1	.86	None.	- -
Ammonium hydroxide (concentrated).	5	13.49	Much.	Residue darker green.
Ammonium carbonate,	1	6.83	Much.	Blue solution.
Ammonium carbonate,	5	55.93	Excessive.	Blue, nearly complete solution.
Ammonium chloride,	1	2.41	Considerable.	- -
Ammonium nitrate,	1	2.03	Trace.	- -
Ammonium nitrate,	5	4.70	Much.	- -
Ammonium nitrite solution,	1	.36	- -	- -
Ammonium nitrite solution,	5	.36	- -	- -
Ammonium sulfate,	1	4.20	Considerable.	- -
Sodium carbonate (anhydrous),	1	3.15	None.	- -
Sodium bicarbonate,	1	.84	Very slight trace.	- -
Sodium chloride,	1	.96	None.	- -
Sodium nitrate,	1	.86	None.	- -
Sodium nitrite,	1	.88	- -	- -
Sodium sulfate (anhydrous),	1	1.67	Very slight trace.	- -
Boiling water, one hour,	-	14.93	Much.	Change in color of residue.

[1] About 5 gallons of gas used, water pressure.

Cold water dissolved a small amount of arsenic, boiling water very much more. The green appeared to resist hot water for a considerable time after which the change was noticeable. If the boiling had been continued all the arsenic would probably have passed into solution. The .10 per cent. ammonium salts, exclusive of nitrite, dissolved on the average 58 per cent.[1] more arsenic than the corresponding sodium salts. In both instances the carbonate was the most active, followed respectively by the sulfate, chloride and nitrate. Sodium bicarbonate was apparently inactive under the conditions employed. Free carbonic acid was effective and so was ammonia when in sufficient amount to overcome the resistance of the green, and jointly, carbonic acid and ammonia dissolved the most arsenic.

It is evident from what has been stated that carbonic acid and ammonia of the atmosphere in conjunction with dew, fogs or light rains and high temperature will materially increase the dissociation of Paris green. Data more or less contradictory have been offered by various investigators relative to the influence of weather conditions on the effect of arsenic on foliage. While more or less problematical, certain deductions seem warranted: conditions favoring a rapid drying of the green and its continuance in a dry state are propitious. For instance, a relatively high temperature, low humidity and a good circulation of air at the time of application, followed by warm, dry weather should tend toward a minimum of arsenical injury. On the other hand, factors conducive to solubility of the arsenic and its passage by osmosis into the substance of the leaf are detrimental; as, for example, warm, "muggy" weather or warm weather accompanied by fogs or heavy dews. Rains are not necessarily injurious if of sufficient quantity to remove the soluble arsenic from its sphere of influence. The addition of milk of lime to Paris green tends to reduce arsenical injury by forming, with the free arsenic, arsenite of lime insoluble in the presence of excess lime. As lime flocculates the particles of green, it is not advisable to prepare the spray mixture until shortly before application.

In conclusion, it may be said that Paris green contains a fairly high per cent. of arsenic, is nominally insoluble in water

[1] Direct comparison.

but unstable, hydrolizing readily under favorable conditions. It has a low power of suspension though its fineness permits of reasonable distribution. It is a poor indicator without lime of the leaf surface covered, but possesses fair adhesive qualities.

B. Calcium Arsenite.

Historical.

Early attempts to use arsenous oxide as an insecticide by Riley [1] in 1869 and Saunders and Reed [2] in 1871 were unsatisfactory. John Smith [3] in 1868 appears to have been more successful, applying it in water, but the practice proved too hazardous to warrant its continuance, although freshly prepared mixtures have been applied in numerous instances without injury. The relatively high cost of Paris green and London purple, and the necessity of adding lime to neutralize the free arsenic, led to the production of lime arsenite. So far as known this has always been a farm preparation and not a commercial product.

Kilgore [4] recommended adding 1 pound of white arsenic to 2 pounds of lime in 2 to 5 gallons of water and boiling thirty minutes. Taft [5] advised adding 2 pounds of freshly slaked lime to 1 pound of arsenic in 2 gallons of water and boiling forty minutes. Kedzie [6] suggested dissolving the arsenic in a solution of sal soda and offered the formula which bears his name. Boil 2 pounds of arsenic with 8 pounds of sal soda in 2 gallons of water until dissolved. Slake 2 pounds of lime, add to 40 gallons of water and stir in 1 pint of the arsenic solution. Stewart [7] evidently noted the undue amount of sal soda in the Kedzie formula and reported better results, using equal parts, 2 pounds of arsenic and 2 pounds of sal soda. E. L. Smith [8] recommended 2 pints of Kedzie mixture to 6 to 10 pounds of lime in 50 gallons of water, and claimed that the additional lime increased safety and adhesiveness.

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[1] Potato Pests, p. 60 (1876).

[2] Can. Ent., 3, pp. 45–47 (1871).

[3] Western Pomologist, 2, p. 125 (1871). Cited by Lodeman.

[4] N. Car. Exp. Sta., Bul. No. 77b, pp. 7–8 (1891).

[5] Mich. Bd. Agr. Rept., 35, p. 119 (1897). In Rept. 37, p. 466 (1899), the amount of lime was increased 8 pounds on application.

[6] Mich. Farmer, 31, p. 132 (1897).

[7] Penn. Exp. Sta., Bul. No. 99, p. 11 (1910).

[8] Cal. Exp. Sta., Bul. No. 126, p. 24 (1899).

Authorities differ as to the arsenite that results from the union of lime and arsenic. Prescott and Johnson [1] state that the arsenites of the alkaline earth are usually ortho compounds, Merck & Co.[2] and Gooch and Walker [3] give neutral orthoarsenite of lime, while Comey [4] and Watts' Dictionary [5] recognize the ortho, $Ca_3(AsO_3)_2$, the meta, $Ca(AsO_2)_2$, and the pyro, $Ca_2As_2O_5$, salts. The latter is designated a mixture of basic salts with 1 molecule of water, $2CaO.As_2O_3.H_2O$. So far as noted the formula acknowledged by experiment station workers has been that of the neutral ortho salt, although the subject has been given little attention.

As determined by Colby [6] the suspension, in 1 foot column, of arsenite of lime made according to directions published by Taft was forty-four minutes, and by Kedzie formula fifty-seven minutes. Headden [7] noted that arsenite of lime was almost entirely soluble in water and in dilute solutions of sodium sulfate and sodium chloride.

Experimental Results.

For the preparation of a high-grade arsenite of lime required for the work in view, precipitation from soluble salts of lime and of arsenic, while more costly, promised a more definite and uniform product. As lime arsenite is noncrystallizable, precipitation from perfect solutions insured better combination and greater freedom from admixtures. The comparative insolubility of lime, CaO, necessitated the use of a soluble salt. Lime salts of strong oxidizing acids were deemed objectionable on account of possible action on the arsenite and were excluded. The acetate of organic compounds and the chloride of the halogens were selected for trial, but after several tests the chloride was considered preferable. The fused salt was almost invariably employed. It should be free from other bases forming insoluble compounds with arsenic. The direct use of arsenous oxide is not advisable with a lime *salt*, not only for

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1 Qual. Chem. Anal., 6th edition, p. 57 (1905).
2 Merck's 1907 Index, p. 113.
3 Outlines of Inorg. Chem. Pt. 2, p. 184 (1905).
4 Dict. of Chem. Sol., p. 41 (1896).
5 Watts' Dict. of Chem., 3d edition, 1, p. 306 (1893).
6 Cal. Exp. Sta., Bul. No. 151, p. 34 (1903).
7 Col. Exp. Sta., Bul. No. 131, p. 22 (1908).

the reason that ordinary porcelaneous arsenic in pulverulent condition is difficult to moisten and of low solubility, but more particularly because it would induce a secondary reaction from lack of base to satisfy the acid that was previously combined with the lime. Sodium arsenite, $NaAsO_2$, is readily soluble and proved a satisfactory source of arsenic. A salt of fair quality can be procured on the market, or is easily prepared by adding 1 part of arsenous oxide to a boiling solution of 1.45 parts of sal soda, or an equivalent amount of soda in the form of anhydrous carbonate, bicarbonate or hydroxide. A slight excess of arsenic is required to insure complete volatilization of the carbonic acid.

$$Na_2CO_3 \cdot 10\,H_2O + As_2O_3 = 2\,NaAsO_2 + CO_2 + 10\,H_2O.$$

The resulting arsenite should be free from arsenates, carbonates, sulfates or other acids forming insoluble compounds with lime.

Any decision as to concentration of solutions is naturally more or less arbitrary; dilution tends to make difficult precipitation with considerable loss of salt, and the opposite an unwieldy precipitate with greater occlusion. As a compromise solutions of ½ molecular strength (M/2) were finally adopted. Another factor studied was the influence of temperature of solutions on the resulting precipitate, ranging from that of the laboratory to nearly boiling point at the moment of precipitation. Room temperature with two hours' standing gave a product of practically the same composition, and of probably better physical characteristics, than the higher temperatures and was considered more desirable.

As the alkalinity of the soda in sodium arsenite is not destroyed by the arsenous acid, it should be run into the calcium chloride solution slowly with constant agitation in order to prevent any precipitation of calcium hydroxide. An excess (10 per cent.) of sodium arsenite was found desirable to perfect the salt. After standing several hours the liquor was removed by means of a Buchner funnel, and the lime arsenite washed rapidly with cold water until nearly free from chlorides. A centrifuge or filter press might give equally good or better results provided the work was done rapidly. Undue washing was avoided, as it was thought safer to retain a small amount of sodium chloride than to take chances on *possible* hydrolysis and decomposition of the arsenite, an action readily inferred from the behavior of Paris green under similar conditions. The above method of preparation was employed in all subsequent work unless otherwise noted. Minor changes were attempted in some instances from which no apparent benefit was derived.

As previously stated there was considerable uncertainty as to the composition of the lime precipitate. To ascertain whether the resulting product was a definite compound and, if so, its composition, salts were produced from an excess of sodium arsenite into calcium chloride and *vice versa*, observing the usual precautions as to dilution, precipitation of calcium hydroxide, oxidation of the arsenic, etc. Incomplete analyses of a few laboratory samples are given.

Calcium Arsenite produced in the Laboratory (Per Cent.).

	Excess $NaAsO_2$ into $CaCl_2$.			Excess $CaCl_2$ into $NaAsO_2$.
	Precipitated Hot.	Precipitated at 90° C.	Precipitated and held at 90° C. for Two Hours.	Precipitated Hot.
Water,	.12	.12	-	.12
Arsenic trioxide,	77.01	77.04	76.75	76.80
Insoluble matter,	-	-	-	.03

The small samples were of uniform composition, indicating a definite compound of about 77 per cent. arsenic content. This amount of arsenic exceeds the requirements of the ortho and pyro salts, and substantially conforms to that of the meta compound with a theoretical content of 77.92 per cent. The following equation illustrates the reaction that must have occurred: —

$$CaCl_2 + 2\,NaAsO_2 = Ca(AsO_2)_2 + 2\,NaCl.$$

Attention has been called on pages 180, 181 and 182 to 5 samples of lime arsenite supplied by several firms for the investigation. Manufacturer C was furnished directions deduced from experimental work in the station laboratory. A and B evidently employed a different method.

Calcium Arsenite from Chemical Manufacturers.

	As received.					In Dry Matter.	Theoretical.
Manufacturer,[1]	A	B	C_1	C_2	C_3	C_3	-
Character of product,	Dry, granular.	Moist powder.	Dry, granular.	Gritty[2] paste.	Smooth paste.	-	-
Color,	White.	White.	Slightly pink.	Pink.[2]	Nearly white.	-	-
Water (per cent.),	.67	16.27	.80	-	67.87	-	-
Calcium oxide (CaO) (per cent.),	-	-	21.63	-	6.78	21.10	22.08
Arsenic trioxide (As_2O_3) (per cent.),	29.39	29.36	76.31	-	23.87	74.28	77.92
Arsenic pentoxide (As_2O_5) (per cent.),	-	-	-	-	.09	.28	-
Magnesium oxide (MgO) (per cent.),	-	-	-	-	.05	.16	-
Chlorine (Cl) (per cent.),	-	-	-	-	.80	2.49	-
Sodium oxide (estimated) (Na_2O) (per cent.),	-	-	-	-	.70	2.18	-
Insoluble matter (per cent.),	5.63	.20	.02	-	.01	.03	-
	-	-	-	-	100.17	100.52	100.00
Less oxygen equivalent to chlorine (per cent.),	-	-	-	-	.18	.56	-
	-	-	-	-	99.99	99.96	-
Arsenic (As) (per cent.),	-	-	-	-	18.14	56.46	59.02
Suspension in lime water, hours,	-	-	-	-	56	-	-
Suspension in lime water after drying, hours,	-	-	-	-	48	-	-

[1] A, B and C refer to individual manufacturers, the numerals to different samples.
[2] Gritty on account of compressed air being used to agitate and pink due to the presence of manganese.

Sample C_1 and C_3 confirmed the former analyses as to arsenous oxide, and the molecular ratio of calcium oxide to arsenous oxide was almost theoretical for calcium metarsenite. It would, therefore, appear safe to assume that lime arsenite precipitated from soluble salts of lime and of arsenic is invariably the meta salt.

Sample C_3 was employed in spraying, although in the process of manufacture it had been imperfectly washed, contained a small amount of magnesia and showed a slight oxidation of arsenic. Any arrangement of constituents is of doubtful value; still, the following may be suggested: —

Calcium Arsenite employed in Spraying.

Manufacturer,	C_3
Water (per cent.),	67.87
Calcium orthoarsenate ($Ca_3(AsO_4)_2 \cdot 3\,H_2O$) (per cent.),	.18
Magnesium metarsenite ($Mg(AsO_2)_2$) (per cent.),	.30
Calcium metarsenite ($Ca(AsO_2)_2$) (per cent.),	30.31
Sodium chloride (NaCl) (per cent.),	1.32
Insoluble matter (per cent.),	.01
	99.99

The above analysis would indicate a purity, on a water-free basis, of 94.34 per cent.

Calcium metarsenite, prepared according to the directions given, is a smooth white gelatinous mass or jell of very fine, adhesive particles. The power of suspension which has to be determined in lime water to prevent partial solution is extremely high but lessened by drying. Sample C_3 gave phenomenal results, though the actual figures are indicative rather than absolute. A moist paste of arsenite of lime proved unstable, gradually changing to arsenate with the separation of free arsenic (As). Calcium arsenite is probably the most soluble arsenical insecticide in use as shown by the following results: —

Solubility.

MANUFACTURER,	A	B	C_1	C_2	C_3
Water (per cent.),	.67	-	.80	-	67.87
Calcium acetate soluble: —					
Arsenic trioxide (per cent.),	27.55	-	11.62	-	-
Water soluble (Hilgard Method): —					
Calcium oxide (per cent.),	-	-	10.98	-	3.14
Arsenic trioxide (per cent.),	24.78	-	40.88	-	11.58
Solids (per cent.),	64.90	-	53.48[1]	-	16.54
Lime water soluble: —					
Arsenic trioxide (per cent.),	.14	-	.17	-	.05

The calcium acetate soluble appeared to have no particular significance, and the test was eventually dropped. The water soluble results are only approximate, as slight variations in temperature or agitation caused marked differences. Solubility is apparently not a result of hydrolysis, as proportionally the lime passed into solution almost as rapidly as the arsenic. If hydrolysis played any part it would seem to be inappreciable. Lime arsenite was nearly insoluble in lime water. In order to secure additional data relative to the solubility of lime arsenite, 1 gram of sample C_3, after drying, was subjected to the action of various solvents for twenty-four hours in stoppered flasks with occasional agitation, the results of which are stated below: —

Solubility Tests, Sample C_3 Dried.

SOLVENT.	Amount of Solvent in a Liter of Water (Grams).	Soluble As_2O_3 (Per Cent.).	Lime.	Remarks.
Distilled water,	-	38.45	Present.	-
Water saturated with CO_2,	-[2]	62.22	Present.	-
Ammonium hydroxide (concentrated),	1	36.66	Present.	-
Ammonium carbonate,	1	64.36	Trace.	-
Ammonium chloride,	1	53.40	Present.	-
Ammonium nitrate,	1	51.97	Present.	-
Ammonium nitrite solution,	1	43.06	Present.	-
Ammonium sulfate,	1	52.71	Present.	-
Sodium carbonate (anhydrous),	1	59.32	None.	-
Sodium bicarbonate,	1	62.19	None.	-
Sodium chloride,	1	41.20	Present.	-
Sodium nitrate,	1	40.53	Present.	-
Sodium nitrite,	1	40.72	Present.	-
Sodium sulfate (anhydrous),	1	41.08	Present.	-
Boiling water, 1 hour,	-	58.63	Much.	-

[1] Contained .39 per cent. of ferric and aluminum oxides and .08 per cent. of magnesium oxide.
[2] About 5 gallons of gas used, water pressure.

Calcium metarsenite was fairly soluble in cold water, but much more so in boiling water. The ammonium salts, exclusive of nitrite, dissolved about 19 per cent.[1] more arsenic than the corresponding sodium salts. The carbonate in both instances proved very effective, followed by the chloride, sulfate and nitrate with only slight differences between the latter. An interchange of bases must have resulted in many instances to permit the high solubility recorded. Carbonic acid, combined and free, was the most active of any single agent, consequently excess lime should afford one of the best methods of protection under atmospheric conditions. Ammonium hydroxide depressed slightly the solubility of the arsenic.

Calcium metarsenite contains the highest per cent. of arsenic of all the common insecticides, and is quite soluble except in presence of excess lime; the fineness of its particles and the high power of suspension insure uniform distribution; the white film readily indicates the surface covered; and its adhesiveness provides protection for a reasonable period under average weather conditions.

C. Lead Arsenates.

Historical.

F. C. Moulton,[2] chemist for the Massachusetts Gypsy Moth Commission, was the first to prepare arsenate of lead for insecticidal purposes. He employed lead acetate and sodium arsenate. The work was continued by F. J. Smith,[3] who studied the composition of the chemicals used, the reactions and other matters pertaining to the manufacture. He stated that ordinary spray material was not a single salt, but a mixture of neutral and acid arsenates, and believed that the relative amount of each depended principally upon the source of the soluble lead salt, although temperature and concentration at the moment of precipitation affected the results; in other words, that acetate of lead had a tendency, other factors being equal, to yield the neutral salt and the nitrate the acid arsenate.

An electrolytic process for making arsenate of lead was patented by C. D. Vreeland in 1907, using lead, sodium arsenate

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[1] Direct comparison.

[2] Mass. Bd. Agr. Rept., 41, p. 282 (1894).

[3] *Ibid.*, 45, pp. 357–371 (1898).

and an electrolyte of sodium nitrate. Patents have also been taken out on various other methods of manufacture, references to which are found in technical journals. I. W. Drummond patented a dry preparation of lead nitrate, sodium arsenate and corn starch to be mixed with water when applied.

Most authorities recognize neutral orthoarsenate of lead, $Pb_3(AsO_4)_2$, and acid arsenate, $PbHAsO_4$, and a few mention pyroarsenate, $Pb_2As_2O_7$. W. H. Volck [1] claims the latter salt may occur in commercial pastes, though Lefevre [2] states that it is decomposed by cold water. Pyroarsenate differs from 2 molecules of the acid salt by 1 molecule of water.

$$Pb_2As_2O_7 + H_2O = 2\,PbHAsO_4.$$

So far as noted, the presence of pyroarsenate in insecticides has not been proved.

The low specific gravity of lead arsenate, 1.00668 according to Smith [3] (salt not specified), results in a high power of suspension as shown by Colby,[4] from nitrate one hundred and thirty minutes and from acetate two hundred and forty minutes. Investigators have found lead arsenates comparatively little affected by hot water or carbonic acid. Dilute solutions of sodium carbonate, sodium chloride and sodium sulfate have an appreciable action as shown by Headden [5] and others. The acid salt has invariably proved the more unstable. Volck [6] noted that under alkaline conditions it tends to decompose with the formation of the ortho salt and arsenic acid, and he states that this reaction appears to take place in the orchards of the Pacific coast as a result of the continuous fogs and heavy dews. P. J. O'Gara [7] also claims that the acid salt is very injurious under certain climatic conditions. Haywood [8] recommended the addition of lime to arsenate of lead to prevent injury to delicate foliage.

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[1] Science, 33, p. 868 (1911).
[2] Cited by A. M. Comey, Dict. of Chem. Sol., p. 35.
[3] Mass. Bd. Agr. Rept., 45, p. 355 (1898).
[4] Cal. Exp. Sta., Bul. No. 151, p. 34 (1903).
[5] Col. Exp. Sta., Bul. No. 131, p. 22 (1908); Bul. No. 157, pp. 29, 30 (1910).
[6] *Loc. cit.*
[7] Science, 33, p. 900 (1911).
[8] Bur. Chem., Bul. No. 131, p. 49 (1910).

Experimental Results.

In the production of lead arsenates pure chemicals are a prime requisite for a high-grade product. The lead salts should be free from other bases forming insoluble arsenates, and the sodium arsenate ($Na_2HAsO_47H_2O$) from arsenites, carbonates, chlorides and sulfates. Acetate of lead is objectionable as a source of lead in that it readily carbonates on exposure to air. As to concentration of solutions, our experience has shown that for salts of such high molecular weight dilute solutions not exceeding ⅕ molecular (M/5) are preferable. At that dilution, laboratory temperature gives a very finely divided precipitate which is highly desirable from the standpoint of suspension. The arsenate should be run into the lead salt *very slowly* with thorough agitation in order to prevent precipitation of lead hydroxide due to the alkalinity of the sodium salt. The reverse precipitation, lead into the arsenic, proved less satisfactory both as to formation and behavior of the precipitate. While arsenic acid is stronger than arsenous, it neutralizes only about one-half the alkalinity of the soda in disodium hydrogen arsenate.

Neutral Lead Arsenate. — After many attempts, employing di and tri sodium and ammonium arsenates, salts containing arsenic and lead in proper molecular ratio were finally produced according to the following equation: —

$$3\,Pb(C_2H_3O_2)_23\,H_2O + 2\,Na_2HAsO_47\,H_2O$$
$$= Pb_3(AsO_4)_2 + 4\,NaC_2H_3O_23\,H_2O + 2\,C_2H_4O_2 + 11\,H_2O.$$

To obtain these results it was necessary to prepare the disodium arsenate in order to exclude carbonic acid which was present in the commercial salts purchased. The principal difficulties, however, arose from failure to add the strongly alkaline sodium arsenate slowly and with sufficient agitation to prevent the precipitation of lead hydroxide and to maintain an excess of at least 5 per cent. of lead to prevent the formation of the acid salt. The usual precautions as to concentration, temperature and thoroughness of washing were carefully observed. The following analyses of two samples show the material to be practically of theoretical composition: —

Neutral Lead Arsenate produced in the Laboratory.

Sample number,	31	32
Water 100° C. (per cent.),	.75	.70
Arsenic pentoxide (per cent.),	25.10	25.18
Lead oxide (per cent.),	73.15	73.20
Water occluded (per cent.),	.98	.82
	99.98	99.90

The lead salt invariably contained a small amount of water probably held by occlusion which is not volatilized at 100° C.

Acid lead arsenate is readily prepared from nitrate of lead and sodium arsenate provided dilute solutions are employed and the sodium salt added carefully in excess (10 per cent.).

$$Pb(NO_3)_2 + Na_2HAsO_4 7\ H_2O = PbHAsO_4 + 2\ NaNO_3 + 7\ H_2O.$$

By this method of procedure no difficulty was experienced in producing salts of theoretical composition. The acetate can be used as a source of lead, but is less satisfactory.

Six samples of lead arsenate were supplied by three manufacturers for the spraying tests. Manufacturer C was furnished full directions as outlined above for making the acid salt. The detailed process for preparing the neutral salt was not deduced until later.

Lead Arsenates from Chemical Manufacturers.

	Supplied as —								
	Unknown.	Neutral.			Acid.				
	–	–	–	Theoretical.	–	–	–	In Dry Matter.	Theoretical.
Manufacturer,[1]	A	B_1	C_1	–	B_2	C_2	C_3	C_3	–
Character of product,	Dry, granular.	Dry, powder.	Dry, slightly granular.	–	Dry, powder.	Dry, powder.	Smooth paste.	–	–
Color,	Yellowish.	Dirty white.	White.	–	White.	White.	White.	–	–
Water (per cent.),	–[2]	.34	6.39	–	.66	.35	46.99	–	–
Lead oxide (PbO) (per cent.),	–	66.11	69.74	74.43	63.63	65.39	34.58	65.23	64.28
Arsenic pentoxide (As_2O_5) (per cent.),	–	29.47	22.75	25.57	29.50	30.92	17.11	32.27	33.12
Water in combination (per cent.),	–	–	–	–	–	1.06	1.33	2.51	2.60
Chlorine (Cl) (per cent.),	–	–	–	–	–	–	.04	.08	–
Insoluble matter (per cent.),	–	.36	.01	–	.08	.00	.01	.02	–
	–	–	–	100.00	–	–	100.06	100.11	100.00
Less oxygen equivalent to chlorine (per cent.),	–	–	–	–	–	–	.01	.02	–
	–	–	–	–	–	–	100.05	100.09	–
Arsenic (As) (per cent.),	–	–	–	16.67	–	–	11.16	21.05	21.60
Suspension in water, minutes,	–	–	–	–	–	–	81	–	–
Suspension in water after drying, minutes,	–	–	–	–	–	–	42	–	–

[1] A, B and C refer to individual manufacturers, the numerals to different samples.

[2] Sample rejected.

Neutral and acid arsenates of lead are quite insoluble, although both salts will undoubtedly yield arsenic slowly to continuous percolation, the acid salt decomposing the more readily.

Solubility.

	Supplied as —					
	Neutral.			Acid.		
Manufacturer,	A	B_1	C_1	B_2	C_2	C_3
Water (per cent.),	–[1]	.34	6.39	.66	.35	46.99
Water soluble (Hilgard method): —						
Lead oxide (per cent.),	–	None.	.01	None.	.14	.06
Arsenic pentoxide (per cent.),	–	.48	.05	.16	.02	.03
Solids (per cent.),	–	2.33	1.13	4.21	2.10	.30

The acid salt C_3 was practically insoluble under the conditions tested, and nearly free from soluble by-products.

The legal standard[2] for commercial lead arsenate in form of paste specifies not more than 50 per cent. of water nor less than 12.50 per cent. of arsenic pentoxide and not more than .75 per cent. of arsenic pentoxide soluble in water. Sample C_3, acid salt, which was used in experimental work, exceeded standard requirements in all particulars. A careful study of the analytical results, C_3, might warrant the following combination: —

Acid Lead Arsenate employed in Spraying.

	Per Cent.
Water,	46.99
Acid lead arsenate ($PbHAsO_4$),	51.61
Lead chloride ($PbCl_2$),	.16
Lead hydroxide ($2\,PbO \cdot H_2O$),	1.34
Insoluble matter,	.01
	100.11

Exclusive of water, the purity was approximately 97.36 per cent. There was a small amount of lead chloride, but the most objectionable feature appeared to be the precipitated lead hydroxide due to careless preparation.

[1] Sample rejected.
[2] The insecticide act of 1910, section 7.

There is evidently a difference in stability between acid and neutral lead arsenates as measured by boiling ammoniacal solutions, but, contrary to general belief, it is apparently only a matter of degree. Both salts are decomposable, yielding soluble arsenic acid.

Neutral arsenate, sample 31, page 204, after being twice heated with ammonia and washed, gave a residue which was practically stable and tested as follows: —

	Per Cent.
Water,	.44
Arsenic pentoxide,	23.84
Lead oxide,	75.02
Occluded water,	.64
	99.94

Stability was apparently the result of a reversible reaction, ammonia setting arsenic acid free, and lead hydroxide, when present in sufficient excess (10 per cent.), completely reprecipitating it. Similar results were obtained by adding freshly precipitated lead hydroxide, litharge and lime to neutral arsenate, the excess base preventing the separation of arsenic acid.

If properly made, neutral and acid arsenates of lead are smooth, white pastes of very fine particles, low specific gravity, excellent suspension and exceptional adhesiveness. The power of suspension is injured by drying. The readings reported for sample C_3 are not the maximum, but were taken when no movement of particles was perceptible, although the mixture continued milky for a considerable period thereafter.

Both acid and neutral lead arsenates are slow-acting poisons of low arsenic content, and that in the form of pentoxide. They are practically insoluble in water and fairly stable. The fineness of the particles and low specific gravity insure a high power of suspension and uniform distribution. The white mixture readily indicates the leaf surface covered and dries to a film which adheres with great persistence.

THE NATURAL FERTILITY OF CRANBERRY BOGS.

BY F. W. MORSE, M.SC.

Years of experience by practical men have shown that cranberries are best grown on a peat bog the surface of which has been covered with a thin layer of sand. Furthermore, the best results with this soil are obtained only when there is an abundance of water by which at times the land may be flooded and at other times irrigated; and at the same time there must be opportunities for thoroughly draining the land at some stages of growth. This combination of peat subsoil, sandy surface and varying amounts of water is unusual in any other line of crop production, and most of the present methods pursued in cranberry culture are wholly empirical in their character.

One important problem now puzzling the cranberry grower is that of fertilization; is it necessary or unnecessary? The potential fertility of a true peat soil, that is, the amount of the elements of plant nutrition contained in its dry matter, is known to be high. Hopkins [1] states that a peat soil contains in the upper layer (6⅔ inches thick) of 1 acre, 35,000 pounds of nitrogen, 2,000 pounds of phosphorus and 2,900 pounds of potassium, while a layer 40 inches deep over 1 acre contains 197,000 pounds of nitrogen, 8,600 pounds of phosphorus and 21,400 pounds of potassium. He further states [2] that but little of this enormous store of material is in an actively available form, and estimates that a corn crop can get at not more than 7 pounds of potassium per acre, while in an experiment on a poorly drained field, corn was benefited by the addition of nitrogen.[3] The sand on the surface of the peat may be disregarded as a source of plant nutrients, but it is an important agent in making availa-

[1] Hopkins, C. G., Soil Fertility, Ginn & Co., 1910, pp. 83-87.
[2] *Ibid.*, p. 471.
[3] *Ibid.*, p. 472.

ble the elements contained in the peat. The water used in flooding and irrigating may be regarded in a similar way, since it is as pure as the average public water supply and often purer.

Analyses of the cranberries and cranberry vines reveal an unusually low proportion of nitrogen and ash constituents, especially in the fruit which, as a rule, is all that is removed from the bog.

TABLE I. — *Composition of Cranberries and Vines.*

	Water.	Ash.	Nitrogen.	Phosphoric Acid.	Potash.	Lime.	Magnesia.
Berries, Massachusetts,[1]	89.40	0.195	0.07	0.025	0.08	0.03	-
Berries, New Jersey,[2]	-	0.175	0.05	0.020	0.07	0.01	0.009
Vines, Massachusetts,[1]	13.07	2.450	0.77	0.270	0.33	0.40	0.250
Vines, New Jersey,[2]	-	2.070	0.64	0.180	0.24	0.49	0.190
Vines, New Jersey,[2]	-	2.100	0.65	0.310	0.40	0.50	0.190

A crop of 100 barrels of cranberries per acre, weighing 10,000 pounds, will contain only 7 pounds of nitrogen, 3 pounds of phosphoric acid and 8 pounds of potash. One ton of dried vines would contain 15 pounds of nitrogen, 6.2 pounds of phosphoric acid and 8 pounds of potash. These figures show clearly that the cranberry crop will never exhaust the potential fertility of the bog; but it is equally plain that it has become accustomed to a scanty nourishment, and they do not answer the question, "Shall fertilizers be used?"

There are on record only three series of fertilizer tests on the cranberry crop. They are somewhat empirical and throw little light on the problem.

An experiment in New Jersey was reported in 1895.[3] A complete fertilizer gave the best results, with the next best from the nitrogen with phosphorus and nitrogen with potash. This was indicative of the actual need of nitrogen; but the soil was described as a black sand somewhat too dry for a good bog.

In Wisconsin Whitson began a series of fertilizer tests in 1904,[4] the last detailed report of which was published in 1907.[5]

[1] Mass. State Exp. Sta. Rept., 1889, p. 274; 1893, pp. 330, 370.
[2] N. J. Agr. Exp. Sta. Rept., 1898, pp. 122, 123.
[3] Ann. Rept., N. J. Agr. Exp. Sta., 1895, p. 110.
[4] Whitson, A. R., Ann. Rept., Wis. Agr. Exp. Sta., 1905, pp. 291 and 292.
[5] Ann. Rept., Wis. Agr. Exp. Sta., 1907, p. 305.

The largest increase in fruit was from the use of sodium nitrate with acid phosphate, and the next best yield was from the nitrate with potash salts, while nitrate of soda alone was more effective than either of the other substances used singly. The actual character of the soil to which the fertilizers were applied is not stated, but from the general description of the bog it is inferred that the soil was a deep peat with the usual surface layer of sand.

In Massachusetts Brooks began a fertilizer test in 1906.[1] Three years later he reported [2] that nitrate of soda greatly promoted the growth of vines, and seemed to be favorable to fruitfulness, but when used in excess of 100 pounds per acre the growth of vines was liable to be too luxuriant. High-grade sulfate of potash was decidedly favorable, and the maximum yield was obtained from a heavy dressing of this salt supplemented by a moderate application of nitrate of soda and acid phosphate. The soil of the Massachusetts bog was not a deep peat, but a sand colored with peat as shown by a chemical analysis which revealed less than 2 per cent. of organic matter. In this instance there is evidence of a low potential fertility, which does not help clear up the problem of the use of fertilizers on a true peat soil.

When peat soils have been well drained and planted to common farm crops like corn, they have not been found to require nitrogen, but have been noticeably improved by the addition of potash salts and phosphates.[3] The conditions required by corn and staple farm crops differ, however, very much from those required by the cranberry. In the former conditions drainage is maintained continuously as a rule, while in the latter case the soil is saturated and even flooded through nearly three-fourths of the year. In the former case nitrification is favored, but in the latter case it is hindered, which may account for the agreement of all three fertilizer tests in showing an increase of fruit upon applications of nitrate of soda.

A consideration of the methods followed by cranberry growers in regulating the water supply of their bogs is helpful in connec-

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[1] Brooks, Wm. P., Ann. Rept., Mass. Agr. Exp. Sta., 1908, p. 17.

[2] Ann. Rept., Mass. Agr. Exp. Sta., 1910, p. 32.

[3] Hopkins, C. G., Soil Fertility, Ginn & Co., 1910, pp. 471–472; Whitson, A. R., Ann. Rept., Wis. Agr. Exp. Sta., 1905.

tion with a study of the natural fertility of the soil. Where conditions permit the bog is completely overflowed from some time in November until May, sometimes until the latter part of this month. During this period the changes within the soil must be limited to solution of matter in the water and putrefactive decomposition in the vegetable matter. Both will be at the lowest point because of the winter temperature. In the spring, when the sluices are opened, there is a rapid run-off from the surface followed finally by seepage into the ditches. The water table falls in the soil to a point a little higher than the level maintained in the drains. It is only above this water table that the activities of useful bacteria can occur, and while it is not definitely known how deep the cranberry roots penetrate, it is probable that they do not extend below the permanent water table. Through a large part of the growing season the water is maintained in the ditches at a level 12 to 15 inches below the surface of the soil. This permits oxidation changes and free root development in a soil depth of not more than 1 foot.

Moist sand is a well known medium for ærobic bacterial action, and the same is true of peat when it contains the optimum amount of water. Sewage filters are constructed of both types of soils, while several proposed processes for production of nitrates are based on the rapid nitrification known to take place in peat under favorable conditions.

During the summer season there must be a movement of water upward from the level of the water table into the surface peat and sand. This upward current is produced mainly by the transpiration of water from the plants, as they cover the surface so completely that actual evaporation must be small. But this makes little difference since it has been shown that transpiration follows the same laws as evaporation from a free surface.[1] Botanists have also observed that bog plants, for some reason, take on the character of desert plants and resist transpiration. The peat which is continually saturated or submerged must be constantly yielding soluble material to the enveloping water, and the solution must be nearly saturated. This soluble matter is poisonous to plants of many families, but

[1] Montgomery, Proc. Am. Soc. Agronomy, 1911, pp. 261, 283.

its influence on cranberry vines is not known. In the aerated surface soil, however, it will be transformed into the beneficial highly oxidized compounds, as nitrates and sulfates.

The present use of water on cranberry bogs is empirical, but a consideration of the conditions under which soil changes occur leads me to believe that water should be withdrawn from the surface at the earliest possible moment in the spring consistent with safety from frost, and held at the lowest possible level at which the vines can secure sufficient moisture for free growth during dry and hot weather. By this arrangement the period of active soil change, and the volume of soil in which it can take place, will be at a maximum, with a consequent increase in the amount of available nutrients for the plants. Flooding the bogs followed by the spring draining undoubtedly causes some loss of soluble fertility, and, on account of the close approach to saturation of the soil during the summer, heavy rains will also result in loss through seepage into the ditches.

This experiment station has begun an investigation of the problem of cranberry-bog fertility, and Director Brooks has devised a series of 30 miniature bogs described by him in a recent article.[1] Each bog is constructed in a 24-inch tile, 48 inches deep, and connected with it is a 6-inch tile that corresponds to the ditch on a large bog, by which the bog can be drained or irrigated. Analyses of the drainage water during the past two summers throw some light on the development of soluble material in the peat and its transformation into active nutrients for the vines. The first analyses were made on samples collected July 14, 1910. Other samples were analyzed at intervals until October 19. During most of this period frequent additions of water were required by the bog because the rainfall was abnormally small. All the water was applied to the surface of the bogs in order to promote diffusion into the small drainage cylinders.

There was much variation in the composition and also in the color of the different samples, which continued until the collection of September 12. There was, however, a steady progress toward uniformity. A few days previous to September 12, viz., on the 8th, there was an exceptionally heavy rainfall which

[1] Brooks, Wm. P., Proc. Soc. Promotion Agr. Sci., 1911, pp. 23-28.

flooded the bogs, covering the surface with an inch of water. The percolation which followed forced the bog water into the drainage cylinders. The water from nearly every bog on September 12 was a dark coffee color, whereas before this date there had been a wide range of tints from dark coffee to light amber. The total solids, and particularly the volatile solids, had now reached a maximum in all but two or three samples, and the amounts were of the same order of magnitude. When sampled for the last time in 1910, on October 19, there was another noticeable change in the water. Nearly all the samples were now a greenish black in color, and opaque and inky in appearance. They also were filtered with difficulty. All the samples collected during the season had been filtered through dry paper filters to remove suspended matter and sand. The water ran rapidly through the paper and in the earlier collections left little or no stain behind. As the colors deepened the later collections stained the filters more and more. The last series deposited a colloidal film on the paper which hindered the passage of the water through the pores and caused the filtration to occupy several hours, in some cases nearly twenty-four hours, while the filtered water had lost its inky appearance and was as a rule a light coffee color. This behavior, together with the appearance of a maximum point in the total solids and volatile solids, points conclusively to a saturated solution with respect to the organic constituents of the peat.

TABLE II. — *Inorganic Solids in Bog Waters, 1910.*

[Parts in 100,000.]

Bog Number.	July 14.	July 27.	August 22.	September 12.	October 19.
1,	11.8	34.8	53.0	62.4	59.6
2,	19.8	56.2	67.6	58.6	64.0
3,	31.4	49.8	76.6	64.6	63.8
4,	83.2	60.4	62.0	64.6	50.0
5,	73.6	69.4	70.0	53.8	59.6
6,	11.0	23.6	40.2	54.6	62.8
15,	11.2	–	52.0	73.4	68.0
16,	11.4	–	39.0	63.0	78.8
17,	54.6	49.4	51.4	63.0	–
18,	50.8	53.8	56.8	49.8	–
22,	63.4	56.2	58.6	49.0	–
25,	23.8	41.0	55.0	52.0	53.0

TABLE III. — *Organic Solids in Bog Waters, 1910.*

[Parts in 100,000.]

Bog Number.	July 14.	July 27.	August 22.	September 12.	October 19.
1, ...	5.8	12.8	18.6	94.0	73.6
2, ...	8.2	25.8	37.6	107.4	80.2
3, ...	10.4	16.4	28.0	112.6	94.0
4, ...	25.0	66.2	78.0	106.6	67.2
5, ...	44.8	62.6	70.4	131.2	101.2
6, ...	5.8	11.8	20.4	114.8	96.0
15, ...	3.2	-	22.0	102.8	104.2
16, ...	4.6	-	15.4	65.8	64.4
17, ...	54.4	89.2	101.6	93.8	-
18, ...	70.6	108.2	113.2	92.0	-
22, ...	48.6	60.2	118.0	96.6	-
25, ...	-	21.6	32.0	93.2	88.8

The inorganic solids were more or less influenced by the cement used in the construction of the cylinders.

The samples of 1911 are best considered in two groups, one of which represents the bog water in the spring, while the other shows its composition at the end of the summer. The first group consisted of two series of samples which were taken from 10 of the bogs on the 10th and 12th of May, before the flood water was drained off. The samples therefore represented the results of six months of solution, diffusion and precipitation on the organic and inorganic matter in the bogs. One set of samples was filtered through dry paper filters before they were analyzed, while the other set was allowed to stand over night to settle, and then used without filtering. The samples were inky in appearance when taken and changed but little on standing. Filtration required from twenty-four to forty-eight hours and a change of filter papers, because their surfaces were soon covered with a dark slime which rendered them nearly impervious. The filtered water was much lighter in color than the original sample. The material removed by the filters was largely organic in its nature, since the organic solids in the filtered water were lower proportionally than the inorganic solids when compared with the corresponding figures for the unfiltered water.

Table IV. — *Average Composition of Bog Waters, May 10–12, 1911.*

	Organic Solids.	Inorganic Solids.
Unfiltered,	63.0	48.0
Filtered,	38.8	34.0

The behavior of the samples in filtering, their opaque appearance before it, and the lower solids compared with the results of the previous season, point toward a saturation of the water in the bogs by the soluble material in the soil.

On June 2 chemical fertilizers were added to 22 of the 30 bogs, and the bogs were renumbered in pairs; 1A, 1B to 15A, 15B, and each cylinder of a pair was a duplicate of the other.

Table V. — *Scheme for Fertilizers on Bogs, 1911.*

Bog Number.	Nitrate Soda (Grams).	Acid Phosphate (Grams).	Sulfate Potash (Grams).	Calcium Hydrate (Grams).
1A, 1B,	3.25	–	–	–
2A, 2B,	–	13	–	–
3A, 3B,	–	–	6.5	–
4A, 4B,	3.25	13	–	–
5A, 5B,	3.25	–	6.5	–
6A, 6B,	–	–	–	–
7A, 7B,	–	13	6.5	–
8A, 8B,	3.25	13	6.5	–
9A, 9B,	6.50	13	6.5	–
10A, 10B,	–	–	–	–
11A, 11B,	–	–	–	–
12A, 12B,	3.25	26	6.5	–
13A, 13B,	3.25	13	13.0	–
14A, 14B,	–	–	–	–
15A, 15B,	3.25	13	6.5	65

Note. — Area of bogs, 1/14,000 of an acre.

After the fertilizers were added all irrigation of the bogs was executed by adding water to the drainage cylinders instead of to the surface of the bogs. The rainfall was scanty during the summer, and frequent additions of water were necessary to maintain the water level within 14 to 16 inches of the surface. Beginning in the latter part of August, and continuing throughout September and October, frequent rains, some very heavy, caused copious percolation and resulted in considerable overflow from the drainage cylinders. Numerous samples were collected during this period and form the second group already mentioned. About two-thirds of these samples were analyzed after subsidence of sediment without filtration, and one-third were filtered through porcelain filter tubes under a pressure of 40 to 45 pounds per square inch. The character and appearance of the samples were like those of the May group. They were inky in color until filtered, and were then transparent and of varying shades of coffee color. The amount of solids was remarkably uniform and a little higher in the unfiltered water than was found in May, but much lower than the figures obtained the previous year. It is pretty conclusive that the peat had now become a stable bog soil, and the bog water had reached a stage of equilibrium with its soil environment.

TABLE VI. — *Organic Solids in Bog Waters, Unfiltered, 1911.*

[Parts in 100,000.]

Bog Number.	September 5.	September 11.	September 20.	October 3.	October 25.
1,	75.2	-	-	-	-
2,	84.6	-	-	-	-
3,	-	-	71.6	-	-
4,	-	-	87.2	89.2	-
5,	78.0	-	74.2	82.4	-
6,	-	-	-	-	86.4
7,	-	-	64.2	71.4	-
8,	80.0	79.0	-	79.0	86.4
9,	-	69.4	74.2	65.4	82.0
10,	-	-	-	64.6	89.1
11,	-	69.8	60.8	-	-
12,	82.8	-	-	64.8	88.6
13,	-	-	-	82.0	92.4
14,	63.4	79.2	75.8	77.0	92.0
15,	94.2	-	85.2	92.8	97.6

TABLE VII. — *Inorganic Solids in Bog Waters, Unfiltered, 1911.*

[Parts in 100,000.]

Bog Number.	September 5.	September 11.	September 20.	October 3.	October 25.
1,	50.4	-	-	-	-
2,	71.6	-	-	-	-
3,	-	-	68.8	-	-
4,	-	-	63.6	56.2	-
5,	61.4	-	63.8	51.6	-
6,	-	-	-	-	48.8
7,	-	-	58.6	48.6	-
8,	54.6	52.6	-	47.0	51.0
9,	-	50.6	47.8	41.0	49.4
10,	-	-	-	58.0	55.6
11,	-	63.8	56.9	-	-
12,	66.4	-	-	45.8	50.8
13,	-	-	-	43.0	51.0
14,	70.6	58.4	63.4	53.0	50.0
15,	68.6	-	66.2	54.4	65.2

TABLE VIII. — *Organic and Inorganic Solids in Bog Waters, Filtered, 1911.*

[Parts in 100,000.]

Bog Number.	Organic.			Inorganic.		
	August 24.	September 11.	October 25.	August 24.	September 11.	October 25.
1,	-	35.8	-	-	41.4	-
5,	29.8	-	-	36.6	-	-
6,	-	-	27.4	-	-	33.8
7,	20.0	-	-	21.4	-	-
8,	-	32.4	30.8	-	39.2	38.0
9,	14.4	28.0	35.0	20.4	34.2	44.8
10,	21.6	-	32.2	19.8	-	37.6
12,	-	-	47.2	-	-	43.6
13,	-	-	38.2	-	-	35.6
14,	-	37.4	33.6	-	47.1	32.2
15,	-	-	46.0	-	-	40.0

Since the primary object of the cranberry experiment is to ascertain the needs of the crop for fertilizers and the fate of the fertilizing materials added to the soil, numerous determinations of the total nitrogen, free ammonia and nitrates were made on samples of water from the drainage cylinders between July 14 and Oct. 25, 1911. Nitrates were invariably found, but in insignificant amounts, and there was no practical difference between the water from bogs treated with nitrates and from those without them. Twenty-nine samples from bogs with nitrates contained 0.0299 part of nitric nitrogen in 100,000 parts of water, while 23 samples from bogs without nitrates contained 0.0298 part in 100,000. Free ammonia was much more prominent than nitrates and formed about one-third of the total nitrogen. There was a slight difference in favor of the fertilized bogs, since 34 samples from bogs fertilized with nitrate of soda contained 1.358 parts of ammonia in 100,000 parts of water, while 21 samples from bogs receiving no nitrates contained 1.227 parts of ammonia in 100,000. This slight difference indicates a possible denitrification and loss of nitrates in the form of ammonia. In determining total nitrogen about one-third of the samples were filtered through porcelain tubes before making the analysis. The slimy precipitate thus removed contained nearly two-fifths of the nitrogen present in the unfiltered waters. Forty-eight samples of unfiltered water contained 3.296 parts of nitrogen in 100,000 parts of water, while 27 samples of filtered water contained 2.058 parts of nitrogen in 100,000 parts of water.

TABLE IX. — *Total Nitrogen in Bog Waters, Unfiltered, 1911.*

[Parts in 100,000.]

Bog No.	FERTILIZER.	September 5.	September 11.	September 21.	October 3.	October 9.	October 25.
1	Nitrate,	2.993	–	–	–	–	–
2	No nitrate,	3.977	–	–	–	–	–
3	No nitrate,	–	–	3.485	–	–	–
4	Nitrate,	–	–	4.100	3.767	–	–
5	Nitrate,	3.485	–	3.362	3.362	3.726	–
6	Nothing,	–	–	–	–	–	3.198
7	No nitrate,	2.911	–	2.993	2.788	3.280	–
8	Nitrate,	–	3.034	3.157	2.952	3.485	3.378
9	Double nitrate,	–	3.034	3.034	2.911	3.378	3.075
10	Nothing,	–	–	–	3.280	3.526	3.075
11	Nothing,	–	3.017	2.788	–	–	–
12	Nitrate,	3.485	–	–	3.280	3.526	–
13	Nitrate,	–	–	–	3.198	3.485	3.321
14	Nothing,	3.280	3.157	3.362	3.485	3.567	3.034
15	Nitrate,	3.977	–	3.936	3.854	–	3.485

Average nitrogen in 27 samples from nitrate bogs, 3.399 parts.
Average nitrogen in 18 samples from no nitrate bogs, 3.233 parts.

Table X. — *Total Nitrogen in Bog Waters, Filtered, 1911.*

[Parts in 100,000.]

Bog Number.	August 9.	August 14.	August 24.	September 11.	October 25.
1,	-	-	-	2.583	-
4,	-	1.312	-	-	-
5,	-	1.476	1.722	-	-
6,	-	-	-	-	2.173
7,	-	0.820	1.107	-	-
8,	-	-	2.419	2.419	2.337
9,	-	-	-	2.337	2.419
10,	-	-	1.148	-	2.173
11,	-	0.984	-	-	-
12,	2.337	-	2.720	-	-
13,	2.173	-	-	-	2.337
14,	2.378	-	2.214	2.706	2.173
15,	2.665	-	2.829	-	2.747

In 1910 total nitrogen was determined in the waters from all the bogs on September 12, at the time of maximum total solids. The 29 samples of that date averaged 3.260 parts nitrogen in 100,000 parts of water, or practically like the average for 1911 in the unfiltered water.

A few determinations of phosphoric acid and potash were made in 1911 in the unfiltered waters. Samples were taken from bogs receiving fertilizers and from those without. The results were too nearly alike to justify any statements about the two groups, and only averages will be used to show the composition of the bog water. Eighteen samples representing 7 pairs of bogs contained an average of 1.772 parts of phosphoric acid in 100,000 parts of water. Sixteen samples representing 6 pairs of bogs contained an average of 5.15 parts of potash in 100,000 parts of water. A few analyses of filtered samples showed that the potassium compounds in the water were completely soluble and passed through the filters with the water; but practically all the phosphoric acid in the unfiltered water was removed by the filter with the slime. Since the slime when burned showed marked evidence of iron in the residue, it is probable that any phosphoric acid which dissolves in the bog water soon becomes iron phosphate, which is well known as a highly gelatinous precipitate when formed in dilute solutions.

Summarizing the composition of the bog water from the analyses of September and October, 1911, we have the following figures as the average composition of the water standing in contact with the peat in a saturated condition.

TABLE XI. — *Average Composition of Bog Water.*

[Parts in 100,000.].

	Unfiltered.	Filtered.
Organic matter,	79.2400	31.8600
Inorganic matter,	55.6500	35.3600
Total nitrogen,	3.2960	2.0580
Free ammonia,	1.4500 [1]	1.4500
Nitrogen in nitrates,	0.0417 [1]	0.0417
Phosphoric acid,	1.7720	Traces.
Potash,	5.1500	5.1500

This preliminary study does not throw much light on the problem of fertilizing cranberry bogs. It points, however, to certain conditions worthy of consideration in the use of fertilizers. The cranberry crop does not draw heavily on the soil. Its period of growth is, however, comparatively short, especially if the flood water is retained late, and its soil volume is relatively small when the water level is maintained near the surface. Bog conditions do not favor nitrification and oxidation on account of the saturated soil and low temperature, hence the bog water is low in active fertilizing constituents, especially in nitrates. Therefore it is probable that small amounts of soluble chemicals applied in the late spring would be effective in stimulating growth.

[1] Ammonia and nitrates averaged somewhat higher during this period than for the season as a whole.

TYPES OF CORN SUITED TO MASSACHUSETTS CONDITIONS.

BY P. H. SMITH AND J. B. LINDSEY.

Introduction.

Since 1903 experiments have been in progress with corn to determine, if possible, those varieties, or rather types, best suited to Massachusetts conditions. With this end in view the total yield of dry matter per acre, the digestibility, the relative proportions, and in some cases the composition, of the various parts of the plant (stalk, leaf, ear and husk), and the relation of the stage of development to the relative proportion of different parts as affecting the food value have been carefully studied.

Soil, Cultivation, Size of Plots, Fertilizers used.

With the exception of the Eureka and Pride of the North, varieties tested in 1904, the corn was grown upon one-twentieth acre plots (30 by 73 feet), rows running east and west. The soil consisted of a light sandy loam such as might be considered satisfactory corn land. Each plot was liberally and uniformly fertilized.

1906. — Varieties: Leaming and Pride of the North.

Fertilizers used per acre: —

200 pounds high-grade sulfate of potash, equivalent to about 100 pounds potash.
300 pounds acid phosphate, equivalent to about 45 pounds available phosphoric acid.
200 pounds nitrate of soda, equivalent to about 30 pounds nitrogen.
200 pounds dry ground fish, equivalent to about 16 pounds organic nitrogen.

The corn planted in 1906 produced an exceptionally fine crop. This was evidently due to very favorable weather conditions. The yield may also have been favored to some extent by the growth of medium green soy beans on the same plots the preceding year.

1907. — Varieties: Leaming and Pride of the North.

Fertilizers used per acre: —

200 pounds high-grade sulfate of potash, equivalent to about 100 pounds potash.
500 pounds phosphatic slag, equivalent to about 75 pounds available phosphoric acid.
200 pounds nitrate of soda, equivalent to about 30 pounds nitrogen.
300 pounds dry ground fish, equivalent to 24 pounds organic nitrogen.

1908. — Varieties: Sanford, Longfellow, Rustler, Early Mastodon, Klondike, Red Cob Silage and White Cap Yellow.

Fertilizers used per acre: —

300 pounds high-grade sulfate of potash, equivalent to about 150 pounds potash.
500 pounds acid phosphate, equivalent to about 75 pounds available phosphoric acid.
200 pounds nitrate of soda, equivalent to about 30 pounds nitrogen.
500 pounds dry ground fish, equivalent to about 40 pounds organic nitrogen.

1909. — Varieties: Twitchell's, Rustler, Brewer's, Early Mastodon, White Cap Yellow, Wing's Improved White Cap.

Fertilizers used per acre: —

300 pounds high-grade sulfate of potash, equivalent to about 150 pounds potash.
700 pounds acid phosphate, equivalent to about 105 pounds available phosphoric acid.
200 pounds nitrate of soda, equivalent to about 30 pounds nitrogen.
500 pounds dry ground fish, equivalent to about 40 pounds organic nitrogen.

1910. — Varieties: Rustler, Brewer's, Longfellow, Eureka.

Fertilizers used per acre: —

300 pounds high-grade sulfate of potash, equivalent to about 150 pounds potash.
700 pounds acid phosphate, equivalent to about 105 pounds available phosphoric acid.
200 pounds nitrate of soda, equivalent to about 30 pounds nitrogen.
500 pounds dry ground fish, equivalent to about 40 pounds organic nitrogen.

A larger amount of fertilizer was added during the last few years of the experiment in order to insure the maximum development of the crop. The yield of corn when planted on the same land for several successive years is likely to decrease, and it was thought that the additional amount of plant food applied would in a measure check this probable shrinkage.

The chemicals were mixed, sown broadcast and harrowed in just before the corn was planted. While the application of commercial fertilizer was liberal, it is believed that larger yields might have been secured, in some cases at least, if more organic matter had been added to the soil either through the medium of barnyard manure or as a cover crop to be ploughed under in the spring.

The Pride of the North and Eureka corn grown in 1904 were not planted on the twentieth-acre plots, but were grown on one-half acre plots in an adjoining field. It was fertilized with cow manure at the rate of six cords to the acre and the land well fitted. In this case the rows ran north and south and the corn was sown in drills and thinned to one plant to the foot at the time of hoeing.

The corn grown on one-twentieth acre plots was planted in hills 3½ by 3½ feet, and thinned to four plants at the time of hoeing. It was seeded May 20–25 and harvested September 15, which is about as late as it is advisable to allow corn to stand and be safe from frosts.

Description of Varieties.

Twitchell's. — A small growing yellow flint bred in Maine. On account of its early maturing qualities (with us in the vicinity of August 20) it may be grown as far north as corn culture can be considered profitable. It has a short stalk of small diameter and a good-sized ear, in some cases two ears being noted on each stalk. It cannot be considered well suited for forage or silage where larger varieties will mature.

Sanford White. — A white flint corn, quite like Longfellow in general appearance, size of plant and time of ripening.

Longfellow. — An old established yellow flint variety extensively grown in Massachusetts. It is one of the best of the yellow flint varieties.

Pride of the North. — One of the earliest and apparently most satisfactory yellow dent varieties for Massachusetts. It does not usually make as large a growth as the Leaming, but in an average season will reach maturity.

Rustler Minnesota Dent. — A white dent corn believed to have been first raised in Massachusetts, on the Agricultural College farm, from seed procured in Minnesota. It has given uniformly good results and can be considered a satisfactory dent variety in spite of the fact that the ears do not usually develop well at the tip. It is believed that this corn can be greatly improved by careful breeding.

Leaming. — Yellow dent. Somewhat like the Pride of the North, but makes a larger growth and matures a little later. It is extensively grown for silage in Massachusetts, and, unless the season is unusually backward, will mature sufficiently for this purpose.

Brewer's. — Yellow dent. This is believed to be a western dent variety improved by N. H. Brewer of Hockanum, Conn. Mr. Brewer has raised enormous crops by following an intensive system of fertilization and cultivation. We have not been successful in ripening it on the station farm. At the time of cutting (September 15) the ears were hardly in milk, and consequently not suitable to harvest for grain. It evidently needs a somewhat longer growing season than is usually experienced in the vicinity of Amherst.

Early Mastodon. — Yellow dent. Bred by C. S. Clark of Ohio. A large growing variety evidently rather too late for grain in Massachusetts.

Klondike. — Yellow dent. Quite like the Early Mastodon in appearance, but noticeably later and unsuited to New England conditions.

Red Cob Silage. — White dent. Medium late.

White Cap Yellow Dent. — Resembles Leaming in size, but matures rather later. Fairly satisfactory for silage.

Wing's Improved White Cap. — Originated by J. E. Wing of Ohio. Some of the stalks bore two ears. It would probably form a very satisfactory variety in the middle western States, but the season is not sufficiently long to enable it to reach maturity in New England.

Eureka White Dent. — A large growing southern variety. It reaches a height of some 13 or more feet and has very coarse stalks. It has never matured in Amherst. The ears set very high on the stalk and the kernels are forming by September 15.

Yield Per Acre of Entire Corn Plant (Pounds).

Year.	Variety.	Condition.	Total Yield.	Dry Matter.
1909	Twitchell's,	Mature,	13,800	4,236
1908	Sanford White,	Mature,	28,400	8,148
1908	Longfellow,	Mature,	34,960	8,981
1910	Longfellow,	Mature,	25,400	6,480
1904	Pride of the North,	Fairly ripe, kernels glazing,	27,800	6,253
1906	Pride of the North,	Mature,	42,600	11,664
1907	Pride of the North,	In milk, not quite ripe,	28,500	5,141
1908	Rustler,	Mature,	23,067	7,843
1909	Rustler,	Mature,	27,100	5,328
1910	Rustler,	Mature,	22,400	6,772
1906	Leaming,	Mature,	51,560	12,307
1907	Leaming,	In milk, not quite ripe,	28,200	5,144
1909	Brewer's,	In milk, green,	35,100	6,286
1910	Brewer's,	In milk, green,	28,100	7,226
1908	Early Mastodon,	In milk to dent stage, green,	39,320	9,488
1909	Early Mastodon,	In milk to dent stage, green,	36,220	6,436
1908	Klondike,	Green and poorly eared,	37,340	9,069
1908	Red Cob Silage,	In milk to dent stage, green,	43,500	11,210
1908	White Cap Yellow,	In milk to dent stage, green,	35,300	11,038
1909	White Cap Yellow,	In milk to dent stage, green,	24,900	5,784
1909	Wing's Improved White Cap,	In milk, green,	28,300	5,671
1904	Eureka,	Immature, kernels scarcely formed,	40,800	6,671
1910	Eureka,	Immature, ears just forming,	43,800	9,044

The preceding table shows the total yield per acre as cut and also the total yield of dry matter. The entire crop for each one-twentieth acre plot was cut and immediately hauled to the barn and weighed. The dry matter was determined by taking a representative sample at the time of harvesting, running it through a cutter, subsampling, placing the subsample in a glass-stoppered jar and drying at 100° C.

Twitchell's corn was well matured in spite of the unfavorable season, and although the 4,236 pounds of dry matter were much less than for any of the other varieties, it probably represented a fair average yield of its kind.

The yields of Longfellow and Sanford, both grown in favorable seasons, may be considered normal in amount. The season of 1908 was rather better than 1910, which would probably account for the larger yield of Longfellow corn in the former year.

Pride of the North was grown during three seasons. The seasons of 1904 and 1907 were both unfavorable, while 1906 was especially satisfactory, and in this year it yielded approximately twice as much dry matter as was secured in the average crop of the other two seasons.

Rustler, also grown for three seasons, showed a reasonably uniform dry matter content with the highest yield in the more favorable season (1908).

Leaming, grown in a favorable and unfavorable season, yielded over twice as much dry matter in the favorable year.

Brewer's dent, which evidently needs a longer growing season for its maturity than the average in Massachusetts, did not show a very decided variation between the two years.

Early Mastodon and White Cap Yellow, both grown in 1908 and 1909, showed the larger yields in 1908, the more favorable year.

Klondike and Red Cob Silage were both grown in 1908, a favorable year. Neither ripened satisfactorily, but showed good yields of dry matter. The former was noticeably immature when harvested.

Wing's Improved White Cap — grown in 1909, a poor corn year — did not yield well, and evidently needs a longer growing season.

Eureka, grown in 1909 and 1910, showed the better yield in 1910. In neither case was the corn well matured, nor did it show a larger yield of dry matter than some of the smaller varieties that showed a very much larger percentage of mature ears.

The total yield of dry matter, rather than the green material, gives a much better indication of the value of the crop for feeding purposes. A green, immature crop will often furnish a large apparent yield, but it contains an excessive amount of water. This fact is especially evidenced by the Eureka and Klondike which, while they gave high yields of green material, did not show the highest production of dry matter.

Morrow,[1] as a result of four years' observations, states that in no year was there more than half the total amount of dry matter when the plant had reached its full height, and not more than 75 per cent. of the maximum when the ears were in dough stage. Ladd,[2] as a result of a two years' experiment, found the greatest weight of green fodder to be between the period of full silking and milky stage of kernel, and that while the total weight diminished after this date the total dry matter increased. Our own results, corroborated by those of other investigators, indicate that such varieties as the Twitchell, Sanford, Longfellow, Pride of the North (in one case) and Rustler can be considered as having reached a maximum weight in dry matter under the conditions in which they were grown. The remaining varieties, with the exception of the Eureka, would surely have increased in dry matter and decreased in total weight had their growing season been longer, while the Eureka would probably have increased in both total weight and dry matter. On account of their high water content and less mature condition the last 8 varieties in the preceding table cannot be considered as valuable pound for pound as the more mature types.

Effect of Season on Yield.

The following data, taken from the Massachusetts Crop Report, will show the weather conditions for the years during which the corn was grown: —

1904. Season, as a whole, cool and dry which made corn unusually late and poorly ripened.

1906. Season, as a whole, warm, especially in July and August. Good rainfall in June and July, hot and humid weather in August, with warm, dry weather the first part of September. The weather conditions were very favorable for corn and the crop ripened exceedingly well.

1907. Season, as a whole, hot and dry. August being the hottest month for thirty-six years. A late spring, together with succeeding dry weather, hindered the development of the crop which was below normal.

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[1] Bul. No. 25, Ill. Exp. Sta., p. 200.

[2] Eighth Ann. Rept., N. Y. Exp. Sta., p. 90.

1908. Season variable, with high temperature and rainfall at opportune times. July hot with little rain till the last part. August cool with plenty of rain. The early part of September dry and warm which hastened the development of the crop that was exceptionally good.

1909. Season, as a whole, dry and cool. The crop germinated well, but the growth was checked by drought and cool weather to such an extent that in many cases the ears did not ripen in spite of no killing frosts until late.

1910. Season, as a whole, hot and dry. Rain at such times as to greatly benefit crop, which was above normal and well matured.

The most striking feature brought out by the preceding table is the extreme variation in yield, not only between different varieties, but between the same varieties grown in different years. This point is well illustrated by Pride of the North, grown in 1904, 1906 and 1907, the yield being a third more for 1906, a very favorable corn year. Morrow [1] found this to be the case in experiments conducted in Illinois, and states that the rain and heat were more influential on the rate of growth than the difference in the variety of corn. It is believed that the total yield of dry matter can be affected by climatic conditions in two ways: a lack of rain at critical periods may cause the corn to ripen before it has obtained its maximum growth, while a cold, wet season will retard the growth of the crop so that it does not reach maturity in the growing season.

The data in the above table make especially clear that: —

1. The small varieties as represented by the Twitchell, because of the relatively low yield of total dry matter, are not economical for Massachusetts conditions.

2. The flint varieties, such as Longfellow and Sanford and the medium dents — Rustler and Pride of the North — are quite well suited for grain and also serve fairly well for silage.

3. The larger medium dents — including the Leaming, White Cap Yellow, Red Cob and Early Mastodon — give a very good yield of dry matter, and in average season bring their ears to the milk stage. All conditions considered, these varieties are rather preferable for silage purposes.

4. The coarse, late maturing varieties as represented by the

[1] Bul. No. 31, Ill. Exp. Sta., p. 363.

Klondike, Wing's Improved, Brewer's, and particularly the Eureka, while yielding a fair average amount of dry matter are not satisfactory because of their failure to mature; the resulting silage has been repeatedly shown by other observers as being watery, sour and of less nutritive value.

5. The season has a marked influence upon the yield of the corn crop, the same variety of corn under otherwise identical conditions yielding from 50 to 100 per cent. more in a year particularly favorable to its growth.

Composition of Different Varieties of Corn Fodder (Entire Plant) (Per Cent.).

[As harvested.]

Number of Analyses.	Variety.	Water.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
1	Twitchell's,	69.11	3.03	.94	20.21	5.34	1.37
1	Sanford White,	71.31	1.97	.75	19.03	5.78	1.16
1	Longfellow,	74.31	2.30	.60	16.38	5.03	1.38
6	Pride of the North,	75.33	2.02	.60	15.74	5.18	1.13
3	Rustler,	71.62	2.17	.68	18.36	5.94	1.23
4	Leaming,	76.85	1.77	.47	14.21	5.60	1.10
2	Brewer's,	81.35	1.82	.27	10.90	4.72	.94
3	Early Mastodon,	77.77	1.86	.41	13.77	5.14	1.05
1	Klondike,	75.71	1.31	.42	14.09	6.98	1.49
1	Red Cob Silage,	74.23	1.58	.40	15.69	6.93	1.17
2	White Cap Yellow Dent,	72.75	2.17	.50	17.38	6.02	1.18
2	Wing's Improved White Cap,	80.39	1.72	.32	12.06	4.53	.98
1	Eureka,	82.58	1.63	.27	9.26	4.78	1.08

Composition of Different Varieties of Corn Fodder (Entire Plant) (Per Cent.).

[Dry Matter.]

Number of Analyses.	Variety.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
1	Twitchell's,	9.82	3.05	65.43	17.28	4.42
1	Sanford White,	6.85	2.61	66.36	20.13	4.05
1	Longfellow,	8.96	2.34	63.77	19.56	5.37
6	Pride of the North,	8.18	2.43	63.08	21.01	4.58
3	Rustler,	7.66	2.39	64.68	20.94	4.33
4	Leaming,	7.63	2.01	61.40	24.19	4.77
2	Brewer's,	9.75	1.43	58.43	25.33	5.06
3	Early Mastodon,	8.37	1.85	61.97	23.10	4.71
1	Klondike,	5.43	1.72	57.99	28.74	6.14
1	Red Cob Silage,	6.12	1.57	60.87	26.90	4.54
2	White Cap Yellow Dent,	7.98	1.83	63.78	22.10	4.33
2	Wing's Improved White Cap,	8.75	1.65	61.48	23.10	5.02
1	Eureka,	9.34	1.54	55.52	27.41	6.19

The varieties of corn given in the preceding tabulation can be divided into four different groups according to their period of ripening.

1. Mature (dents and flints): Twitchell's, Sanford White, Longfellow, Pride of the North and Rustler.

2. Medium mature (coarse dents): Leaming, Early Mastodon, Red Cob Silage and White Cap Yellow Dent.

3. Immature (very coarse dent): Brewer's, Klondike and Wing's Improved White Cap.

4. Very immature (very coarse dent): Eureka.

The average water content of the four groups was as follows: —

	Per Cent.
Mature,	74.34
Medium mature,	75.40
Immature,	79.15
Very immature,	82.58

While there is a gradual diminution in the water content from the time that the ears are formed until maturity, as shown by this table, the total dry matter gradually increases to maturity.[1]

It is not believed that, owing to individual variations, conclusions can be readily drawn relative to the chemical composition of the different varieties. By averaging the four groups previously given the following results are obtained: —

Dry Matter (Per Cent.).

	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Mature,	8.29	2.56	64.81	19.78	4.55
Medium mature,	7.52	1.82	62.00	24.07	4.59
Immature,	7.97	1.60	59.30	25.72	5.41
Very immature,	9.34	1.54	55.52	27.41	6.19

The very green, immature corn contains a larger relative percentage of protein, but more of it in the amido form.[2] The fat, and particularly the nitrogen-free extract matter, increase the more mature the variety. This is to be expected, for the corn is a carbohydrate plant, and stores up large amounts of starch in the latter stages of its growth. As the starch increases the percentage of fiber and ash relatively decrease. The ash is always at its highest point in the early stages of development.

[1] Ladd, N. Y. Exp. Sta., Rept., 1889.
[2] Eighth Ann. Rept. N. Y. Exp. Sta., p. 90.

The preceding facts are substantiated by the investigations of Schweitzer,[1] Jordan,[2] Ladd [3] and others.

The general conclusion can be drawn that the changes in chemical composition which the plant undergoes in its development are such that its maximum feeding value exists at its maturity.

Digestibility of the Plant.

The digestibility of 7 representative varieties of the entire plant was determined with sheep. The method followed in conducting such experiments is illustrated and described in detail elsewhere.[4] The entire data of the several experiments have been presented in previous reports; only the digestion coefficients, therefore, are given in this connection. As only four sheep were available, but two duplicate digestion trials could be completed in a single season. The method of procedure was as follows: each experiment was begun about September 5th, when the sheep received their first feeding. The corn was allowed to stand in the field, sufficient being cut for only two consecutive days. The entire digestion period lasted fourteen days, the first seven of which were preliminary. The corn was cut in 2-inch pieces before being fed. Two days' feeding were weighed out in advance, and samples taken for dry-matter determinations and for complete chemical analysis. The difference between the amount and chemical composition of the fodder fed and the amount and chemical composition of the feces excreted served as a basis for computing the amount digested and utilized by the animals.

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[1] Bul. No. 9, Mo. Exp. Sta.

[2] Ann. Rept. Me. Exp. Sta., 1893.

[3] Eighth Ann. Rept. N. Y. Exp. Sta., 1899.

[4] Eleventh Rept. of the Mass. State Agr. Exp. Sta., pp. 126–149; also 22d Rept. of the Mass. Agr. Exp. Sta., p. 84.

Digestion Coefficients.[1]

[Per Cent. Dry Matter digested.]

Variety Corn.	Condition of Crop at Time of Harvest.	Digestion Coefficients.					
		Dry Matter.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
Pride of the North,	In dough to denting,	71	63	76	77	65	34
Pride of the North,	In dough to denting,	77	63	84	84	66	36
Rustler,	In dough to denting,	69	43	76	78	59	28
Leaming,	Corn in late milk,	70	60	76	77	61	36
Brewer's,	Corn in milk,	72	69	68	77	69	46
Early Mastodon,	Corn in milk,	72	57	81	79	60	36
Wing's Improved White Cap,	Corn in milk,	70	63	70	76	65	39
Eureka,	Kernels just forming,	67	67	66	72	60	42
Pride of the North stover,	- - -	54	45	64	54	60	31
Eureka stover,	- - -	54	48	67	53	59	45

A study of the above coefficients shows no wide variations in the relative digestibility of the several varieties. Naturally the larger the percentage of ear present the higher should be the digestibility of the entire plant, the grain having a much higher digestibility than the stalk. This in a general way is made clear by classifying the results according to the stage of growth. Corn that is immature and with ears partially formed may show nearly as high an absolute digestibility as a mature variety because of the soft, incompletely developed stalks. If it had been possible to determine the net available energy of each variety according to the method employed by Kellner,[2] those varieties having the mature ears would unquestionably have shown a much larger amount of energy than the less mature varieties.

Attention may also be called to the variation in the percentage of nitrogen-free extract of the several varieties. With one exception [3] the digestibility varies to a limited extent inversely

[1] For figures in detail see supplement.

[2] The Scientific Feeding of Animals, pp. 48-50.

[3] In case of Rustler Dent rather more was fed than the animals could well utilize, which explains the low coefficient for this variety.

with the percentage of nitrogen-free extract, or, otherwise explained, the larger the percentage of extract or starchy matter present, the higher the digestibility of the corn plant.

A division and tabulation of the results according to the stage of growth of the varieties gives us the following results:[1] —

Dry Matter.

	Average Yield per Acre.	Per Cent. digested.	Pounds per Acre digested.
Mature,	7,686	74	5,688
Medium mature,	8,344	71	5,924
Immature,	6,394	71	4,540
Very immature,	7,858	67	5,265

It would appear from the above that the larger growing varieties, such as Leaming, Red Cob, Early Mastodon and White Cap, will produce rather more dry and digestible matter than do the medium dent or flints as typified in the Longfellow or Rustler, and the former varieties, on the whole, are to be given the preference for silage purposes. It is questionable, however, if they furnish any more final nutritive effect (net available energy) than do the varieties that will thoroughly mature by the middle of September. The percentage of dry matter digested, on the other hand, is in favor of the mature varieties. The extremely late varieties, such as the Eureka and Klondike, are not at all suited to New England conditions.

Experiments were made with a sample of Pride of the North and a sample of Eureka corn stover during the year of 1904, the two lots proving to be equally digestible. The former variety of stover contained 18.13 per cent. of water when sampled (December 27), and the latter contained 59.92 per cent. (February 29). Both samples had been stored in the barn since late autumn. When drawn from the field the former contained 37.84 per cent. and the latter 68.92 per cent. of water. The Eureka stover, because of its coarse, immature condition, retained the moisture to a much greater extent than did the fully matured corn.

[1] Omitting coefficients for Rustler Dent from the mature varieties.

Proportions and Composition of Parts.

(a) Proportions at Time of Cutting (100 Pounds).

Year.	Variety.	Stalks.	Leaves.	Husks.	Ears.
1909	Twitchell's, ...	27	26	10	37
1908	Sanford White, ...	45	20	11	24
1908	Longfellow, ...	48	21	10	21
1910	Longfellow, ...	38	25	9	28
1904	Pride of the North, . . .	47	20	11	22
1906	Pride of the North, . . .	40	17	12	31
1907	Pride of the North, . . .	52	16	14	18
1908	Rustler, ...	46	19	7	28
1909	Rustler, ...	41	14	15	30
1910	Rustler, ...	40	19	9	32
1906	Leaming, ...	48	19	11	22
1907	Leaming, ...	52	17	12	19
1909	Brewer's, ...	51	17	13	19
1910	Brewer's, ...	53	17	10	20
1908	Early Mastodon, ...	52	19	9	20
1909	Early Mastodon, ...	50	13	12	20
1908	Klondike, ...	62	19	9	10
1908	Red Cob Silage, ...	53	17	12	18
1908	White Cap Yellow, ...	46	19	11	24
1909	White Cap Yellow, ...	50	16	12	22
1909	Wing's Improved White Cap, .	52	19	10	19
1904	Eureka, ...	64	22	7	7
1910	Eureka, ...	62	21	7	10

(b) Proportions in Dry Matter (100 Pounds).

Year.	Variety.	Stalks.	Leaves.	Husks.	Ears.
1909	Twitchell's, ...	15	21	9	55
1908	Sanford White, ...	35	20	10	35
1908	Longfellow, ...	34	18	9	39
1910	Longfellow, ...	23	21	7	49
1904	Pride of the North, . . .	37	18	9	36
1906	Pride of the North, . . .	28	14	9	49
1907	Pride of the North, . . .	50	19	11	20
1908	Rustler, ...	33	19	7	41
1909	Rustler, ...	32	13	12	43
1910	Rustler, ...	30	17	8	45
1906	Leaming, ...	41	19	9	31

(*b*) *Proportions in Dry Matter* (*100 Pounds*) — Concluded.

Year.	Variety.	Stalks.	Leaves.	Husks.	Ears.
1907	Leaming,	48	20	10	22
1909	Brewer's,	51	20	12	17
1910	Brewer's,	47	20	10	23
1908	Early Mastodon,	44	19	9	28
1909	Early Mastodon,	47	21	11	21
1908	Klondike,	59	22	7	12
1908	Red Cob Silage,	50	19	11	20
1908	White Cap Yellow,	38	19	10	33
1909	White Cap Yellow,	47	19	11	23
1909	Wing's Improved White Cap,	52	23	9	16
1904	Eureka,	63	25	6	6
1910	Eureka,	59	28	6	6
	Average,	42	20	9	29

Condition of Crop when cut and Character of Season.

1904. *Poor Corn Year.* — Varieties grown: Pride of the North and Eureka. In spite of the unfavorable season, Pride of the North was fairly ripe when cut and contained a fair proportion of ear. The Eureka was quite immature, with ears just forming.

1906. *An Exceptionally Favorable Corn Year.* — Varieties grown: Pride of the North and Leaming. Both matured, gave a large total yield and showed a noticeably large proportion of ears.

1907. *Poor Corn Year.* — Varieties grown: Pride of the North and Leaming. Neither variety did as well as in 1906 and the proportion of ear was much less.

1908. *Satisfactory Corn Year.* — Varieties grown: Sanford White, Longfellow, Rustler, Early Mastodon, Klondike, Red Cob Silage and White Cap Yellow. Of these the first three were fully developed when cut, and showed a larger development of ear than did the last four, which were in the milk-to-denting stage. White Cap Yellow was the best developed of the last-named varieties, and showed a fair proportion of ear.

1909. *Poor Corn Year.* — Varieties grown: Twitchell's, Rustler, Brewer's, Early Mastodon, White Cap Yellow, Wing's Improved White Cap. The first two varieties matured. The Twitchell, a very small variety, has a short stalk with a long ear setting low on the stalk. It showed the largest proportion of ear of any variety raised. The last three varieties were in milk when cut.

1910. *Favorable Corn Year.* — Varieties: Longfellow, Rustler, Brewer's, Eureka. The first two varieties were mature when cut. Brewer's was in milk and the ears just forming on the Eureka.

It will be observed that in many cases the proportion of the several parts differ in the green stage and on the dry-matter basis. Thus Twitchell's shows 27 per cent. of stalk when cut and only 15 per cent. when all of the water is eliminated. Sanford White shows 24 per cent. of ears when cut and 35 per cent. in dry matter.

The remarks which follow refer to the proportions of the parts on the basis of dry material. In general it may be said that there is a wide difference between the proportion of stalks and ears; the difference between the leaves and husks is less marked.

A decided difference is noted between the *same variety* grown *in different* years. This variation is evidently due, to some extent, to the stage of maturity of the plant when cut and also to unfavorable conditions, which checked the development of the ear. *The stalks and ears form practically 70 per cent. of the dry matter of the plant. The leaves and husks 30 per cent.* From the data at hand the inference can be drawn that this is an inherent characteristic of the maize plant. While other investigators [1] have determined the relative proportions of the plant, it is believed that this fact has not before been noticed.

Those coarse varieties maturing late naturally have less ear and a correspondingly larger proportion of stalk. Note the mature varieties, including the Longfellow with an average of 28 per cent. of stalk and 44 per cent. of ears; the Pride of the North with an average of 38 per cent. of stalk and 35 per cent. of ears; the Rustler with 32 per cent. of stalk and 35 per cent. of ears, against the later maturing varieties, such as the Brewer's with 49 per cent. of stalk and 19 per cent. of ears; the Leaming with 44 per cent. of stalk and 26 per cent. of ears; and finally the Eureka with 61 per cent. of stalk and 6 per cent. of ears. On the whole, the proportion of leaves and husks does not vary widely in any of the varieties, averaging 20 per cent. for the leaves and 9 per cent. for the husks. The Eureka shows rather

[1] Schweitzer, Bul. No. 9, Mo. Exp. Sta., Caldwell, Bul. Nos. 7–11; Rept. of 1890, pp. 30–43, Pa. Exp. Sta.; Bul. No. 21, Iowa Exp. Sta.

more leaf and correspondingly less husk than the other varieties; in fact, this variety as cut was largely stalk and leaf.

The following general conclusions can be drawn: —

1. The stalks and ears form substantially 70 per cent. of the entire maize plant.

2. The small, early maturing varieties of which the Twitchell is a type show an exceptionally large proportion of ears.

3. The mature medium varieties average 33 per cent. of stalk and 37 per cent. of ears.

4. The coarser, less mature varieties show 45 per cent. of stalk and 26 per cent. of ears.

5. The very coarse, immature varieties (excepting Eureka) show 52 per cent. of stalks and 17 per cent. of ears.

6. Most of the varieties have in the vicinity of 20 per cent. of leaves and 10 per cent. of husks.

The above conclusions are for corn grown in Massachusetts and cut about September 15. These conclusions might not hold, especially for the larger immature varieties, had they been ripe at the time of cutting.

Average Composition of Parts (Per Cent.).

Number of Analyses.	Variety.	Water.	Dry Matter.				
			Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
	Stalks.						
2	Pride of the North,	79.84	4.04	.89	56.52	32.91	5.64
2	Leaming,	80.97	3.91	.94	58.94	31.56	4.65
1	Eureka,	83.08	4.80	1.07	52.94	35.77	5.42
	Leaves.						
2	Pride of the North,	76.28	13.99	3.39	48.89	24.06	9.67
2	Leaming,	76.53	13.65	3.03	48.89	25.16	9.27
1	Eureka,	81.17	14.53	2.43	45.63	28.43	8.98
	Husks.						
2	Pride of the North,	77.49	5.14	1.36	62.23	27.98	3.29
2	Leaming,	81.87	6.77	1.50	61.69	26.74	3.30
1	Eureka,	85.35	8.66	1.46	62.22	24.64	3.02
	Ears.						
2	Pride of the North,	56.54	9.53	3.73	75.50	9.46	1.78
2	Leaming,	71.77	9.56	2.90	71.48	13.82	2.24
1	Eureka,	86.91	12.00	1.44	63.84	19.47	3.25

While the analyses are not sufficient in number to enable one to draw any positive conclusions, attention may be called to a few of the more striking facts.

Stalks. — A comparatively low percentage of both protein and fat is noted in the stalks of all the several kinds. The proportion of extract matter is lowest in the Eureka and the fiber percentage the highest.

Leaves. — The protein percentage is highest in the leaves. Naturally, the fiber percentage is less in the leaves than in the stalks, while the percentage of ash is noticeably high and quite constant for the three types. The leaves of the three varieties analyzed resemble each other quite closely in the proportion of all of the several groups of constituents.

Husks. — The one noticeable difference in the case of the husks of the several varieties consists in the low protein content in the Pride of the North and the high protein content of the Eureka. This is, of course, due to the fact that the ears of the latter were in the formative stage, while those of the former had matured and the protein had entered into the kernel. The fiber content of the Pride of the North was somewhat higher than that contained in the Eureka, which is explained on similar grounds.

Ears. — The composition of the ears of the three varieties indicate a very immature condition on the part of the Eureka, — high protein and fiber and low carbohydrates and fat, — and a reasonably mature condition of the ears yielded by the Pride of the North and Leaming.

Relative Proportions of Grain and Cob.

Ten representative ears of corn were selected at the time of husking from the crops of 1908 and 1909 and preserved for analysis. The corn and cob were weighed separately at the time of shelling, dry-matter determinations made, and percentage of cob and kernel determined.

Weights of Ten Average Ears with Proportion of Kernel and Cob in Dry Matter.

Variety.	Condition when cut.	Dry Matter (Pounds).			Dry Matter (Per Cent.).	
		10 Ears.	Kernel.	Cob.	Kernel.	Cob.
Twitchell's,	Mature.	3.37	2.93	.44	86.9	13.1
Sanford White,	Mature.	3.37	2.65	.72	78.6	21.4
Longfellow,	Mature.	3.53	2.95	.58	83.6	16.4
Rustler,	Mature.	4.71	4.08	.63	86.6	13.4
Rustler,	Mature.	4.87	4.23	.64	86.9	13.1
Average,	. .	3.97	3.37	.60	84.5	15.5
Brewer's,	In milk.	4.29	3.57	.72	83.2	16.8
Early Mastodon,	In milk.	4.05	3.37	.68	83.2	16.8
Early Mastodon,	In milk.	5.48	4.55	.93	83.0	17.0
Klondike,	In milk.	3.60	2.66	.94	73.9	26.1
Red Cob Silage,	In milk.	4.37	3.59	.78	82.2	17.8
White Cap Yellow,	In milk.	3.70	3.12	.58	84.3	15.7
White Cap Yellow,	In milk.	3.71	3.11	.60	83.8	16.2
Wing's Improved White Cap,	In milk.	4.14	3.39	.75	81.9	18.1
Average,	. .	4.17	3.42	.75	81.9	18.1

Wide variations were noted depending upon stage of ripeness. The Twitchell, a long eared and early maturing flint, showed the smallest percentage of cob (13.1), and the Klondike, a quite immature dent, the largest amount of cob (26.1). The average of the several mature types was 15.5 per cent. cob, and 84.5 per cent. kernel, while the average for the less mature varieties was 18.1 for cob and 81.9 for kernel. If the less mature varieties had been grown in a climate favorable to their complete maturity, it is probable that they would have shown equally as favorable a proportion of cob and kernel.

The weight of the Massachusetts legal bushel in case of shelled corn is 56 pounds, and for a bushel of ears 70 pounds. This allows 14 pounds, or 20 per cent., for the cob. With but two exceptions the samples tested contained less than 20 per cent. cob in dry matter. Assuming that the standard of 70 pounds per bushel for corn was based upon the average of a large number of trials, is it not possible that the corn crop has been improved since the time that such a standard was adopted, and that corn is now being grown that contains relatively less cob and more kernel than formerly?

The results of these trials are substantiated by work done by the author in connection with corn grown for the Bowker prize in 1910. The proportions of corn and cob in dry matter in 10 representative ears of 9 varieties were determined with the following results: —

	Grain (Per Cent.).	Cob (Per Cent.).
1. Flint,	83.7	16.3
2. Flint,	84.8	15.2
3. Flint,	85.8	14.2
4. Flint,	78.7	21.3
5. Flint,	83.6	16.4
6. Flint,	84.6	15.4
Average,	83.5	16.5
7. Dent,	85.0	15.0
8. Dent,	80.7	19.3
9. Dent,	83.9	16.1
Average,	83.2	16.8

Composition of Grain and Cob.

During the seasons of 1908 and 1909 samples of corn kernels were analyzed with the following results: —

Analyses of Grain (Per Cent.).

[Dry Matter.]

Year.	Variety.	Condition.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.	Starch.
1909	Twitchell's,	Mature.	11.30	5.12	80.49	1.58	1.51	67.54
1908	Sanford White,	Mature.	10.92	5.22	80.83	1.53	1.50	71.35
1908	Longfellow,	Mature.	10.80	5.46	80.72	1.43	1.59	70.86
1908	Rustler,	Mature.	9.55	4.44	82.79	1.77	1.45	72.84
1909	Rustler,	Mature.	9.56	4.55	82.33	1.41	1.52	70.00
1909	Brewer's,	In milk.	9.64	3.97	81.99	2.70	1.70	67.27
1908	Early Mastodon,	In milk.	9.22	4.62	82.29	2.33	1.54	72.98
1909	Early Mastodon,	In milk.	9.69	4.36	82.06	2.21	1.68	68.39
1908	Klondike,	In milk.	10.81	4.40	80.73	2.27	1.79	71.48
1908	Red Cob Silage,	In milk.	10.69	3.61	81.80	2.33	1.57	72.70
1908	White Cap Yellow,	In milk.	10.30	3.93	82.13	2.09	1.55	73.13
1909	White Cap Yellow,	In milk.	9.06	4.42	82.77	2.24	1.51	69.16
1909	Wing's Improved White Cap,	In milk.	10.21	4.35	81.18	2.52	1.74	67.90

A study of the analytical results shows very slight variations in composition. The protein of the first varieties is rather in excess of the Rustler Dent. The protein of the coarse, less mature dents would probably have been somewhat less had they been more completely matured. The fiber percentage is noticeably less in the mature lots, 1.54 as against 2.34 for the immature types. A high fiber is believed to be characteristic of immature corn. The percentages of starch are remarkably uniform.

While corn has been bred in an experimental way which bore decidedly different chemical characteristics (namely, high protein, high starch and high fat), such corn has not come into general use; when, therefore, the grain is grown primarily as a food for stock it is believed that the farmer can do no better than to grow the variety that will in his experience produce the largest number of bushels of mature corn per acre. This fact is borne out not only by the analyses herein reported, but also by others made by the author. Chemical composition cannot, at the present time, be considered a factor in the selection of seed corn where the crop is used for the sustenance of live stock.

An evident effect of the season upon the starch content is shown in the case of Rustler, Early Mastodon and White Cap Yellow, all grown in two successive years. In each case the starch content was slightly lower for 1909, an unfavorable year.

Analysis of Corn Cob (Per Cent.).

[Dry Matter.]

Year.	Variety.	Condition.	Protein.	Fat.	Nitrogen-free Extract.	Fiber.	Ash.
1908	Sanford White,	Mature.	1.97	.27	58.21	38.01	1.54
1908	Longfellow,	Mature.	1.98	.30	59.11	36.91	1.70
1908	Rustler,	Mature.	1.70	.44	62.15	34.12	1.59
1908	Early Mastodon,	In milk.	1.84	.32	60.79	35.49	1.56
1908	Klondike,	In milk.	2.21	.38	61.80	33.86	1.75
1908	Red Cob Silage,	In milk.	2.09	.38	60.07	35.75	1.75
1908	White Cap Yellow Dent,	In milk.	2.17	.34	60.08	35.98	1.49
	Average,	-	1.99	.33	60.32	35.73	1.63

The above analyses represent the product of several varieties of cob produced during the season of 1908. One notes comparatively little variation in the composition. The cob is characterized by its very low protein and fat content and its high extract matter and fiber. It is doubtful if the cob from any number of different varieties would show substantial variations from the figures reported above. Lindsey and Holland [1] have shown the cob to contain over 30 per cent. of pentosans which have a digestibility of 63 per cent., and, further,[2] that the total dry matter of the cob has a digestibility of 59 per cent. So far as known, further studies of the chemical character of the extract matter have not been made. It is evident that the chief feeding value of the cob is to be found in its 59 per cent. of digestible carbohydrates.

On the basis of the work done by Kellner,[3] the net available energy in 100 pounds of cob containing 11 per cent. water is 40.2 therms, as against 85.5 therms in a like amount of corn meal; or 100 pounds of corn cob has 47 per cent. of the energy value of corn meal.

The practical feeder, therefore, cannot afford to pay grain prices for the cob when used as an adulterant of wheat-mixed feed, hominy meal or the like. Its use, however, is warranted when produced upon the farm and ground together with the kernel as a food for farm animals.

Summary.

Yield. — The small, early maturing types of corn are not economical for Massachusetts conditions; the medium dent and flint varieties that will mature in the average season are quite well suited for grain, and also serve fairly well for silage. The larger medium dent varieties that in an average season bring their ears to the milk stage are, all conditions considered, rather preferable for silage purposes, while the coarse, late maturing varieties, which never ripen seed in this locality, are not satisfactory because of the less net available energy produced (actual food value).

The season has a marked influence upon the yield of the corn crop, the same variety of corn under otherwise identical

[1] Fifteenth Rept. of the Hatch Exp. Sta., pp. 78–79.
[2] Eighteenth Rept. of the Hatch Exp. Sta., p. 243.
[3] Die Ernährung die Landw. Nützthiere, fünfte Auflage, pp. 159–169, also p. 601.

conditions yielding from 50 to 100 per cent. more in a year particularly favorable to its growth.

Composition of the Corn Plant. — The general conclusion can be drawn that the changes in chemical composition which the plant undergoes in its development are such that its maximum feeding value exists at its maturity.

Digestibility of the Corn Plant. — Digestion experiments conducted with the entire corn plant showed no wide variation in the digestibility of the several varieties, the range being from 67 to 77 per cent. With one exception the digestibility appeared to depend upon the percentage of nitrogen-free extract. The higher the percentage of extract or starchy matter present, the higher the digestibility.

Proportion and Composition of Parts. — The stalks and ears form practically 70 per cent. of the dry matter of the plant, the leaves and husks 30 per cent.

Relative Proportion of Grain to Cob. — The percentage of grain to cob varies widely, depending to some extent upon the maturity of the plant when cut. The average for the several mature types was 15.5 per cent. cob and 84.5 per cent. kernel, while the average for the less mature varieties was 18.1 per cent. cob and 81.9 per cent. kernel. In either case the percentage of cob was less than that of the Massachusetts legal bushel, which in the case of shelled corn is 56 pounds, and for ear corn 70 pounds, thus allowing 14 pounds, or 20 per cent., for cob.

Composition of Grain and Cob. — The grain analyzed showed only slight variations in composition. Chemical composition cannot at the present time be considered a factor in the selection of seed corn where the crop is used for the sustenance of live stock.

There appears to be very little variation in the composition of the corn cob. The net available energy in 100 pounds of cob, after the method of calculation suggested by Kellner, is 40.2 therms as against 85.5 therms in a like amount of corn meal; hence on this basis ground corn cob would have 47 per cent. of the energy value of corn meal.[1]

[1] The Kellner method of calculation is the best we have for making comparative estimates of relative values.

THE DIGESTIBILITY OF CATTLE FOODS.

BY J. B. LINDSEY AND P. H. SMITH.

The digestion experiments herein reported were made during the autumn, winter and early spring of 1906–07, 1908–09 and 1909–10, and form part of what are known as Series XII., XIV. and XV. The experiments made in these series and not here included have been published in previous reports.

The usual method was employed and has been fully described elsewhere.[1] The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, averages only are given. The periods extended over fourteen days, the first seven of which were preliminary, collection of feces being made during the last seven. Ten grams of salt were given each sheep daily with water *ad libitum.*

Series XII.

Three lots of Southdown wethers were employed and were known as Old Sheep, Young Sheep and Paige Sheep. The former were fully seven years of age, and the latter two lots four to five years old.

The hay used in connection with the several experiments consisted of fine-mixed grasses, and contained a large proportion of June grass. The digestion coefficients of this hay as applied to the experiments in this series were obtained in 1905, and were as follows: —

[1] Eleventh report of the Mass. State Agr. Exp. Sta., pp. 146–149; also the 22d report of the Mass. Agr. Exp. Sta., p. 84.

Digestion Coefficients used in these Experiments.[1]

[English Hay.]

	Old Sheep II. and III.	Young Sheep I., II. and III.	Paige Sheep IV. and V.
Dry matter,	67.87	65.92	65.48
Ash,	49.17	51.95	44.60
Protein,	62.31	61.98	61.53
Fiber,	76.30	72.87	73.81
Nitrogen-free extract,	66.39	64.66	64.46
Fat,	52.37	54.23	50.20

Composition of Feedstuffs (Per Cent.).

[Dry Matter.]

	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Pride of the North corn fodder (entire plant),	4.07	7.69	17.96	67.62	2.66
Leaming corn fodder (entire plant),	4.69	7.89	22.42	62.94	2.06
English hay,	6.75	12.23	33.45	44.67	2.90
Biles Union grains,	6.67	27.11	10.55	47.45	8.22
Schumacher's stock feed,	4.44	11.73	11.70	67.31	4.82
Protena dairy feed,	7.28	19.56	20.16	49.92	3.08
Buffalo Creamery feed,	4.68	21.87	13.58	55.32	4.55
Waste, Paige Sheep, IV., Period I.,	3.77	8.70	14.28	69.92	3.33

Composition of Feces (Per Cent.).

[Dry Matter.]

Old Sheep II.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Pride of the North corn fodder,	10.21	11.74	27.77	48.65	1.63
VI.	Biles Union grains,	13.30	17.90	21.39	43.81	3.60

Old Sheep III.

II.	Leaming corn fodder,	9.67	10.90	28.21	49.49	1.73

[1] Made in 1905.

Composition of Feces (Per Cent.) — Concluded.

[Dry Matter.]

Young Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
VIII.	Schumacher's stock feed, . .	11.58	13.62	24.06	47.40	3.34
XIII.	Buffalo Creamery feed, . .	10.07	13.59	25.17	47.61	3.56
	Young Sheep II.					
IX.	Biles Union grains, . . .	11.32	17.33	22.28	45.71	3.36
	Young Sheep III.					
VIII.	Schumacher's stock feed, . .	11.63	12.95	25.14	46.91	3.37
XIII.	Buffalo Creamery feed, . .	10.03	13.62	25.14	47.87	3.34
	Paige Sheep IV.					
I.	Pride of the North corn fodder,.	12.89	12.75	24.61	47.65	2.10
XII.	Protena dairy feed, . . .	11.72	14.49	27.15	43.42	3.22
	Paige Sheep V.					
II.	Leaming corn fodder, . .	10.23	10.30	29.40	48.50	1.57
XII.	Protena dairy feed, . . .	11.24	13.77	28.24	43.67	3.08

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Old Sheep II.

Period.	English Hay.	Pride of the North Corn Fodder.	Leaming Corn Fodder.	Schumacher's Stock Feed.	Buffalo Creamery Feed.	Biles Union Grains.	Protena Dairy Feed.	Waste.	Feces.
I.	-	29.50	-	-	-	-	-	-	89.78
VI.	88.20	-	-	-	-	90.91	-	-	92.15
				Old Sheep III.					
II.	-	-	24.52	-	-	-	-	-	89.92
				Young Sheep I.					
VIII.	89.82	-	-	90.78	-	-	-	-	92.79
XIII.	90.65	-	-	-	90.55	-	-	-	94.48

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Young Sheep II.

Period.	English Hay.	Pride of the North Corn Fodder.	Leaming Corn Fodder.	Schumacher's Stock Feed.	Buffalo Creamery Feed.	Biles Union Grains.	Protena Dairy Feed.	Waste.	Feces.
IX.	89.82	-	-	-	-	92.57	-	-	92.34
Young Sheep III.									
VIII.	89.82	-	-	90.78	-	-	-	-	92.97
XIII.	90.65	-	-	-	90.55	-	-	-	94.26
Paige Sheep IV.									
I.	-	29.50	-	-	-	-	-	36.26	90.19
XII.	90.45	-	-	-	-	-	91.36	-	94.55
Paige Sheep V.									
II.	-	-	24.52	-	-	-	-	-	90.76
XII.	90.45	-	-	-	-	-	91.36	-	94.42

Average Daily Amount of Manure excreted and Water drunk (Grams).

Old Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Pride of the North corn fodder,	1,008	31.84	937
VI.	Biles Union grains,	751	25.68	1,899
Old Sheep III.				
II.	Leaming corn fodder,	795	28.64	893
Young Sheep I.				
VIII.	Schumacher's stock feed,	540	24.96	1,936
XIII.	Buffalo Creamery feed,	545	25.68	2,286
Young Sheep II.				
IX.	Biles Union grains,	770	25.41	2,271

Average Daily Amount of Manure excreted and Water drunk (Grams) — Concluded.

Young Sheep III.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
VIII.	Schumacher's stock feed,	528	25.32	2,185
XIII.	Buffalo Creamery feed,	551	25.32	2,179

Paige Sheep IV.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Pride of the North corn fodder,	613	20.03	1,101
XII.	Protena dairy feed,	823	26.36	1,364

Paige Sheep V.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
II.	Leaming corn fodder,	1,143	29.91	1,050
XII.	Protena dairy feed,	769	27.03	1,764

Weights of Animals at Beginning and End of Period (Pounds).[1]

Old Sheep II.

Period.	Character of Food or Ration.	Beginning.	End.
I.	Pride of the North corn fodder,	110.0	111.0
VI.	Biles Union grains,	108.5	103.5

Old Sheep III.

Period.	Character of Food or Ration.	Beginning.	End.
II.	Leaming corn fodder,	113.5	125.5

Young Sheep I.

Period.	Character of Food or Ration.	Beginning.	End.
VIII.	Schumacher's stock feed,	102.0	101.5
XIII.	Buffalo Creamery feed,	102.0	100.0

Young Sheep II.

Period.	Character of Food or Ration.	Beginning.	End.
IX.	Biles Union grains,	93.5	89.0

Young Sheep III.

Period.	Character of Food or Ration.	Beginning.	End.
VIII.	Schumacher's stock feed,	94.5	92.5
XIII.	Buffalo Creamery feed,	92.0	93.0

[1] The weights of the sheep in several cases vary much more widely than would be expected, and it is possible that errors were made in recording them. In order to guard against this, weights for two consecutive days are now made at the beginning and end of each trial.

Weights of Animals at Beginning and End of Period (Pounds) — Concluded.

Paige Sheep IV.

Period.	Character of Food or Ration.	Beginning.	End.
I.	Pride of the North corn fodder,	121.5	116.5
XII.	Protena dairy feed,	124.5	122.5

Paige Sheep V.

Period.	Character of Food or Ration.	Beginning.	End.
II.	Leaming corn fodder,	108.0	110.0
XII.	Protena dairy feed,	119.0	112.0

Pride of the North Corn Fodder, Period I.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Pride of the North corn fodder fed daily.	1,062.00	43.22	81.67	190.74	718.12	28.25
318.41 grams manure excreted,	285.87	29.19	33.56	79.39	139.08	4.66
Grams digested,	776.13	14.03	48.11	111.35	579.04	23.59
Per cent. digested,	73.08	32.46	58.91	58.38	80.63	83.50

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Pride of the North corn fodder fed daily.	1,062.00	43.22	81.67	190.74	718.12	28.25
335.4 grams waste,	121.62	4.59	10.58	17.37	85.04	4.05
Amount consumed,	940.38	38.63	71.09	173.37	633.08	24.20
200.26 grams manure excreted,	180.61	23.28	23.03	44.45	86.06	3.79
Grams digested,	759.77	15.35	48.06	128.92	547.02	20.41
Per cent. digested,	80.79	39.74	67.60	74.36	86.41	84.34
Average per cent. for both sheep,	76.94	36.10	63.26	66.37	83.52	83.92

Leaming Corn Fodder, Period II.

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Leaming corn fodder fed,	882.72	41.40	69.65	197.91	555.58	18.18
286.43 grams manure excreted,	257.56	24.91	28.07	72.66	127.47	4.46
Grams digested,	625.16	16.49	41.58	125.25	428.11	13.72
Per cent. digested,	70.82	39.83	59.70	63.29	77.06	75.47

Leaming Corn Fodder, Period II — Concluded.

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Leaming corn fodder fed, . .	882.72	41.40	69.65	197.91	555.58	18.18
299.08 grams manure excreted, ...	271.45	27.77	27.96	79.81	131.65	4.26
Grams digested, ...	611.27	13.63	41.69	118.10	423.93	13.92
Per cent. digested, ...	69.25	32.92	59.86	59.67	76.30	76.57
Average per cent. for both sheep, . .	70.04	36.38	59.78	61.48	76.68	76.02

Biles Union Grains, Period VI.

Old Sheep II.

650 grams English hay fed, ...	573.30	38.70	70.11	191.77	256.09	16.63
250 grams Biles Union grains fed, . .	227.28	15.16	61.62	23.98	107.84	18.68
Amount consumed, ...	800.58	53.86	131.73	215.75	363.93	35.31
256.76 grams manure excreted, ...	236.60	31.47	42.35	50.61	103.65	8.52
Grams digested, ...	563.98	22.39	89.38	165.14	260.28	26.79
Minus hay digested, ...	389.10	19.03	43.69	146.32	170.02	8.71
Biles Union grains digested, ...	174.88	3.36	45.69	18.82	90.26	18.08
Per cent. digested, ...	76.94	22.16	74.15	78.48	83.70	96.79

Biles Union Grains, Period IX.

Young Sheep II.

600 grams English hay fed, ...	538.92	36.38	65.91	180.27	240.74	15.63
200 grams Biles Union grains fed, . .	185.14	12.35	50.19	19.53	87.85	15.22
Amount consumed, ...	724.06	48.73	116.10	199.80	328.59	30.85
254.10 grams manure excreted, ...	234.86	26.59	40.70	52.33	107.35	7.89
Grams digested, ...	489.20	22.14	75.40	147.47	221.24	22.96
Minus hay digested, ...	355.26	18.90	40.85	131.36	155.66	8.48
Biles Union grains digested, ...	133.94	3.24	34.55	16.11	65.58	14.48
Per cent. digested, ...	72.35	26.23	68.84	82.49	74.65	95.14

Schumacher's Stock Feed, Period VIII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	494.01	33.35	60.42	165.25	220.67	14.33
250 grams Schumacher's stock feed fed,	226.95	10.08	26.62	26.55	152.76	10.94
Amount consumed,	720.96	43.43	87.04	191.80	373.43	25.27
249.64 grams manure excreted,	231.64	26.82	31.55	55.73	109.80	7.74
Grams digested,	489.32	16.61	55.49	136.07	263.63	17.53
Minus hay digested,	325.65	17.33	37.45	120.42	142.69	7.77
Schumacher's stock feed digested,	163.67	-	18.04	15.65	120.94	9.76
Per cent. digested,	72.12	-	67.77	58.95	79.17	89.21

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	720.96	43.43	87.04	191.80	373.43	25.27
253.20 grams manure excreted,	235.40	27.38	30.48	59.18	110.43	7.93
Grams digested,	485.56	16.05	56.56	132.62	263.00	17.34
Minus hay digested,	325.65	17.33	37.45	120.42	142.69	7.77
Schumacher's stock feed digested,	159.91	-	19.11	12.20	120.31	9.57
Per cent. digested,	70.46	-	71.79	45.95	78.76	87.48
Average per cent. for both sheep,	71.29	-	69.78	52.45	78.97	88.35

Protena Dairy Feed, Period XII.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	542.70	36.63	66.37	181.53	242.42	15.74
200 grams Protena dairy feed fed,	182.72	13.30	35.74	36.84	91.21	5.63
Amount consumed,	725.42	49.93	102.11	218.37	333.63	21.37
263.57 grams manure excreted,	249.21	29.21	36.11	67.66	108.21	8.02
Grams digested,	476.21	20.72	66.00	150.71	225.42	13.35
Minus hay digested,	355.36	16.34	40.84	133.99	156.26	7.90
Protena dairy feed digested,	120.85	4.38	25.16	16.72	69.16	5.45
Per cent. digested,	66.14	32.93	70.40	45.39	75.83	96.80

Protena Dairy Feed, Period XII — Concluded.

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	725.42	49.93	102.11	218.37	333.63	21.37
270.27 grams manure excreted,	255.19	28.68	35.14	72.07	111.44	7.86
Grams digested,	470.23	21.25	66.97	146.30	222.19	13.51
Minus hay digested,	355.36	16.34	40.84	133.99	156.26	7.90
Protena dairy feed digested,	114.87	4.91	26.13	12.31	65.93	5.61
Per cent. digested,	62.87	36.92	73.11	33.41	72.29	99.64
Average per cent. for both sheep,	64.51	34.93	71.76	39.40	74.06	98.22

Buffalo Creamery Feed, Period XIII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	543.90	36.71	66.52	181.93	242.96	15.77
200 grams Buffalo Creamery feed fed,	181.10	8.48	39.61	24.59	100.18	8.24
Amount consumed,	725.00	45.19	106.13	206.52	343.14	24.01
256.84 grams manure excreted,	242.66	24.44	32.98	61.08	115.53	8.64
Grams digested,	482.34	20.75	73.15	145.44	227.61	15.37
Minus hay digested,	358.54	19.07	41.23	132.57	157.10	8.55
Buffalo Creamery feed digested,	123.80	1.68	31.92	12.87	70.51	6.82
Per cent. digested,	68.36	19.81	80.59	52.34	70.38	82.77

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	725.00	45.19	106.13	206.52	343.14	24.01
253.23 grams manure excreted,	238.69	23.94	32.51	60.01	114.26	7.97
Grams digested,	486.31	21.25	73.62	146.51	228.88	16.04
Minus hay digested,	358.54	19.07	41.23	132.57	157.10	8.55
Buffalo Creamery feed digested,	127.70	2.18	32.39	13.94	71.78	7.49
Per cent. digested,	70.55	25.71	81.77	56.69	71.65	90.90
Average per cent. for both sheep,	69.46	22.76	81.18	54.52	71.02	86.84

Summary of Coefficients (Per Cent.).

Food.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Pride of the North corn fodder,	Old Sheep II.,	73.08	32.46	58.91	58.38	80.63	83.50
	Paige Sheep IV.,	80.79	39.74	67.60	74.36	86.41	84.34
Average,	- -	76.94	36.10	63.26	66.37	83.52	83.92
Leaming corn fodder,	Old Sheep III.,	70.82	39.83	59.70	63.29	77.06	75.47
	Paige Sheep V.,	69.25	32.92	59.86	59.67	76.30	76.57
Average,	- -	70.04	36.38	59.78	61.48	76.68	76.02
Biles Union grains,	Old Sheep II.,	76.94	22.16	74.15	78.48	83.70	96.79
	Young Sheep II.,	72.35	26.23	68.84	82.49	74.65	95.14
Average,	- -	74.65	24.20	71.50	80.49	79.18	95.97
Schumacher's stock feed,	Young Sheep I.,	72.12	-	67.77	58.95	79.17	89.21
	Young Sheep III.,	70.46	-	71.79	45.95	78.76	87.48
Average,	- -	71.29	-	69.78	52.45	78.97	88.35
Protena dairy feed,	Paige Sheep IV.,	66.14	32.93	70.40	45.39	75.83	96.80
	Paige Sheep V.,	62.87	36.92	73.11	33.41	72.29	99.64
Average,	- -	64.51	34.93	71.76	39.40	74.06	98.22
Buffalo Creamery feed,	Young Sheep I.,	68.36	19.81	80.59	52.34	70.38	82.77
	Young Sheep III.,	70.55	25.71	81.77	56.69	71.65	90.90
Average,	- -	69.46	22.76	81.18	54.52	71.02	86.84

Discussion of the Results.

The most important results obtained from the experiments reported in the previous pages are discussed under the following headings: —

Pride of the North Corn Fodder. — The fodder used was of excellent quality and exceptionally well eared. The one-twentieth acre plot on which it was grown yielded at the rate of slightly over 21 tons to the acre and contained 49 per cent. of ears in dry matter. The unusually high percentage of ears naturally increased the digestibility of the fodder. The corn was cut from the field every two days, the first cutting being September 5, and the last September 19. The entire plant was finely cut before being fed, dry matter determinations being made of each single cutting.

Summary of Coefficients, Period I. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II.,	1	1	73.08	32.46	58.91	58.38	80.63	83.50
Paige Sheep IV.,	1	1	80.79	39.74	67.60	74.36	86.41	84.34
Average,	1	2	76.94	36.10	63.26	66.37	83.52	83.92
Average of all experiments, mature dent corn fodder for comparison.	12	23	69.00	34.00	54.00	59.00	75.00	75.00

Paige Sheep IV. gave higher results than did Old Sheep II., probably due in part to the fact that the former left a portion of the tougher and less digestible part. The present experiment shows in a fairly satisfactory manner the digestibility of a variety of dent corn that will mature in Massachusetts, and also emphasizes the fact that a fodder containing a higher percentage of ears is noticeably more digestible than one containing relatively fewer ears and a larger percentage of stalk.

Leaming Corn Fodder. — The fodder used was fed at the same time and handled in the same manner as was the preceding variety. The one-twentieth acre plot yielded at the rate of 25½ tons per acre. The crop contained 31 per cent. of ears in dry matter. The stalks are rather larger than the Pride of the North, and in the average season the Leaming matures a little later.

Summary of Coefficients, Period II. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep III.,	1	1	70.82	39.83	59.70	63.29	77.06	75.47
Paige Sheep V.,	1	1	69.25	32.92	59.86	59.67	76.30	76.57
Average,	1	2	70.04	36.38	59.78	61.48	76.68	76.02
Average all experiments, mature dent corn fodder for comparison.	12	23	69.00	34.00	54.00	59.00	75.00	75.00

The sheep consumed the entire ration fed. The coefficients for both sheep agreed closely, not only with each other, but also with the average of all experiments with dent fodder. The Leaming is shown to be rather less digestible than the Pride of the North, due to its rather coarser stalks and to its relatively less ear production. It is believed, however, that this variety of dent fodder is quite well suited for silage in Massachusetts.

Biles Union Grains. — Biles Union Grains is a proprietary feed consisting principally of a mixture of distillers' dried grains and malt sprouts, together with some corn and wheat products, cottonseed meal and salt. The amount of its several components is likely to vary more or less from time to time, depending upon the feeding stuffs available and their cost. This variation in composition varies its digestibility within narrow limits. It is intended, when fed with home-grown roughage, to constitute a balanced ration for dairy stock.

Summary of Coefficients, Periods VI. and IX. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II.,	1	1	76.94	22.16	74.15	78.48	83.70	96.79
Young Sheep II.,	1	1	72.35	26.23	68.84	82.49	74.56	95.14
Average,	1	2	74.65	24.20	71.50	80.49	79.18	95.97

The coefficients agree fairly well, although the Young Sheep II. did not appear to digest the nitrogen-free extract as well as did Old Sheep II. The feed can be considered fairly digestible.

Schumacher's Stock Feed. — This material consists of a mixture of corn, oat and barley residues resulting from the manufacture of human foods from these cereals. It contains about 10 per cent. protein, 3.50 per cent. fat and 9 per cent. fiber. It is extensively advertised as a food for horses and dairy stock.

Summary of Coefficients, Period VIII. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	1	1	72.12	-	67.77	58.95	79.17	89.21
Young Sheep II.,	1	1	70.46	-	71.79	45.95	78.76	87.48
Average,	1	2	71.29	-	69.78	52.45	78.97	88.35
Oats, unground, for comparison,	2	6	70.00	-	77.00	31.00	77.00	89.00

The coefficients obtained for both sheep with the exception of that for fiber agree satisfactorily. The digestibility as well as the composition of this feed resembles that of oats, for which it is often substituted in feeding horses. When used for this purpose it would be advisable to moisten it because of its fine and dry condition.

Protena Dairy Feed. — This material is no longer found in the Massachusetts market. It was composed of ground alfalfa as a basis, together with cottonseed meal, wheat by-products and salt.

Summary of Coefficients, Period XII. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV.,	1	1	66.14	32.93	70.40	45.39	75.83	96.80
Paige Sheep V.,	1	1	62.87	36.92	73.11	33.41	72.29	99.64
Average,	1	2	64.51	34.93	71.76	39.40	74.06	98.22

The presence of so much alfalfa gave it a relatively high fiber content, and a low fiber digestibility. The digestibility of the entire foodstuff is decidedly below the minimum desired for a high-grade concentrate, due also to the large amount of alfalfa used.

Buffalo Creamery Feed. — This is a proprietary mixture containing about 20 per cent. protein, 5 per cent. fat and 9 per cent. fiber. According to the manufacturer's guarantee it contains corn, wheat middlings, oat hulls, hominy feed, cottonseed meal and gluten feed.

Summary of Coefficients, Period XIII. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	1	1	68.36	19.81	80.59	52.34	70.38	82.77
Young Sheep III.,	1	1	70.55	25.71	81.77	56.69	71.65	90.90
Average,	1	2	69.46	22.76	81.18	54.52	71.02	86.84

The coefficients agree closely, and the feed approaches the minimum degree of digestibility (70 per cent.) for a concentrate. Its protein digestibility is fairly satisfactory. Its economy as a dairy feed would naturally depend upon its cost. Feeds of this character are likely to cost more than the ingredients of which they are composed.

Series XIV.

Eleven experiments were made in this series, all of which, with the exception of the 4 that follow, were carried out with Porto Rico molasses and are published elsewhere. The digestion coefficients for the hay used in periods VIII. and X. were those obtained in period XI. The 4 sheep used in this experiment were yearling Shropshires of substantially uniform weight.

Composition of Feedstuffs (Per Cent.).

[Dry Matter.]

Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
English hay,	6.82	7.67	30.35	52.79	2.37
Early Mastodon Dent corn fodder.	4.31	7.38	19.40	66.74	2.17
Rustler White Dent corn fodder,	4.38	6.87	19.46	66.96	2.33
Unicorn dairy ration,	3.60	29.61	9.76	50.11	6.92
Waste, Sheep IV., period II.,	2.85	3.37	29.12	63.58	1.08

Composition of Feces (Per Cent.).

[Dry Matter.]

Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Early Mastodon Dent corn fodder,	9.52	11.12	27.34	50.57	1.45
VIII.	Unicorn dairy ration, . . .	10.55	15.61	24.37	46.56	2.91
X.	Unicorn dairy ration, . . .	11.64	13.63	25.18	46.47	3.08
XI.	English hay, ...	11.16	10.65	27.78	46.91	3.50

Sheep II.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
I.	Early Mastodon Dent corn fodder,	10.16	11.41	27.70	49.17	1.56
VIII.	Unicorn dairy ration, . . .	11.01	14.66	25.32	46.14	2.87
XI.	English hay, ...	10.45	10.17	29.55	46.65	3.18

Sheep III.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
II.	Rustler White Dent corn fodder, .	9.77	12.07	26.62	49.87	1.67

Sheep IV.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
II.	Rustler White Dent corn fodder, .	11.17	14.11	25.11	47.61	1.99

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	English Hay.	Early Mastodon Dent Corn Fodder.	Rustler White Dent Corn Fodder.	Unicorn Dairy Ration.	Waste.	Feces. .
I., ...	–	24.80	–	–	–	89.08
VIII., ...	89.45	–	–	91.11	–	93.36
X., ...	90.22	–	–	92.46	–	93.52
XI., ...	90.05	–	–	–	–	93.41

Sheep II.

Period.	English Hay.	Early Mastodon Dent Corn Fodder.	Rustler White Dent Corn Fodder.	Unicorn Dairy Ration.	Waste.	Feces. .
I., ...	–	24.80	–	–	–	88.92
VIII., ...	89.45	–	–	91.11	–	93.27
XI., ...	90.05	–	–	–	–	93.49

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.) — Concluded.

Sheep III.

Period.	English Hay.	Early Mastodon Dent Corn Fodder.	Rustler White Dent Corn Fodder.	Unicorn Dairy Ration.	Waste.	Feces.
II.,	-	-	31.46	-	-	88.51

Sheep IV.

II.,	-	-	31.46	-	94.05	88.64

Average Daily Amount of Manure excreted and Water Drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Early Mastodon Dent corn fodder,	594	18.62	404
VIII.	Unicorn dairy ration,	1,000	21.97	2,325
X.	Unicorn dairy ration,	751	23.97	2,493
XI.	English hay,	633	24.55	2,292

Sheep II.

I.	Early Mastodon Dent corn fodder,	733	18.99	416
VIII.	Unicorn dairy ration,	891	21.85	2,500
XI.	English hay,	722	26.62	2,251

Sheep III.

II.	Rustler White Dent corn fodder,	929	26.67	1,889

Sheep IV.

II.	Rustler White Dent corn fodder,	1,184	24.15	904

Weights of Animals at Beginning and End of Period (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.	End.
I.	Early Mastodon Dent corn fodder,	89.0	89.0
VIII.	Unicorn dairy ration,	86.5	87.5
X.	Unicorn dairy ration,	86.0	88.0
XI.	English hay,	90.0	88.5

Sheep II.

Period.	Character of Food or Ration.	Beginning.	End.
I.	Early Mastodon Dent corn fodder,	86.5	86.0
VIII.	Unicorn dairy ration,	87.5	87.0
XI.	English hay,	90.5	88.5

Sheep III.

Period.	Character of Food or Ration.	Beginning.	End.
II.	Rustler White Dent corn fodder,	85.5	90.0

Sheep IV.

Period.	Character of Food or Ration.	Beginning.	End.
II.	Rustler White Dent corn fodder,	97.0	95.0

Early Mastodon Dent Corn Fodder, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,400 grams Mastodon corn fodder fed,	595.20	25.67	43.93	115.47	397.21	12.92
186.21 grams manure excreted (air-dry),	165.88	15.79	18.45	45.35	83.88	2.41
Grams digested,	429.32	9.88	25.48	70.12	313.33	10.51
Per cent. digested,	72.13	38.49	58.00	60.73	78.88	81.35

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,400 grams Mastodon corn fodder fed,	595.20	25.67	43.93	115.47	397.21	12.92
189.90 grams manure excreted (air-dry),	168.86	17.16	19.27	46.77	83.03	2.63
Grams digested,	426.34	8.51	24.66	68.70	314.18	10.29
Per cent. digested,	71.63	33.15	56.13	59.50	79.10	79.64
Average per cent. for both sheep,	71.88	35.82	57.07	60.12	78.99	80.50

Rustler White Dent Corn Fodder, Period II.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,400 grams Rustler corn fodder fed,	755.04	33.07	51.87	146.93	505.56	17.59
266.74 grams manure excreted (air-dry),	236.09	23.07	28.50	62.85	117.72	3.93
Grams digested,	518.95	10.00	23.37	84.08	387.84	13.66
Per cent. digested,	68.73	30.24	45.05	57.22	76.71	77.66

Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,400 grams Rustler corn fodder fed,	755.04	33.07	51.87	146.93	505.56	17.59
37.86 grams waste,	35.61	1.01	1.20	10.37	22.65	.38
Amount consumed,	719.43	32.06	50.67	136.56	482.91	17.21
241.53 grams manure excreted,	214.09	23.91	30.21	53.76	101.95	4.26
Grams digested,	505.34	8.15	20.46	82.80	380.96	12.95
Per cent. digested,	70.24	25.42	40.38	60.63	78.89	75.25
Average per cent. for both sheep,	69.49	27.83	42.72	58.93	77.80	76.46

Unicorn Dairy Ration, Period VIII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	447.35	30.51	34.31	135.77	236.21	10.55
200 grams Unicorn dairy ration fed,	182.22	6.56	53.96	17.78	91.31	12.61
Amount consumed,	629.57	37.07	88.27	153.55	327.52	23.16
219.65 grams manure excreted (air-dry),	205.07	21.63	32.01	49.98	95.48	5.97
Grams digested,	424.50	15.44	56.26	103.57	232.04	17.19
Minus hay digested,	277.36	12.81	16.81	90.97	153.54	5.17
Unicorn dairy ration digested,	147.14	2.63	39.45	12.60	78.50	12.02
Per cent. digested,	80.74	40.09	73.11	70.87	85.97	95.32

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	629.57	37.07	88.27	153.55	327.52	23.16
218.50 grams manure excreted (air-dry),	203.79	22.44	29.87	51.60	94.03	5.85
Grams digested,	425.78	14.63	58.40	101.95	233.49	17.31
Minus hay digested,	277.36	12.81	16.81	90.97	153.54	5.17
Unicorn dairy ration digested,	148.42	1.82	41.59	10.98	79.95	12.14
Per cent. digested,	81.45	27.74	77.07	61.75	87.55	96.27
Average per cent. for both sheep,	81.10	33.92	75.09	66.31	86.76	95.80

Unicorn Dairy Ration, Period X.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	541.32	36.92	41.52	164.29	285.73	12.86
150 grams Unicorn dairy ration fed,	138.69	4.98	41.07	13.54	69.50	9.60
Amount consumed,	680.01	41.90	82.59	177.83	355.23	22.46
239.67 grams manure excreted (air-dry),	224.14	26.09	30.55	56.44	104.16	6.90
Grams digested,	455.87	15.81	52.04	121.49	251.07	15.56
Minus hay digested,	335.62	15.51	20.34	110.07	185.72	6.30
Unicorn dairy ration digested,	120.25	.30	31.70	11.42	65.35	9.26
Per cent. digested,	86.70	6.02	77.19	84.34	94.03	96.46

English Hay, Period XI.

Sheep I.

700 grams English hay fed,	630.35	44.82	48.85	205.74	315.24	15.70
245.46 grams manure excreted (air-dry),	229.28	25.59	24.42	63.69	107.56	8.02
Grams digested,	401.07	19.23	24.43	142.05	207.68	7.68
Per cent. digested,	63.63	42.91	50.01	69.04	65.88	48.92

Sheep II.

700 grams English hay fed,	630.35	44.82	48.85	205.74	315.24	15.70
266.16 grams manure excreted (air-dry),	248.83	26.00	25.31	73.53	116.08	7.91
Grams digested,	381.52	18.82	23.54	132.21	199.16	7.79
Per cent. digested,	60.53	41.99	48.19	64.27	63.18	49.62
Average per cent. for both sheep,	62.08	42.45	49.10	66.66	64.53	49.27

Summary of Coefficients (Per Cent.).

FOOD.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Early Mastodon Dent corn fodder,	Sheep I.,	72.13	38.49	58.00	60.73	78.88	81.35
	Sheep II.,	71.63	33.15	56.13	59.50	79.10	79.64
Average,	. . .	71.88	35.82	57.07	60.12	78.99	80.50
Rustler White Dent corn fodder,	Sheep III.,	68.73	30.24	45.05	57.22	76.71	77.66
	Sheep IV.,	70.24	25.42	40.38	60.63	78.89	75.25
Average,	. . .	69.49	27.83	42.72	58.93	77.80	76.46
Unicorn dairy ration,	Sheep I.,	80.74	40.09	73.11	70.87	85.97	95.32
	Sheep I.,	86.70	6.02	77.19	84.34	94.03	96.46
	Sheep II.,	81.45	27.74	77.07	61.75	87.55	96.27
Average,	. . .	82.96	24.62	75.79	72.32	89.18	96.02
English hay,	Sheep I.,	63.63	42.91	50.01	69.04	65.88	48.92
	Sheep II.,	60.53	41.99	48.19	64.27	63.18	49.62
Average,	. . .	62.08	42.45	49.10	66.66	64.53	49.27

Discussion of the Results.

Early Mastodon Dent Corn Fodder. — This is a large growing yellow dent variety bred by C. S. Clark of Ohio. It is evidently rather too late for the average Massachusetts season. At the time of cutting (September 5–19) it was in the milk-to-denting stage, and could not be considered ripe enough to be cut for the grain. It yielded about 20 tons to the acre of green fodder which contained 28 per cent. of ears in dry matter.

Summary of Coefficients, Period I. (Per Cent.).

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1	1	72.13	38.49	58.00	60.73	78.88	81.35
Sheep II.,	1	1	71.63	33.15	56.13	59.50	79.10	79.64
Average,	1	2	71.88	35.82	57.07	60.12	78.99	80.50
Average of all experiments, dent fodder for comparison.	12	23	69.00	34.00	54.00	59.00	75.00	75.00

The results obtained in this trial were very satisfactory. They also agreed quite closely with the average for all trials for dent corn.

Rustler White Dent Corn Fodder. — So far as known this variety of corn originated in Minnesota; it was first grown at the Massachusetts Agricultural Experiment Station, where it has given excellent satisfaction. At the time of cutting (September 5–19) it was dented and glazing and ready to harvest. It yielded about 12 tons of green fodder which contained 41 per cent. of ears in dry matter. The yield was not so large as on other fields nearby. The tendency of this variety is to mature in our latitude and yield a fair amount of stalk with a relatively high grain percentage.

Summary of Coefficients, Period II. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep III.,	1	1	68.73	30.24	45.05	57.22	76.71	77.66
Sheep IV.,	1	1	70.24	25.42	40.38	60.63	78.89	75.25
Average,	1	2	69.49	27.83	42.72	58.93	77.80	76.46
Average of all experiments, dent fodder for comparison.	12	23	69.00	34.00	54.00	59.00	75.00	75.00

While the coefficients obtained in this experiment agreed closely, the digestibility was not as great as would naturally be expected, considering the percentage of ears and degree of maturity. This may be due, in part at least, to the fact that this corn was comparatively dry when cut, and the animals were fed rather more dry matter than was intended; in fact, more than they could readily care for. Sheep IV. left a part of the daily ration. With a smaller amount of dry matter in the ration, the coefficients might have been somewhat higher.

Unicorn Dairy Ration. — This is a proprietary mixture consisting of corn, distillers' grains, cottonseed meal, hominy feed, barley feed and sprouts and wheat bran. It contained on a natural moisture basis about 26 per cent. protein, 6 per cent. fat and 9 per cent. fiber.

Summary of Coefficients, Periods VIII. and X. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1	1	80.74	40.09	73.11	70.87	85.97	95.32
Sheep II.,	1	1	81.45	27.74	77.07	61.75	87.55	96.27
Sheep I.,	1	1	86.07	6.02	77.19	84.34	94.03	96.46
Average,	1	2	81.10	33.92	75.09	66.31	86.76	95.80

The results secured in case of Sheep I. in period X. are noticeably above those for the other two trials, and it is thought best not to include them in the average. The reason for this variation cannot be explained. The coefficients for Sheep I. and II. in period VIII. agree fairly well, and show this proprietary feed to have a high digestibility. These results, together with its high protein and a low fiber content, indicate a high-grade protein dairy feed.

English Hay. — The hay used in this period consisted of mixed grasses with June grass predominating. It was cut while in blossom, well cured and in good condition. Before feeding it was cut fine by running it through a feed cutter, and thoroughly mixed to insure uniformity through the entire lot.

Summary of Coefficients, Period XI. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1	1	63.63	42.91	50.01	69.04	65.88	48.92
Sheep II.,	1	1	60.53	41.99	48.19	64.24	63.18	49.62
Average,	1	2	62.08	42.45	49.10	66.66	64.53	49.27
Average of all trials, similar hay for comparison.	21	73	61.00	47.00	57.00	62.00	62.00	50.00

The coefficients obtained in this trial agree closely. With the exception of the coefficient obtained for protein they also agree closely with the average of all results obtained with similar hay.

Series XV.

This series of experiments was conducted during the fall and winter of 1909–10. Those not reported concerned the effect of lactic acid and calcium lactate upon digestibility, and will be published at a later date. The sheep used were the same as for the preceding year.

Composition of Feedstuffs (Per Cent.).

[Dry Matter.]

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
I.	Brewer's Dent corn fodder, . . .	5.32	9.84	23.94	59.40	1.50
II.	Wing's Improved White Dent corn fodder,	4.85	9.36	22.58	61.64	1.57
III.	Alfalfa hay, first cutting, third-year growth,	7.55	16.62	30.16	43.78	1.89
IV.	Alfalfa hay, second cutting, third-year growth.	6.70	15.31	38.03	38.67	1.29
V.	Alfalfa hay, first cutting, first-year growth,	7.63	16.49	35.28	39.10	1.50
VI.	Clover, second cutting, ...	8.96	15.28	29.76	44.12	1.88
VII.	Clover, first cutting, ...	11.22	17.82	28.30	40.70	1.96

Composition of Feces (Per Cent.).

Sheep I.

I.	Brewer's Dent corn fodder, . . .	10.00	11.27	25.93	51.17	1.63
III.	Alfalfa hay, first cutting, third-year growth,	10.13	11.35	43.90	31.33	3.29
V.	Alfalfa hay, first cutting, first-year growth,	10.41	11.01	45.14	30.87	2.57
VII.	Clover hay, first cutting, ...	12.26	18.09	30.28	36.75	2.62

Sheep II.

I.	Brewer's Dent corn fodder, . . .	10.50	10.87	27.75	49.08	1.80
III.	Alfalfa hay, first cutting, third-year growth,	10.70	10.74	44.82	30.74	3.00
V.	Alfalfa hay, first cutting, first-year growth,	10.34	11.04	44.99	30.86	2.77
VII.	Clover hay, first cutting, ...	12.14	17.23	32.45	35.68	2.50

Sheep III.

II.	Wing's Improved White Cap corn fodder, .	9.96	11.66	28.33	48.54	1.51
IV.	Alfalfa hay, second cutting, third-year growth.	9.47	10.23	48.09	29.78	2.43
VI.	Clover hay, second cutting, . . .	9.87	14.78	40.15	33.19	2.01

Composition of Feces (Per Cent.) — Concluded.

Sheep IV.

Period.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
II.	Wing's Improved White Cap corn fodder, .	9.99	11.73	25.08	51.55	1.65
IV.	Alfalfa hay, second cutting, third-year growth.	9.50	9.68	48.46	29.79	2.57
VI.	Clover hay, second cutting, . . .	9.73	15.56	38.93	33.63	2.15

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Feces (Per Cent.).

Sheep I.

Period.	Brewer's Dent Corn Fodder.	Wing's Improved Dent Corn Fodder.	Alfalfa Hay, First Cutting, Third-year Growth.	Alfalfa Hay, First Cutting, First-year Growth.	Alfalfa Hay, Second Cutting, Third-year Growth.	Clover Hay, First Cutting.	Clover Hay, Second Cutting.	Feces.
I., . .	19.39	-	-	-	-	-	-	89.59
III., . .	-	-	85.42	-	-	-	-	91.53
V., . .	-	-	-	86.97	-	-	-	93.88
VII., . .	-	-	-	-	-	88.65	-	93.12

Sheep II.

Period.	Brewer's Dent Corn Fodder.	Wing's Improved Dent Corn Fodder.	Alfalfa Hay, First Cutting, Third-year Growth.	Alfalfa Hay, First Cutting, First-year Growth.	Alfalfa Hay, Second Cutting, Third-year Growth.	Clover Hay, First Cutting.	Clover Hay, Second Cutting.	Feces.
I., . .	19.39	-	-	-	-	-	-	89.71
III., . .	-	-	85.42	-	-	-	-	91.62
V., . .	-	-	-	86.97	-	-	-	93.87
VII., . .	-	-	-	-	-	88.65	-	93.22

Sheep III.

Period.	Brewer's Dent Corn Fodder.	Wing's Improved Dent Corn Fodder.	Alfalfa Hay, First Cutting, Third-year Growth.	Alfalfa Hay, First Cutting, First-year Growth.	Alfalfa Hay, Second Cutting, Third-year Growth.	Clover Hay, First Cutting.	Clover Hay, Second Cutting.	Feces.
II., . .	-	19.18	-	-	-	-	-	89.17
IV., . .	-	-	-	-	86.75	-	-	93.51
VI., . .	-	-	-	-	-	-	88.10	93.05

Sheep IV.

Period.	Brewer's Dent Corn Fodder.	Wing's Improved Dent Corn Fodder.	Alfalfa Hay, First Cutting, Third-year Growth.	Alfalfa Hay, First Cutting, First-year Growth.	Alfalfa Hay, Second Cutting, Third-year Growth.	Clover Hay, First Cutting.	Clover Hay, Second Cutting.	Feces.
II., . .	-	19.18	-	-	-	-	-	89.72
IV., . .	-	-	-	-	87.90	-	-	93.37
VI., . .	-	-	-	-	-	-	88.10	93.21

Average Daily Amount of Manure excreted and Water drunk (Grams).

Sheep I.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Brewer's Dent corn fodder, ...	403	29.21[1]	262
III.	Alfalfa hay, first cutting, third-year growth, .	563	22.21	1,737
V.	Alfalfa hay, first cutting, first-year growth, .	906	33.06	2,451
VII.	Clover hay, first cutting, ...	807	27.05	2,646

Sheep II.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
I.	Brewer's Dent corn fodder, ...	407	30.91[1]	224
III.	Alfalfa hay, first cutting, third-year growth, .	749	26.03	1,969
V.	Alfalfa hay, first cutting, first-year growth, .	724	29.83	2,475
VII.	Clover hay, first cutting, ...	721	28.48	2,656

Sheep III.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
II.	Wing's Improved White Cap fodder, . .	560	32.42[1]	157
IV.	Alfalfa hay, second cutting, third-year growth.	944	31.80	2,261
VI.	Clover hay, second cutting, ...	972	31.85	2,562

Sheep IV.

Period.	Character of Food or Ration.	Manure excreted Daily.	One-tenth Manure Air-dry.	Water drunk Daily.
II.	Wing's Improved White Cap fodder, . .	372	31.11[1]	95
IV.	Alfalfa hay, second cutting, third-year growth.	779	28.60	1,841
VI.	Clover hay, second cutting, . . .	675	29.26	2,453

Weights of Animals at Beginning and End of Periods (Pounds).

Sheep I.

Period.	Character of Food or Ration.	Beginning.	End.
I.	Brewer's Dent corn fodder, ...	94.50	93.25
III.	Alfalfa hay, first cutting, third-year growth, . .	99.50	97.25
V.	Alfalfa hay, first cutting, first-year growth, . .	101.25	100.00
VII.	Clover hay, first cutting, ...	97.25	100.00

[1] One-fifth of daily amount excreted.

Weights of Animals at Beginning and End of Periods (Pounds) — Concluded.

Sheep II.

Period.	Character of Food or Ration.	Beginning.	End.
I.	Brewer's Dent corn fodder, ...	95.25	93.00
III.	Alfalfa hay, first cutting, third-year growth, . .	101.75	96.25
V.	Alfalfa hay, first cutting, first-year growth, . .	97.75	98.75
VII.	Clover hay, first cutting, ...	102.50	96.50

Sheep III.

II.	Wing's Improved White Cap fodder, . . .	78.50	77.75
IV.	Alfalfa hay, second cutting, third-year growth, .	93.25	89.50
VI.	Clover hay, second cutting, ...	93.75	91.75

Sheep IV.

II.	Wing's Improved White Cap fodder, . . .	107.75	106.75
IV.	Alfalfa hay, second cutting, third-year growth, .	112.75	110.50
VI.	Clover hay, second cutting, ...	113.75	111.50

Brewer's Dent Corn Fodder, Period I.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,500 grams Brewer's Dent corn fodder fed,	484.75	25.79	47.70	116.05	287.94	7.27
146.04 grams manure excreted, . . .	130.84	13.08	14.75	33.93	66.95	2.13
Grams digested, ...	353.91	12.71	32.95	82.12	220.99	5.14
Per cent. digested, ...	73.01	49.28	69.08	70.76	76.75	70.70

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,500 grams Brewer's Dent corn fodder fed,	484.75	25.79	47.70	116.05	287.94	7.27
154.56 grams manure excreted, . . .	138.66	14.56	15.07	38.48	68.05	2.50
Grams digested, ...	346.09	11.23	32.63	77.57	219.89	4.77
Per cent. digested, ...	71.40	43.54	68.41	66.84	76.37	65.61
Average per cent. for both sheep, . .	72.21	46.41	68.75	68.80	76.56	68.16

Wing's Improved White Cap Dent Corn Fodder, Period II.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,500 grams White Cap Dent corn fodder fed,	479.50	23.26	44.88	108.28	295.56	7.52
162.08 grams manure excreted, . . .	144.53	14.40	16.85	40.95	70.15	2.18
Grams digested, ...	334.97	8.86	28.03	67.33	225.41	5.34
Per cent. digested, ...	69.86	38.09	62.46	62.18	76.27	71.01

Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
2,500 grams White Cap Dent corn fodder fed,	479.50	23.26	44.88	108.28	295.56	7.52
155.55 grams manure excreted, . . .	139.56	13.94	16.37	35.00	71.95	2.30
Grams digested, ...	339.94	9.32	28.51	73.28	223.61	5.22
Per cent. digested, ...	70.89	40.07	63.52	67.68	75.66	69.41
Average per cent. for both sheep, . .	70.38	39.08	62.99	64.93	75.97	70.21

Alfalfa Hay, First Cutting, Third-year Growth, Period III.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
750 grams alfalfa hay fed, ...	640.65	48.37	106.46	193.22	280.49	12.11
222.06 grams manure excreted, . . .	203.25	20.59	23.07	89.22	63.68	6.69
Grams digested, ...	437.40	27.78	83.39	104.00	216.81	5.42
Per cent. digested, ...	68.27	57.43	78.33	53.82	77.30	44.76

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
750 grams alfalfa hay fed, ...	640.65	48.37	106.46	193.22	280.49	12.11
260.33 grams manure excreted, . . .	238.51	25.52	25.62	106.89	73.32	7.16
Grams digested, ...	402.14	22.85	80.84	86.33	207.17	4.95
Per cent. digested, ...	62.77	47.24	75.93	44.68	73.86	40.88
Average per cent. for both sheep, . .	65.52	52.34	77.13	49.25	75.58	42.82

Alfalfa Hay, Second Cutting, Third-year Growth, Period IV.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
750 grams alfalfa hay fed, ...	650.63	43.59	99.61	247.43	251.61	8.39
318.04 grams manure excreted, . . .	297.40	28.16	30.42	143.02	88.57	7.23
Grams digested, ...	353.23	15.43	69.19	104.41	163.04	1.16
Per cent. digested, ...	54.29	35.40	69.46	42.20	64.79	13.83

Alfalfa Hay, Second Cutting, Third-year Growth, Period IV — Concluded.

Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
750 grams alfalfa hay fed,	659.25	44.17	100.93	250.71	254.94	8.50
285.99 grams manure excreted,	267.03	25.37	25.85	129.40	79.55	6.86
Grams digested,	392.22	18.80	75.08	121.31	175.39	1.64
Per cent. digested,	59.49	42.56	74.39	48.39	68.80	19.29
Average per cent. for both sheep,	56.89	38.98	71.93	45.30	66.80	16.56

Alfalfa Hay, First Cutting, First-year Growth, Period V.

Sheep I.

800 grams alfalfa hay fed,	695.76	53.09	114.73	245.46	272.04	10.44
330.56 grams manure excreted,	310.33	32.31	34.17	140.07	95.80	7.98
Grams digested,	385.43	20.78	80.56	105.39	176.24	2.46
Per cent. digested,	55.40	39.14	70.22	42.94	64.78	23.56

Sheep II.

800 grams alfalfa hay fed,	695.76	53.09	114.73	245.46	272.04	10.44
298.29 grams manure excreted,	280.00	28.95	30.91	125.97	86.41	7.76
Grams digested,	415.76	24.14	83.82	119.49	185.63	2.68
Per cent. digested,	59.76	45.47	73.06	48.68	68.24	25.67
Average per cent. for both sheep,	57.58	42.31	71.64	45.81	66.51	24.62

Clover Hay, Second Cutting, Period VI.

Sheep III.

800 grams clover hay fed,	704.80	63.15	107.69	209.75	310.96	13.25
318.54 grams manure excreted,	296.40	29.25	43.81	119.00	98.38	5.96
Grams digested,	408.40	33.90	63.88	90.75	212.58	7.29
Per cent. digested,	57.94	53.68	59.32	43.27	68.36	55.02

Sheep IV.

800 grams clover hay fed,	704.80	63.15	107.69	209.75	310.96	13.25
292.57 grams manure excreted,	272.70	26.53	42.43	106.17	91.71	5.86
Grams digested,	432.10	36.62	65.26	103.58	219.25	7.39
Per cent. digested,	61.31	57.99	60.60	49.38	70.51	55.77
Average per cent. for both sheep,	59.63	55.84	59.96	46.33	69.44	55.40

Clover Hay, First Cutting, Period VII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams clover hay fed,	709.20	79.57	126.38	200.70	288.65	13.90
270.50 grams manure excreted,	251.89	30.88	45.57	76.27	92.57	6.60
Grams digested,	457.31	48.69	80.81	124.43	196.08	7.30
Per cent. digested,	64.48	61.19	63.94	62.00	67.93	52.52

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams clover hay fed,	709.20	79.57	126.38	200.70	288.65	13.90
284.76 grams manure excreted,	265.45	32.23	45.74	86.14	94.70	6.64
Grams digested,	443.75	47.34	80.64	114.56	193.95	7.26
Per cent. digested,	62.57	59.49	63.81	57.08	67.19	52.23
Average per cent. for both sheep,	63.53	60.34	63.88	59.54	67.56	52.38

Summary of Coefficients (Per Cent.).

Food.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Brewer's Dent corn fodder,	Sheep I.,	73.01	49.28	69.08	70.76	76.75	70.70
	Sheep II.,	71.40	43.54	68.41	66.84	76.37	65.61
Average,	. . . .	72.21	46.41	68.75	68.80	76.56	68.16
Wing's Improved White Cap Dent corn fodder.	Sheep III.,	69.86	38.09	62.46	62.18	76.27	71.01
	Sheep IV.,	70.89	40.07	63.52	67.68	75.66	69.41
Average,	. . . .	70.38	39.08	62.99	64.93	75.97	70.21
Alfalfa hay,	Sheep I.,	68.27	57.43	78.33	53.82	77.30	44.76
	Sheep I.,	55.40	39.14	70.22	42.94	64.78	23.56
	Sheep II.,	65.52	52.34	77.13	49.25	75.58	42.82
	Sheep II.,	59.76	45.47	73.06	48.68	68.24	25.67
	Sheep III.,	54.29	35.40	69.46	42.20	64.79	13.83
	Sheep IV.,	59.49	42.56	74.39	48.39	68.80	19.29
Average,	. . . .	60.46	45.39	73.77	47.55	69.92	28.32
Clover hay,	Sheep I.,	64.48	61.19	63.94	62.00	67.93	52.52
	Sheep II.,	62.57	59.49	63.81	57.08	67.19	52.23
	Sheep III.,	57.94	53.68	59.32	43.27	68.36	55.02
	Sheep IV.,	61.31	57.99	60.60	49.38	70.51	55.77
Average,	. . . .	61.58	58.09	61.92	52.93	68.50	53.89

Discussion of the Results.

Brewer's Dent Corn Fodder. — This is a yellow dent corn believed to have been first bred in the middle west and improved by N. H. Brewer of Connecticut, who has raised enormous crops by following an intensive system of fertilization and cultivation. We have not been successful in ripening it on the station farm. At the time of cutting (September 5–19) the ears were hardly in milk, and consequently not suitable to harvest for grain. It evidently needs a somewhat longer growing season than is usually experienced in the vicinity of Amherst. It produced at the rate of about 18 tons of green fodder per acre, and yielded about 17 per cent. of ears in dry matter.

Summary of Coefficients, Period I. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1	1	73.01	49.28	69.08	70.76	76.75	70.70
Sheep II.,	1	1	71.40	43.54	68.41	66.84	76.37	65.61
Average,	1	2	72.21	46.41	68.75	68.80	76.56	68.16
Average of all trials, immature dents for comparison.	5	14	68.00	42.00	66.00	65.00	71.00	68.00

The coefficients obtained in this trial are somewhat higher than the average for immature corn. While the percentage of ears was low, the high digestibility can probably be accounted for by the soft, incompletely developed stalks, the fiber showing a relatively high digestibility.

Wing's Improved White Cap Dent Corn Fodder. — This variety of corn was originated by J. E. Wing of Ohio. It would probably form a very satisfactory variety in the middle west, but the season is not sufficiently long to enable it to reach maturity in New England. Two partially developed ears were frequently noticed on a stalk. When cut (September 5–19) it was in milk and still green. It yielded at the rate of about 14 tons of green fodder per acre, and contained 16 per cent. of ears in its dry matter.

Summary of Coefficients, Period II. (Per Cent.).

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep III.,	1	1	69.86	38.09	62.46	62.18	76.27	71.01
Sheep IV.,	1	1	70.89	40.07	63.52	67.68	75.66	69.41
Average,	1	2	70.38	39.08	62.99	64.93	75.97	70.21
Average of all trials, immature dents for comparison.	5	14	68.00	42.00	66.00	65.00	71.00	68.00

This corn is of substantially the same type as the one immediately preceding. It appeared to be slightly less digestible, although the difference may have been partly due to the individuality of the two lots of sheep.

Alfalfa Hay. — The alfalfa hay used in these experiments was grown on the college farm. It was cut while in early blossom, and was quite free from weeds and grass. Period III. represented the first cutting of the third-year growth, period IV. the second cutting of the third-year growth, and period V. the first cutting of the first-year growth. Owing to different weather conditions which prevailed at the time of cutting, and which necessitated different methods of handling, the amount of leaves lost in curing was not uniform; hence a strictly fair comparison could not be made between the different cuttings. The results are therefore reported together, and the average given for the several lots. In order to draw accurate conclusions between cuttings, the crop should either be fed green or cured under uniform conditions. Owing to frequent weather changes this is often not possible in New England.

Summary of Coefficients, Periods III., IV. and V. (Per Cent.).

Sheep.	Cutting.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1[1]	1	1	68.27	57.43	78.33	53.82	77.30	44.76
Sheep I.,	1[2]	1	1	55.40	39.14	70.22	42.94	64.78	23.56
Sheep II.,	1[1]	1	1	62.77	47.24	75.93	44.68	73.86	40.88
Sheep II.,	1[2]	1	1	59.76	45.47	73.06	48.68	68.24	25.67
Sheep III.,	2[1]	1	1	54.29	35.40	69.46	42.20	64.79	13.83
Sheep IV.,	2[1]	1	1	59.49	42.56	74.39	48.39	68.80	19.29
Average,	–	3	6	60.00	44.54	73.57	46.79	69.63	28.00
Average of all trials, alfalfa hay for comparison.	–	42	80	62.00	50.00	74.00	46.00	72.00	40.00
Average of all trials, red clover for comparison.	–	12	25	58.00	36.00	58.00	54.00	65.00	56.00

Unfortunately an exact record of the conditions during the curing process of the several lots was not kept. It would appear that the first cutting of the *third-year growth* was cured without the loss of a great deal of leafy matter. This is shown by the relatively low fiber percentage and the high digestibility. The second cutting of the *third-year growth* evidently lost a considerable portion of its leaves, as indicated by its high fiber percentage and lessened digestibility. The first cutting of the *first-year growth* also must have lost an excess of leaves, as it also shows excessive fiber and low digestion coefficients. It is possible that the tags of the first cutting, third-year growth and the first cutting first-year growth, were reversed, although we have not the slightest evidence to that effect.

While the coefficients obtained vary considerably the average is about the same as the average for all trials, except that the coefficient for fat is somewhat lower. It is believed that the average coefficients obtained in our several trials show fairly the digestibility of eastern grown alfalfa under the adverse conditions due to the loss of leaves in the process of curing.

Red Clover Hay. — The clover was seeded in early August the year previous. It yielded well, was in early blossom when

[1] Third-year growth. [2] First-year growth.

cut, and was cured in cocks. The first cutting did not cure out well, owing to a rainy spell during the curing process. It had a black appearance when taken to the barn, and later had to be spread in the sun for further drying. It did not lose its leaves to any extent. The lot was lacking in a satisfactory odor and was slightly musty. The conditions during the curing of the second cutting were more favorable. Both lots were rich in protein (15.28 and 17.82 per cent. in dry matter) and comparatively low in fiber (29.76 and 28.30 per cent. in dry matter).

Summary of Coefficients, Periods VI. and VII. (Per Cent.).

SHEEP.	Cutting.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1	1	1	64.48	61.19	63.94	62.00	67.93	52.52
Sheep II.,	1	1	1	62.57	59.49	63.81	57.08	67.19	52.23
Sheep III.,	2	1	1	57.94	53.68	59.32	43.27	68.36	55.02
Sheep IV.,	2	1	1	61.31	57.99	60.60	49.38	70.51	55.77
Average,	–	2	4	61.58	58.09	61.92	52.93	68.50	53.89
Average alfalfa hay (our trials).	–	3	6	60.46	45.39	73.77	47.55	69.92	28.32
Average of all trials, clover hay for comparison.	–	12	25	58.00	36.00	58.00	54.00	65.00	56.00
Average of all trials, alfalfa hay for comparison.	–	42	80	62.00	50.00	74.00	46.00	72.00	40.00

The most noticeable difference in the four single trials with clover hay consists in the variation in the digestion coefficients obtained for the fiber (43–62). This is evidently due, in part at least, to the individuality of the several animals. The fiber in the second cutting was apparently not as digestible as in the first cutting. The other coefficients — excepting the ash, which is found to vary widely in most all experiments — may be considered fairly uniform. The coefficients secured by us are higher than the average for all experiments, probably due to the early cuttings of the crop. When the clover coefficients are compared with our reported experiments for alfalfa, it is noted that in case of the total dry matter, the former shows to advantage, although the reverse is true in a comparison of the experiments reported for all trials. The protein in the clover is shown to be substantially 12 per cent. less digestible than in the alfalfa; the coefficients vary 16 per cent. in case of the average for all trials. In case of the fiber the conditions are reversed, differences of from 5 to 8 points being noted in favor of the clover. The comparative digestibility of the extract matter is about the same, although the average figures show 7 points in favor of the alfalfa. In making a comparison of the two plants from the standpoint of digestibility, two important differences are noted: (1) the protein in the alfalfa is noticeably more digestible than in the clover (12 to 16 points), and (2) the fiber from 5 to 8 points less so. In total digested the two plants approach each other, showing an average of about 60 per cent. as against 55 per cent. for timothy, 60 per cent. for early cut fine hay, 65 per cent. for rowen, 70 per cent. for the entire corn plant, and 85 per cent. for corn meal.

It is evident that the relative value of the two crops cannot be determined from their digestibility alone; other important factors to be considered are cost of production, yield and adaptability to Massachusetts conditions. Taking all the evidence into consideration, it would appear that although the cost of seed and preparation of land is somewhat against the alfalfa, yet its much greater length of life, its larger average annual yield, and its rather superior nutritive value are all in its favor. The conditions governing its successful cultivation must be carefully studied by all interested in its production. To the lack of attention to these conditions by the average farmer is due in no small measure the failures reported.

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TWENTY-FOURTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.,

BEING PART IV. OF THE FORTY-NINTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1912.

BOSTON:
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GENERAL REPORT OF THE EXPERIMENT STATION.

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Part II.

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AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-FOURTH ANNUAL REPORT.
PART II.

SUMMARY OF LEADING CONCLUSIONS.

WM. P. BROOKS, DIRECTOR.

A number of the papers included in this part of the annual report are themselves summaries of articles which will be found in Part I. of the report. It is impossible, therefore, to summarize them further. All the articles are brief and concise and should be read in full by those interested in the subjects discussed. Especial attention is called to the following conclusions: —

1. A majority of those who have tried co-operative experiments with alfalfa have attained either complete or partial success, and the results indicate that the crop can be grown profitably in many parts of the State.

2. The most profitable varieties of corn for ensilage are those which bring their ears to the milk stage in an average season.

3. The total yield of grain affects the value of a variety of field corn in greater degree than variation in chemical com-

position, and a large proportion of kernel to cob is a character of much importance.

4. Great improvement in yield of crops can be made by careful selection, and in the case of self-fertilized plants by pollinating from superior individuals.

5. Laboratory experiments indicate that the loss of nitrogen from manure cannot economically be prevented by use of chemicals. The best method of preservation appears to be to keep the manure moist and well packed.

6. Among the different chemicals tested sulfate of magnesia appears to be one of the best nitrogen absorbents, while gypsum (sulfate of lime), although most commonly used in farm practice, is one of the least active absorbents.

7. Tobacco injury, due to malnutrition or overfertilization, usually occurs on land that is underlaid with an impervious subsoil and poorly drained, as increased evaporation brings such an excess of plant food to the surface that normal growth is checked. Deficiency in rainfall may also have some influence. The remedy consists in breaking up the subsoil or in under-drainage, and also planting the land for a year or two to corn or grass.

8. Alfalfa has been shown to be rather superior in nutritive value to clover hay, and while it is a more costly crop to establish, its much greater length of life and larger annual yield render it preferable to clover wherever it can be grown.

9. The bronzing of maple leaves is not caused by pathogenic organisms. It occurs on very hot, dry days in periods of severe drouth, and is purely functional in nature.

10. From the standpoint of cost and efficiency the high-pressure coarse nozzle is superior to the low-pressure mist nozzle, especially for work on large trees. The nozzles at present in use can undoubtedly be greatly improved.

11. The soil best adapted to roses is one which contains from 8–12 per cent. of clay, and is well supplied with silt and the finest grades of sand. The proportion of these three classes of material should exceed 75 per cent.

12. The elm is greatly affected by the texture of the soil in which it grows. If this is right it is usually free from disease and attains enormous size and great beauty.

13. Elms thrive better in pastures and lawns than in mowings, and they are usually benefited by application of fertilizers and by cultivation.

14. The reasons why a seed law framed upon existing models would be unsatisfactory in Massachusetts are presented; the difficulties which must be met are discussed and the conclusion is reached that, for the present at least, while reasonable guarantees as to germination and purity should be required, it seems best to depend chiefly upon inspection and publicity.

ALFALFA CO-OPERATIVE EXPERIMENTS.

WM. P. BROOKS AND H. J. BAKER.

In the late summer of 1910 a number of farmers agreed to co-operate with the experiment station in determining the possible success of growing alfalfa in this State. The experiments have been made in 10 different counties. Northern grown seed treated with "Farmogerm" for inoculation with nitrogen-fixing bacteria was used. The following directions, which are believed to give a satisfactory method of preparing for the crop, were sent to all those taking part in the experiment: —

1. Plow in spring just as soon as possible after the ground can be worked.
2. Apply lime at the rate of about 1½ tons to the acre and disk in at once.
3. About ten days later apply the following mixture per acre: basic slag meal, 1,500 pounds, high-grade sulfate of potash, 400 to 500 pounds, and disk in.
4. Thereafter harrow about once in ten to twelve days, until you are ready to sow the seed, which should not be later than about July 27.
5. When ready to sow the seed, apply per acre: nitrate of soda, 100 pounds, basic slag meal, 300 pounds, mixing them and harrowing in lightly.
6. Sow 30 pounds of seed per acre, in showery weather if possible, and cover as you would grass seed.

The fall months were exceedingly dry and, therefore, somewhat unfavorable; but in most cases the crop made an excellent start and was in good condition before winter began, having made sufficient growth to afford the needed protection. The winter was a rather hard one for alfalfa. In the spring circular letters were sent to the growers asking for information relative to the condition of the crop. Most of the growers sent in a very favorable report. The crop had winter killed to some extent, though in most cases this occurred on poorly drained portions of the field, and in some instances it was due to standing water and ice. Under such conditions it would naturally be expected to winter kill, since it is a crop which demands good drainage. Standing water and ice during the winter are fatal to it. Most of the growers reported about the middle of May. At that time the crop was from 8 to 12 inches in height.

The experiments have been classified under three headings: successful, partially successful and failures. The number under each heading follows: —

Successful,	13
Partially successful,	9
Failures,	7
Total,	29

Causes for Failures. — From the reports of the 7 experiments which failed entirely, one or more of the following conditions are given as the cause of failure: —

1. Winter killing.
   (*a*) Due in most cases to poor drainage, standing water and ice.
   (*b*) Planted too late so that there was not sufficient growth for winter protection.
2. Excessively dry weather so that the crop did not get a good start the first season before winter set in.
3. Weeds and grasses have come in. (This occurred mainly on fields that did not get a good start in the beginning and in places that winter killed.)

Condition as affected by Drouth. — The growing seasons of 1910 and 1911 are noted as excessively dry. The crop in many instances was affected by this long-continued drouth. Alfalfa, however, stood this excessive drouth well, and in several instances better than other farm crops. During this extremely dry time a grower on Nantucket wrote: "It is practically the only green thing on my farm." Another grower said: "It has stood the drouth fully as well as timothy, redtop and clover."

Condition as affected by Frost. — Some of the growers reported that it had heaved to some extent, but in practically all cases this appears to have occurred on land that was not thoroughly drained. Several growers reported that the crop did not heave.

Yield. — The range of yields on the successful experiments, as reported by the growers, is from 1½ to 6 tons per acre. The average yield per acre of 14 growers who reported definite yields is 2½ tons. In most cases the crop was cut three times and had sufficient growth for winter protection. The dates of cutting appear to have been about as follows: —

1. June 1 to June 30.
2. August 3 to August 20.
3. September 1 to October 1.

Opinions of Growers. — Following is a list of farmers who are co-operating in this work and their opinion as to the value of this crop for the section of the State in which they live: —

C. M. Cudworth (Cummington). — If land well prepared and planted on the dryest land it should be a good crop for two years at least.

John H. Bartlett (Nantucket). — Don't see any reason why it can't be raised with success. Have put in 2½ acres more.

Lovett Brothers (Oxford). — Believe it to be a valuable crop.

C. W. Prescott (Concord). — Results very encouraging. Fed green to horses, hogs, cattle and hens with great profit.

F. E. Tatreau (Framingham). — Not promising, which is partly due to extremely dry season.

Frank S. Walker (Dudley). — I feel sure crop will be very valuable.

Edward Kirkham (Holliston). — So far I am not discouraged. Its value depends upon length of time it will remain in sod.

Lyman P. Thomas (Rock). — Can form better estimate next fall. Made a mistake in pasturing too late.

Charles L. Clay (North Dana). — My land is sandy and it was so dry in June and July that it did better than I expected. It seems to be just the grass for this sandy valley.

Paul Cunningham (Bolton). — From results obtained do not think crop will be valuable.

H. A. Parsons (North Amherst). — Results indicate crop to be valuable.

CYRUS S. BARDWELL (Shelburne). — Will be valuable if blight can be controlled, otherwise, clover more valuable.

G. B. TROWBRIDGE (South Weymouth). — From results obtained believe it to be a valuable crop.

J. B. SAWYER (Bradford). — Highly satisfactory. Have planted 1½ acres more. Neighbors are planting it.

In conclusion I would say that the results of these experiments up to the present time indicate that alfalfa can be grown profitably when planted on land that has thorough surface and under-drainage, has been well prepared, and properly fertilized.

If the leaves show much "spot" or blight the crop should be cut at once. The reports of growers make it apparent that many failed to act on this plan.

In not a few instances the first and second crops were cut too late. The best time for cutting is indicated by the formation of buds at the base of the stems. These usually appear about the time blooming begins.

TYPES OF CORN BEST SUITED TO MASSACHUSETTS.[1]

P. H. SMITH AND J. B. LINDSEY.

Since 1903 experiments have been in progress with corn to determine those types best suited to Massachusetts conditions. The total yield of dry matter per acre, digestibility, relative proportions, in some cases the composition of the various parts of the plant (stalk, leaf, ear and husk), and the relation of stage of development to the relative proportion of different parts as affecting the food value, have been carefully studied. The following varieties have been tested: Twitchell's Early Flint, Sanford White, Longfellow, Pride of the North, Rustler Dent, Leaming, Brewer's, Early Mastodon, Klondike, Red Cob Silage, White Cap Yellow, Wing's Improved White Cap, and Eureka.

The results of the study may be summarized under the following headings: —

1. The stalks and ears form substantially 70 per cent. of the entire maize plant; most varieties showed about 20 per cent. leaves and 10 per cent. husks.

2. The Twitchell, a small early maturing variety, showed an exceptionally large proportion of ears (55 per cent.), but it is not economical for Massachusetts conditions. The medium dent and flint varieties (Pride of the North, Rustler, Longfellow, Sanford White) averaged 33 per cent. of stalk and 37 per cent. of ears, and are quite well suited for grain, and serve fairly well for silage. The larger medium dent varieties that in an average season bring their ears to the milk stage, yield about 45 per cent. stalk and 26 per cent. ears, and are rather preferable for silage purposes (Leaming,

[1] The entire article with full data is to be found in Part I. of this report.

White Cap Yellow, Brewer's,[1] Early Mastodon[1]). The very coarse late-maturing varieties which never ripen seed in this locality are not satisfactory for silage purposes.

3. As is well known, the season has a marked influence on the yield of the corn plant, the same variety under otherwise identical conditions yielding from 50 to 100 per cent. more in a year particularly favorable to its growth.

4. The changes in chemical composition which the corn plant undergoes in its development are such that its maximum feeding value exists at its maturity.

5. Numerous digestion experiments have shown no wide variations in the digestibility of the several varieties, the range being from 67 to 77 per cent. with an average of approximately 70 per cent. The general statement can be made that the higher the percentage of extract or starchy matter present (the larger the percentage of ears) the higher the digestibility and resulting feeding value.

6. The percentage of grain to cob varies widely, depending, to some extent, upon the maturity of the plant when cut. The average for the several mature types was 15.5 per cent. cob and 84.5 per cent. kernel, while the average for the less mature varieties was 18.1 per cent. cob and 81.9 per cent. kernel. In either case the percentage of cob was less than that of the legal Massachusetts bushel, which in case of shelled corn is 56 pounds and in case of ear corn 70 pounds, thus allowing 14 pounds or 20 per cent. for cob.

7. The grain showed only slight variations in composition. It is believed that chemical composition cannot be considered an important factor in the selection of seed corn when the crop is to be used for the sustenance of live stock.

8. But little variation was noted in the composition of the corn cob. The net available energy in 100 pounds of cob is 40.2 therms, as against 85.5 therms in a like amount of corn meal; hence the cob has 47 per cent. of the value of the meal for feeding purposes.[2]

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[1] Do better in southern New England.

[2] This is calculated on the basis of the method suggested by Kellner, and is the most satisfactory method available for the estimation of relative energy values.

COMPLETE ANALYSES OF CORN GROWN IN COMPETITION FOR THE BOWKER PRIZE.

BY P. H. SMITH.

The analyses which follow were made from samples grown in competition for the Bowker corn contest for the year 1910.[1] In this contest the production values of the several food ingredients as well as the total yield were considered, which necessitated a complete fodder analysis of the corn. Of the 27 samples sent to the station to be tested 22 were flint and 5 dent varieties. The analyses are figured to a uniform water content of 12 per cent., which is considered a fair average for crib-dried corn.

So far as we have been able to ascertain, all of the flint varieties were fully matured when harvested. Information is not at hand in regard to the stage of maturity of the dent varieties grown by John P. Bowditch and Butler Bros. Silver King, grown by the Middlebrook farm, and Brewer's dent, grown by E. W. Capen, were not fully matured when cut. Early Huron, grown by M. H. Williams, was ripe when harvested.

[1] For complete data see Book of the Bowker Contest, issued by the Bowker Fertilizer Company, 43 Chatham Street, Boston, Mass.

Table of Analyses.

[12 per cent. water basis.]

Grower.	Variety.	Protein (Per Cent.).	Fat (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fiber (Per Cent.).	Ash (Per Cent.).
Flints.						
John P. Bowditch, Framingham, Mass.,	Stickney,	10.03	4.88	70.42	1.23	1.44
Nathaniel I. Bowditch, Framingham, Mass.	Stickney,	10.09	4.66	70.79	1.17	1.29
Samuel Carr, Northborough, Mass.,	Stickney,	10.58	4.85	70.01	1.26	1.30
Martin A. Carey, Brockton, Mass.,	Dibble,	8.97	4.71	72.10	1.14	1.08
Paul Cunningham, Bolton, Mass.,	Stickney,	11.59	4.95	68.83	1.17	1.46
Perley E. Davis, Granby, Mass.,	Davis Improved,	10.32	4.51	70.51	1.28	1.38
Arthur S. Felton, Bolton, Mass.,	Stickney,	10.72	4.89	69.78	1.18	1.43
George H. Fish, North Appleton, Me.,	Yellow Flint,	9.50	4.11	71.12	1.67	1.60
W. C. Ford, Whitefield, Me.,	Yellow Flint,	9.55	4.45	70.31	2.44	1.25
A. J. Guptil & Sons, Berwick, Me.,	Ordway,	10.21	4.77	70.52	1.22	1.28
Arthur T. Hathaway, Monmouth, Me.,	Early Canada,	9.74	4.73	71.08	1.17	1.28
Joseph Howland, Taunton, Mass.,	Yellow Flint,	10.33	4.55	70.48	1.27	1.37
Hathorn J. Libby, Charleston, Me.,	Yellow Flint,	10.09	4.29	70.39	1.69	1.54
L. W. Peet, Middlebury, Vt.,	White Australian,	10.30	4.65	70.49	1.17	1.39
Burton L. Robinson, Monmouth, Me.,	Yellow Flint,	9.21	4.80	71.50	1.20	1.29
William E. Sarle, Shawomet, R. I.,	Longfellow,	10.67	4.73	69.94	1.30	1.36
George E. Stickney, Newburyport, Mass.,	Stickney,	9.30	4.64	71.68	1.13	1.25
Edward P. West, Hadley, Mass.,	Yellow Flint,	10.42	4.61	70.53	1.14	1.30
L. S. White, Collinsville, Conn.,	White Flint,	9.65	4.58	71.06	1.36	1.35
James E. Phelps, Millbury, Mass.,	Yellow Flint,	10.91	4.78	69.73	1.17	1.41
John G. Francis, Bridgewater, Mass.,	Early Canada,	10.33	4.88	70.29	1.11	1.39
J. E. Hamilton, Garland, Me.,	Yellow Flint,	11.20	4.81	68.65	1.70	1.64
Average,		10.17	4.67	70.46	1.33	1.37
Dents.						
John P. Bowditch, Framingham, Mass.,	Funk Bros.,	9.07	3.73	71.84	2.12	1.24
Middlebrook farm, Dover, N. H.,	Silver King,	9.55	4.29	71.10	1.75	1.31
M. H. Williams, Sunderland, Mass.,	Early Huron,	9.44	4.30	71.23	1.65	1.38
E. W. Capen, Monson, Mass.,	Brewer's,	8.84	3.47	72.48	2.01	1.20
Butler Bros., Montello, Mass.,	Diamond Joe,	9.77	3.33	71.63	1.94	1.33
Average,		9.33	3.82	71.67	1.89	1.29

The corn showed the following ranges in analysis: —

Flint.

	High (Per Cent.).	Low (Per Cent.).
Protein,	11.59	8.97
Fat,	4.95	4.11
Nitrogen-free extract,	72.10	68.65
Fiber,	2.44	1.11
Ash,	1.64	1.08

Dent.

	High (Per Cent.).	Low (Per Cent.).
Protein,	9.77	8.84
Fat,	4.30	3.33
Nitrogen-free extract,	72.48	71.10
Fiber,	2.12	1.65
Ash,	1.38	1.20

From the data obtained it is evident that chemical composition cannot be considered an important factor in the selection of seed corn where the crop is used for the sustenance of live stock. For such a purpose that variety should be selected which is suited to the locality where it is grown and which will produce the largest amount of shelled corn to the acre.

The variation in the analyses of the different samples is evidently due largely to the relative size of the several parts of the kernel (hull, gluten layer, starch and germ).

Additional Data.

[Relative proportions of kernels and cob.]

Grower.	Variety.	Weight of Ten Ears (Ounces).		Average Weight per Ear (Ounces).		Weight of Kernels from Ten Ears. Water Free (Ounces).	Weight of Cob from Ten Ears. Water Free (Ounces).	Per Cent. Kernel and Cob in Dry Matter.	
		Air Dry.	Water Free.	Air Dry.	Water Free.			Kernel.	Cob.
Flints.									
Samuel Carr, Northborough, Mass.,	Stickney,	83.4	77.9	8.3	7.8	65.2	12.7	83.6	16.4
Perley E. Davis, Granby, Mass.,	Yellow Flint,	78.5	73.0	7.9	7.3	61.9	11.1	84.8	15.2
W. C. Ford, Whitefield, Me.,	Yellow Flint,	89.6	83.6	9.0	8.4	65.8	17.8	78.7	21.3
A. J. Guptil & Sons, Berwick, Me.,	Ordway,	68.9	64.0	6.9	6.4	53.6	10.4	83.8	16.2
Arthur T. Hathaway, Monmouth, Me.,	Early Canada,	61.0	57.0	6.1	5.7	48.9	8.1	85.8	14.2
L. S. White, Collinsville, Conn.,	White Flint,	53.7	50.1	5.4	5.0	42.4	7.7	84.6	15.4
Average,		72.5	67.6	7.3	6.8	56.3	11.3	83.6	16.4
Dents.									
Middlebrook farm, Dover, N. H.,	Silver King,	84.0	78.3	8.4	7.8	65.7	12.6	83.9	16.1
M. H. Williams, Sunderland, Mass.,	Early Huron,	93.8	87.2	9.4	8.7	74.1	13.1	85.0	15.0
E. W. Capen, Monson, Mass.,	Brewer's,	86.5	79.9	8.7	8.0	64.5	15.4	80.7	19.3
Average,		88.1	81.8	8.8	8.2	68.1	13.7	83.2	16.8

Ten representative ears of 6 of the flint and 3 of the dent varieties were secured from the growers, and the relative proportion of corn to cob determined. With but two exceptions the differences were not marked. The yellow flint corn grown by W. C. Ford consisted of 21.3 per cent. of cob and 78.7 per cent. kernel. This corn had an exceptionally large ear with a bulging butt, and the kernels were quite shallow, a condition which would affect adversely the total yield of grain. Brewer's dent corn, grown by E. W. Capen of Monson, consisted of 80.7 per cent. kernel and 19.3 per cent. cob. This corn was quite immature when cut and would have shown a larger percentage of kernel had it reached maturity.

In the selection of seed corn the relative proportion of kernel to cob should be carefully considered. If seed corn is purchased rather than home grown, it is advisable to obtain ear corn, test its vitality by approved germination tests, and finally determine the proportion of kernels and cob. This is easily done by weighing separately the kernels and cob and calculating the percentage of each. The ear should not contain over 17 per cent. of cob. It is a significant fact that the prize corn in this contest contained only 15.2 per cent. of cob.

METHODS OF SELECTION FOR PLANT IMPROVEMENT.

BY J. K. SHAW.

The fact that plants are unlike lies at the foundation of all plant improvement. Sometimes it is first attempted to bring about increased unlikeness by hybridization or otherwise, but the great part of the work is the choice of desirable plants and by repeated selection securing and maintaining the desired standard. Selection of desirable plants is generally followed by more or less positive results, but not uniformly so; sometimes the results seem to be negative, or at any rate not as satisfactory as might be desired.

The plant is much the subject of its environment; variation in the nature and amount of the available food supply, and the varying conditions of weather and climate, affect it strongly, and selection of plants whose desirable qualities are thus brought about must obviously be less effective than selection of differences that arise from causes within the plant, and which persist from generation to generation. In a collection of varying plant individuals some of the differences are environmental and are inherited in small degrees if at all, while others are innate with the plant and persist from generation to generation. The task of the man who would improve his stock of beans or corn is to distinguish between these two sorts of variation, and select and hold to that which is not due to environment but is inherited by succeeding generations.

Certain investigations that have been carried on by the department of horticulture during the past four years with garden peas bear directly on this. This work is fully reported in Part I. of this report (p. 82), to which the reader may refer for detailed information. It is the purpose of this article to set forth the application of results there indicated to practical methods of plant improvement. The methods used have served to distinguish between those differences that are due to soil and weather conditions and those peculiar to the plant which are inherited and therefore of greatest interest to the practical plant grower. The results which are in harmony with those of other investigations indicate that our common varieties of garden peas are composed of subvarieties or, more properly, strains, which differ from each other in varying degrees, this difference, however, being relatively fixed and permanent.

A planting of Excelsior peas proved to contain two strains, one of which exceeded the other in productiveness by about 15 per cent. in an average of four years crops. While this difference is a pronounced one, it would have been totally hidden by differences in yield due to environment had the two strains not been planted separately and in large numbers. The separation of this more prolific strain should prove advantageous to the gardener.

According to the generally accepted belief, the selection of superior individuals within this strain should result in further improvement. This is doubtful. It is probable that if any real progress can be made by this method it will be small and of doubtful permanency. We do not regard this as a proven fact, but only as a strong probability. The efforts of the gardener should then be directed to the isolation of their superior strains where they exist in our common varieties.

We may now outline a simple method of accomplishing this.

The first step is to secure the best available stock of a variety suited to the purpose of the grower. This should be planted and cared for in the best possible manner. The most uniform plot of ground available should be selected. The grower should study the plants carefully and select those which appear the most desirable, particularly as regards yield. The seed from each plant should be gathered separately and given a number. All shrunken or otherwise imperfect seeds should be thrown out.

The next spring the seeds from the several plants should be planted, each in a row by itself, under the most uniform conditions possible as to space for the plants and soil, and given good care as before. The grower should study them carefully during the growing period and make a note of the rows showing desirable characters. As yield is a most important character, it may be well to provide for a careful record of the yield of equal length of row of the different selections. In the fall the seed from the most successful rows should be saved as before. If one cares to take the trouble to select from the better plants within the row it will do no harm, but it seems doubtful if it will do any good, and it will delay the increase of the stock to a point when it is sufficient for the general crop. The superior rows chosen will each yield seed enough, after rejecting the imperfect seeds by sifting or other convenient method, to plant a longer row or a small plot, thus providing for the growing of the selected strains in greater quantity and enabling one to judge their comparative value better. This operation may be repeated a third time, and this should result in the final selection of the best that the original selection contained.

Fig. 1 will serve to make this method of selection perfectly clear. Twelve plants are chosen from a field plot and sown the

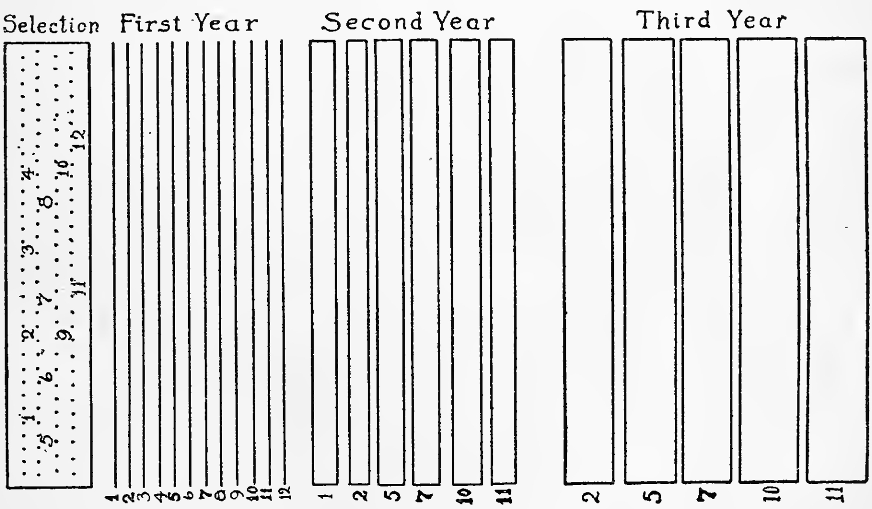

Fig. 1.

first year in 12 rows. The ones with the heavy-faced figures prove the better and are sown the second year in small plots. One of these is rejected and 5 are retained for a third year. Of these number 7 proves the most desirable and is retained for field sowing. If possible a larger number of plants than indicated should be chosen at the start, thus increasing the chances of securing the very best that the variety affords. Experience has shown most conclusively that the character of an individual plant is small indication of the value of its progeny, and the selection that proves finally to be the best may very likely come from one of the less promising plants of the original selection.

The foregoing has been written as applicable to the garden peas alone, for our own investigations along this line have been confined to that plant. The question now arises whether the same methods may be applied to other plants as well.

Our common garden peas are almost invariably self-pollinated, and there is reason to believe that the same general method will succeed equally well with all self-pollinated plants; with naturally cross-pollinated plants some modification will be necessary. Among our common garden and field crops the following are believed to be almost always self-pollinated; peas, beans, tobacco, wheat, oats, barley. Most others are often or generally crossed in the field, and for such the method must be modified to make sure that the pollen for the improved races comes from the best possible plant.

Assuming that naturally cross-fertilizing plants are made up of slightly differing strains, as seems to be the case with peas, a field of plants will be made up largely of individuals that are crosses between the several strains; consequently the task of separating superior strains becomes a complicated one. Furthermore, it is probable that with some, and perhaps many, naturally crossed fertilized plants, crossing between distinct strains or varieties results in the first generation, in greater vigor and more productive plants. Thus is the problem of securing the very best still further complicated.

Nevertheless, great improvement can be made by following substantially the scheme outlined for self-fertilized plants, but taking into consideration the pollen parent, and pollinating from superior individuals either by hand or planting individuals which are desired as parents together in an isolated location. The latter method is often used with corn and other wind-pollinated plants. In any event it is always of the utmost importance to judge the value of any strains by the average of the largest possible number of individuals belonging to it, and if the test can be extended over a period of several years, three or four at least, the estimate of value will be more dependable.

With cross-fertilized plants it may prove best to use for field seeding the first generation hybrid between certain strains which are known to give desirable progeny when so crossed, and repeating the same cross for succeeding years, growing only the first generation of the cross as the benefits derived from crossing tend to disappear in succeeding generations.

We are only beginning to realize the improvement, especially in yield, that may be realized by proper methods of breeding, and great progress is being made in working out these methods. Their general application by practical plant growers will effect most substantial increase in the value of crops. It is, perhaps, not too much to say that the general application in this Commonwealth of our present knowledge of breeding would result in an increase of 20 per cent. in the value of its crops.

It is hoped that the farmers and gardeners of Massachusetts may become more interested in plant improvement, and the department of horticulture of the experiment station will be glad to co-operate with any one desiring further information or specific suggestions.

EXPERIMENTS TO DETERMINE THE NITROGEN ABSORPTION CAPACITY OF SEVERAL WELL-KNOWN CHEMICALS.

BY HENRI D. HASKINS.

Some years since a series of tests was instituted to show the nitrogen-absorbing capacity of several of the better known chemicals, more commonly used as fixers or absorbers of nitrogen in the form of ammonia, resulting from the decomposition of barnyard manure. Four hundred and fifty grams of manure were employed in each test, and 100 grams of each of the following chemicals were used: —

1. Sulfate of magnesia.
2. Sulfate of lime (gypsum).
3. Sulfate of potash-magnesia.
4. Kainit.
5. High-grade sulfate of potash.

The chemicals were all tested for nitrogen with negative results. An analysis of the several manures which are represented by the numbers from 1 to 5, as in case of the chemicals, showed the following percentages of moisture and nitrogen.

Table 1.

Number.	Moisture.	Nitrogen.	Number.	Moisture.	Nitrogen.
1, ...	70.37	.62	4, ...	71.77	.61
2, ...	73.75	.58	5, ...	72.86	.59
3, ...	73.29	.61	Average, . .	72.40	.602

The tests were conducted in the following manner: 450 grams of manure were placed in like-sized crystallization dishes, and a large pipestem triangle was placed across the top of each dish upon which was set a smaller crystallization dish containing, in each case, 100 grams of one of the absorbents. Each crystallization dish thus arranged was set on a ground-glass plate and enclosed within a bell glass, which was made air-tight by the use of tallow and sealed with melted paraffine. The tests were conducted side by side in a room of ordinary temperature (70° to 75° F.) and covered a period of six weeks. At the close of the experiment all of the chemicals were subjected to a chemical analysis, and showed the following content of nitrogen: —

Table 2. — Weight of Nitrogen in Manure and Nitrogen absorbed by Each Chemical.

	Grams Nitrogen in 450 Grams Manure.	Grams Nitrogen absorbed.	Per Cent. Nitrogen absorbed.
Sulfate of magnesia,	2.79	.018409	.66
Kainit,	2.61	.016553	.63
Sulfate of potash-magnesia,	2.75	.006884	.25
High-grade sulfate of potash,	2.75	.003483	.13
Sulfate of lime (gypsum),	2.66	.000851	.03

From the above table of comparative results it will be seen that magnesium sulfate absorbed the greatest amount of nitrogen, and that gypsum, the absorbent more commonly used in general farm practice, had the lowest nitrogen absorption power of any of the chemicals under trial. The percentage of nitrogen absorbed, however, in proportion to the amount contained in the manure was so small (less than 1 per cent.) as to indicate that but little decomposition took place. This is not to be wondered at when it is recalled that the manure was placed in an air-tight dish.

To obtain further data as to the nitrogen-absorbing capacity of the different chemicals during the process of decomposition of barnyard manure, another test was instituted, beginning on the same date as the above-described experiments and continuing through a period of six weeks. Four hundred and fifty grams of manure (analyzing .65 per cent. of nitrogen and 68.57 per cent. of moisture) were placed in a glass vessel and enclosed within a bell glass similar to the ones used in the above tests, with the exception that the bell jar was provided with glass tubes for the ingress and egress of air. The air passing into the bell jar was made to pass through a solution of sulfuric acid to remove any traces of ammonia which might be present in the atmosphere. Upon leaving the bell jar the air was made to pass through a standard solution of half normal hydrochloric acid, which was to absorb any ammonia which might be given off in the process of decomposition of the manure. The exit tube from the flask of standard hydrochloric acid was attached to an aspirator to provide a steady current of air through the apparatus. The apparatus was made perfectly airtight by sealing, so that no air could enter the bell jar except by first passing through the sulfuric acid arranged to remove all traces of ammonia. An analysis of the standard solution of hydrochloric acid at the end of the experiment showed the following amount of nitrogen, expressed in fractions of a gram .001709. The infinitesimal amount of nitrogen liberated may be due to the fact that the steady current of dry air which was constantly passing through the bell jar removed the greater part of the moisture from the manure, thus retarding and preventing its natural decomposition.

For the purpose of verifying the results of the foregoing experiments a series of tests was instituted similar to those previously described, with the exception that 50 grams of each fixer were used and the experiment covered a much longer period of time, beginning March 21, 1901, and continuing through the spring and summer, concluding Feb. 1, 1902.

In the following table the first column shows the amount of nitrogen contained in 450 grams of the manure. The second column shows the nitrogen given off during the experiment, both in grams and percentage, as determined by a chemical analysis of the manure samples before and after the experiment. The third column shows the nitrogen absorbed as determined by a chemical analysis of each fixer at the conclusion of the experiment.

Table 3.

Absorbent.	Nitrogen Present in Manure.	Nitrogen given off.		Nitrogen absorbed (Basis of Grams in Manure).	
	Grams.	Grams.	Per Cent.	Grams.	Per Cent.
Sulfate of magnesia,	2.30	.13449	5.85	.05229	2.27
Kainit,	2.28	.16811	7.37	.04653	2.04
Sulfate of potash-magnesia,	2.39	.11768	4.92	.04031	1.69
High-grade sulfate of potash,	2.46	.31961	12.99	.03660	1.49
Sulfate of lime,	2.35	.26217	11.16	.00179	.08

Table 4. — *Showing the Order of Excellence of the Different Chemicals used as Fixers and the Percentage of Liberated Nitrogen which each Fixer absorbed.*

Order of Excellence of the Absorbents.	Per Cent. of Liberated Nitrogen absorbed.
1. Sulfate of magnesia,	38.88
2. Sulfate of potash-magnesia,	34.25
3. Kainit,	27.67
4. High-grade sulfate of potash,	11.45
5. Sulfate of lime (gypsum),	.68

The above tables show that the 5 different samples of manure, of 450 grams each, contained from 2.28 to 2.46 grams of nitrogen, and of these amounts from 5.85 per cent. to 12.99 per cent. were liberated. Of the relatively small amounts liberated the sulfate of magnesia absorbed 38.88 per cent., and was followed by the other chemicals as indicated in Table 4. How much more nitrogen as ammonia would have been absorbed by the different chemicals had the manure undergone a more normal fermentation it is impossible to state. The above tests strongly indicate sulfate of magnesia and sulfate of potash-magnesia to be decidedly preferable to gypsum as ammonia absorbents.

If the above, however, were typical of actual farm conditions we should have the following results: nitrogen in 1 ton of barnyard manure, 37.2 pounds; per cent. absorbed by sulfate of magnesia (being, of course, a part of the nitrogen set free as ammonia), 1.87, which is equal to .67 pound of nitrogen. In other words, less than 1 pound of nitrogen would be actually saved from a ton of manure, which, of course, is of no practical account. It is probable, however, that much more nitrogen in different forms would be liberated than the amounts secured in the above experiment, and that probably somewhat more would be absorbed.

Extensive investigations by German authorities indicate that the value of the nitrogen saved by chemical absorbents is quite out of proportion to the cost of the chemicals and the labor involved. See the results of their investigations in the paper following, entitled, "Chemical Methods for the Preservation of Manure."

CHEMICAL METHODS FOR THE PRESERVATION OF MANURE.

BY J. B. LINDSEY.

Barnyard manure is composed (*a*) of the undigested part of the food, represented by the solid matter or feces; (*b*) the end products of the protein digestion largely diluted with water, namely, the urine; and (*c*) such materials as straw, sawdust and the like, which are used for bedding. The solid part, or feces, is mixed with more or less of the digestive fluids, such as the bile of the liver, the intestinal juices and minute pieces of the skin or lining of the intestines. The nitrogen-containing matter of the urine of herbivorous or plant-eating animals is composed chiefly of urea, together with such mineral matter as is no longer of use in the blood (potash, soda, phosphates, etc.). A considerable portion of the soluble nitrogenous part of the manure is likely to be lost, both by volatilization and leaching. The loss through volatilization, and in part through leaching, is brought about by the action of bacteria, of which manure contains an innumerable number and a great variety of species.

Briefly stated there are four groups of bacteria which act upon the nitrogenous matter of the manure: —

1. *Putrefactive bacteria,* which attack both the insoluble part of the nitrogenous matter and also the urea or soluble part, and convert them into carbonate of ammonia, which is volatile.

2. *Nitrifying bacteria,* which act upon the ammonia compounds and convert them into nitrites and nitrates. In order to be active they must have plenty of oxygen, and hence act near the surface of the manure pile.

3. *Denitrifying bacteria,* which have the power to take the oxygen from the nitrates, thus decomposing it and setting the

unbound nitrogen free. These bacteria act when the air is excluded, deriving their supply of oxygen both from the nitrates and from the protein and carbohydrates of the manure.

4. *Protein-forming bacteria.* In order for bacteria to live and multiply they must have as a food a certain amount of nitrogen-containing matter. This they take from the ammonia and nitrates (soluble compounds), and convert it again into the insoluble proteid matter, which naturally does not become again available, and then only gradually, until the bacteria cease to live. Certain molds also act in a similar way.

Bacteria, therefore, destroy the nitrogenous matter of the manure by converting it into the volatile ammonia compounds and nitrates, and then reconvert a small portion of the ammonia and nitrates back into protein; they also destroy the nitrates and set the elementary nitrogen free.

If manure is allowed to remain in loose piles exposed to the air for months, about 35 per cent. of its total nitrogen is likely to be lost. The extremes are said to be from 20 to 50 per cent. Fully one-third of the total nitrogen lost has been ascertained to be in the elementary form, *i.e.*, uncombined. No method is known for preventing the loss of the uncombined nitrogen.

Various chemical methods have been tried to catch that portion of the nitrogen which escapes in the form of ammonia. The results of the numerous experiments may be summarized as follows: [1]

Gypsum or Land Plaster.

As early as 1860 ordinary land plaster or calcium sulfate was recommended, particularly by the German investigator, Grouven, as a substance suitable to catch and hold the volatile ammonia. Later the French investigators, Müntz and Girard, by means of carefully conducted experiments, demonstrated that such material was of no particular value for such a purpose. The reports of other investigators confirmed this and showed that the plaster actually hastened the decomposition of the manure.

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[1] After A. Stutzer, Behandlung und Anwendung der Stalldüngers.

Precipitated Gypsum.

About 1870 the manufacture of double superphosphate was undertaken. The method consisted of extracting the raw phosphate with dilute sulfuric acid, and this solution was used again for extracting another portion of the phosphoric acid. This method left behind a large amount of gypsum which contained about 1 per cent. of citrate soluble phosphoric acid. This residue was sold to farmers at a low price, and was used to check the escape of the ammonia from the manure. Experiments by several investigators, particularly by Hansen, showed it to be of no particular value for such a purpose.

Gypsum-superphosphate and Superphosphate.

In Germany low-grade raw phosphates were treated with sulfuric acid, and a product was secured containing 4–6–8 per cent. of soluble phosphoric acid, and this was called gypsum-superphosphate. It was found that this material, if used in sufficient amount, held fast the ammonium carbonate present in the manure and checked the further action of the bacteria. This was due to the action of the free phosphoric acid. Sulfuric acid and ordinary superphosphate had a similar effect. Because of the cost of such materials, however, their use was not advised.

Sulfuric Acid.

After the use oi superphosphate had been discontinued numerous experiments were made with quite dilute sulfuric acid. A 2 per cent. solution of the sulfuric acid was sprinkled over the manure before throwing it out, and also in the gutters after its removal. The dilute acid was also mixed with peat and sand before distributing it. Experiments by Maercker and Pfeiffer showed that such treatment made the manure sour, checked the loss of ammonia, and better results were secured temporarily in the field due to the conserved nitrogen. It was found, however, that one had to be very careful, otherwise the feet and udder of the animal would be injured; and, furthermore, that the resulting manure had a bad effect upon the physical character of heavy soils which required the addition of lime to correct. These disadvantages, together with the cost of the acid, rendered the use of the sulfuric acid inadvisable.

Kainit.

As early as 1860 kainit was recommended as a desirable material for the preservation of manure; it was supposed that the sulfate of magnesia in this salt would act even better than the gypsum. Holderfleiss recommended 5 pounds, and later 2 pounds, of kainit to every 100 pounds of manure. Numerous other investigators experimented with the kainit and came to the conclusion that it was of no particular value for the purpose.

German workers, therefore, have come to the conclusion that there is no economy in attempting to check the loss of nitrogen in manures by chemicals, and advise in their place the following simple method of treatment: —

Halt ihn feucht und tritt ihn feste,
Das ist für den Mist das beste.

Keep the manure moist and well packed,
That is the best method of preservation.

TOBACCO INJURY DUE TO MALNUTRITION OR OVERFERTILIZATION.

BY H. D. HASKINS.

During the past four or five years the experiment station has received occasional inquiries from tobacco growers concerning certain peculiar conditions which affect the young tobacco plant, and which usually manifest themselves soon after transplanting. The young plants may make a small growth in the field during the first week, after which differences in growth are observed. The plants growing on low places or hollows, which receive drainage from the surrounding soil, seem to be more affected and show a more stunted growth than do those on the more elevated portions of the field. It was thought at first that the trouble was due to some fungus disease, but a careful microscopical examination failed to reveal the presence of fungi which could be held accountable for the trouble. An examination of the roots showed that the tap root had been destroyed; that the plant, in its endeavor to recover from the injury, had thrown new secondary roots, which in turn had become injured or destroyed so that it was unable to make any appreciable growth. It was the opinion of Dr. G. E. Stone, the vegetable pathologist, that the trouble was due to overfertilization, the roots having all of the characteristic symptoms of fertilizer burning. The absence of fungi also indicated that some abnormal soil condition was responsible for the trouble.

Samples of the surface soil were, therefore, carefully taken from a field where the trouble was noticed. Numbers 1, 2 and 3 were taken from portions of the field where the trouble was most conspicuous, number 4 from an elevated portion of the field, showing practically a fairly normal growth, and number

5 from the tobacco bed which furnished the plants for setting the field. Exact quantitative determinations of nitrogen, potash, phosphoric acid and lime were made, using 1.115 specific gravity hydrochloric acid as a solvent. For the sake of comparison the results have been calculated to a normal moisture soil condition, namely, 20 per cent. The results have also been expressed in pounds per acre, it being assumed that an acre of the average tobacco soil 1 foot deep would weigh about 3,000,000 pounds.

TABLE 1. — *Showing Constituents soluble in Hydrochloric Acid Solution.*

	Soil No. 1, Abnormal.		Soil No. 2, Abnormal.		Soil No. 3, Abnormal.		Soil No. 4, Normal.		Soil No. 5, Tobacco Bed.	
	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.
Moisture,	20.000	-	20.000	-	20.000	-	20.000	-	20.000	-
Organic matter,	6.456	193,680	6.576	197,280	6.304	189,120	7.304	219,120	5.144	154,320
Nitrogen,	.182	5,472	.221	6,624	.210	6,312	.246	7,380	.092	2,760
Phosphoric acid,	.164	4,920	.110	3,312	.165	4,944	.196	5,880	.478	14,328
Potassium oxide,	.182	5,472	.156	4,680	.110	3,288	.127	3,816	.211	6,336
Calcium oxide,	.640	19,200	.506	15,168	.769	23,064	.568	17,040	1.096	32,880

As may be seen from the table of analysis, it was not possible to account for the trouble from a chemical analysis showing the total amount of the several elements of plant food present, soluble in the acid solution. The soil producing a normal plant showed a *larger amount* of nitrogen and phosphoric acid than the three abnormal soils producing a stunted growth; also in one instance a *larger amount* of potash and lime.

It seemed at least possible that any injurious effect to the growing plant might be due to the *water soluble portion* of the various fertilizer constituents contained in the soil. A given weight (200 grams) of each soil was, therefore, successively washed with the same volume of hot water (1,000 cubic centimeters), the water being allowed to percolate through the soil contained within a separatory funnel, cylindrical in shape. The water solution was evaporated to dryness, carefully weighed, and a chemical analysis was made of the saline residue. The results have been calculated on the basis of 20 per cent. moisture in the soil, and have also been computed to show the pounds of the various constituents per acre.

TABLE 2. — *Showing Constituents soluble in Hot Water, Results figured to Parts in 100 Parts of Soil, the Latter showing a Moisture Content of 20 Per Cent.*

	Soil No. 1, Abnormal.		Soil No. 2, Abnormal.		Soil No. 3, Abnormal.		Soil No. 4, Normal.		Soil No. 5, Tobacco Bed.	
	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.
Total solids (largely saline residue),	.2000	6,000.0	.2096	6,288.0	.1384	4,152.0	.1072	3,216.0	.0800	2,400.0
Water soluble nitrogen,	.0210	631.0	.0229	868.0	.0108	324.0	.0099	298.0	.0068	204.0
Water soluble potash,	.0238	715.0	.0219	658.0	.0199	598.0	.0069	206.0	.0073	218.0
Water soluble phosphoric acid,	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Water soluble calcium oxide,	.0344	1,032.0	.0275	825.0	.0271	814.0	.0144	431.0	.0202	605.0
Water soluble sodium oxide,	.0146	438.0	.0148	444.0	.0188	564.0	.0144	431.0	.0159	478.0
Water soluble magnesium oxide,	.0094	282.0	.0180	540.0	.0073	219.0	.0144	431.0	.0046	137.0
Water soluble iron and aluminum,	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.
Water soluble sulfates calculated as SO_3,	.0272	816.0	.0210	639.0	.0147	442.0	.0158	475.0	.0082	247.0
Water soluble chlorine,	Trace.	.3	Trace.	.7	Trace.	.3	Trace.	.2	Trace.	.1
Acidity,	Trace.	.4	Trace.	.4	Trace.	.4	Trace.	.4	Trace.	.4

The results shown by this table tell quite a different story than do the analyses in the first table. Note the comparatively small amount of total solids, nitrogen, potash and, in fact, of most all of the water soluble constituents in soil No. 4, which showed a normal growth of tobacco, and No. 5, taken from tobacco bed. The soils giving abnormal results showed an increase of over 70 per cent. in total soluble solids, over 85 per cent. in water soluble nitrogen, and over 219 per cent. in water soluble potash. To have supplied the water soluble nitrogen found in soil No. 2, it would have required an application of 3,445 pounds of nitrate of soda per acre; to have supplied the water soluble potash found in soil No. 1 it would have required an application of 1,112 pounds of high-grade sulfate of potash per acre.

It was subsequently discovered that the field was underlaid with a hard impervious subsoil furnishing very poor drainage facilities, the soil had been used for the cultivation of tobacco continuously for more than thirty years. These facts, taken in connection with the very large amount of soluble plant food present, seemed to indicate strongly that the trouble was due to the accumulation of soluble saline constituents, probably originating in the fertilizers which had been applied in very liberal quantities for many years. It is a reasonable assumption that, had the soil been underlaid by an open porous subsoil, the condition would never have occurred, as the soluble salines would have passed out in the drainage water. This is borne out by the fact that all of the soils which have given this trouble have had imperfect drainage. In this connection it seemed of interest to procure several typical, well-drained tobacco soils which had been used continuously for thirty or forty years for tobacco culture. Three samples of soil and subsoil were, therefore, carefully taken from the farms of well known tobacco growers in various parts of the Connecticut valley. The soil was taken to a depth of 1 foot, the subsoil to a depth of 1 foot below the surface soil.

The following table shows the composition of the several soils and subsoils. Hydrochloric acid, specific gravity 1.115, was used as a solvent. The results are expressed on a 20 per cent. moisture basis, also in pounds per acre.

Table 3. — *Averages of Normal Surface Soils used for Over Thirty Successive Years for the Cultivation of Tobacco.*

	Soil No. 1.		Soil No. 2.		Soil No. 3.	
	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.
Moisture,	20.0000	-	20.0000	-	20.0000	-
Nitrogen,	.0970	2,910	.0810	2,430	.0604	1,812
Phosphoric acid,	.2341	7,023	.1535	4,605	.0810	2,430
Potassium oxide,	.1940	5,820	.2020	6,060	.1691	5,073
Calcium oxide,	.2131	6,393	.3300	9,900	.3450	10,350
Sodium oxide,	.1291	3,873	.2340	7,020	.1192	3,576
Magnesium oxide,	.0440	1,320	.0291	873	.0880	2,640

Table 4. — *Analyses of Subsoils taken from Field used for Over Thirty Successive Years for the Cultivation of Tobacco.*

	Soil No. 1.		Soil No. 2.		Soil No. 3.	
	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.
Moisture,	20.0000	-	20.0000	-	20.0000	-
Nitrogen,	.0251	753	.0183	549	.0220	660
Phosphoric acid,	.0880	2,640	.0482	1,446	.0810	2,430
Potassium oxide,	.1530	4,590	.1690	5,070	.1370	4,110
Calcium oxide,	.3770	11,310	.3610	10,830	.2790	11,370
Sodium oxide,	.1280	3,840	.1610	4,830	.1630	4,890
Magnesium oxide,	.0723	2,169	.0580	1,740	.0733	2,199

Two hundred grams of each soil and subsoil were also washed with 1,000 cubic centimeters of hot water. The solution was evaporated to dryness and a chemical analysis was made of the soluble residue. The results are computed on the basis of 20 per cent. moisture in the soils; they are also expressed in terms of pounds per acre of the various ingredients.

Table 5. — *Water Soluble Constituents contained in Normal Surface Soils used for Over Thirty Successive Years for the Cultivation of Tobacco. Underlying Subsoil Open and Porous, furnishing Good Facilities for Drainage.*

	Soil No. 1.		Soil No. 2.		Soil No. 3.	
	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.
Total solids,	.0881	2,643	.0937	2,811	.0509	1,527
Water soluble nitrogen,	.0092	276	.0079	237	.0093	279
Water soluble potash,	.0150	450	.0153	459	.0054	162
Water soluble phosphoric acid,	.0029	87	.0030	90	Trace.	Trace.
Water soluble calcium oxide,	.0091	273	.0107	321	.0098	294
Water soluble sodium oxide,	.0087	261	.0105	315	.0074	222
Water soluble magnesium oxide,	.0046	138	.0034	102	.0030	90
Water soluble sulfuric acid (SO_3),	.0088	264	.0108	324	.0117	351

Table 6. — *Water Soluble Constituents contained in Subsoils. Samples taken from Field used for Over Thirty Successive Years for the Cultivation of Tobacco. Subsoils of a Sandy Character, Open and Porous, insuring Good Drainage.*

	Soil No. 1.		Soil No. 2.		Soil No. 3.	
	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.	Per Cent.	Pounds per Acre.
Total solids,	.0321	963	.0286	858	.0289	867
Water soluble nitrogen,	.0092	276	.0043	129	.0033	99
Water soluble potash,	.0062	186	.0072	216	.0025	75
Water soluble phosphoric acid,	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Water soluble calcium oxide,	.0055	165	.0041	123	.0038	114
Water soluble sodium oxide,	.0051	153	.0064	192	.0066	198
Water soluble magnesium oxide,	.0018	54	.0010	30	.0006	18
Water soluble sulfuric acid (SO_3),	.0109	327	.0092	276	.0092	276

For the sake of comparison a table has been prepared giving the average composition of the three normal soils including both the active hydrochloric acid and water solutions, and likewise the average of the several abnormal soils which have shown strong indication of overfertilization. Results calculated to 20 per cent. moisture basis on soils.

TABLE 7. — *Amounts dissolved by Hydrochloric Acid (Specific Gravity 1.115).*

	Average Analysis of 4 Normal Tobacco Soils.		Average Analysis of 3 Abnormal Tobacco Soils.	
	Parts per 100 Parts of Soil.	Pounds per Acre.	Parts per 100 Parts of Soil.	Pounds per Acre.
Moisture,	20.0000	-	20.000	-
Nitrogen,	.1211	3,633	.204	6,120
Phosphoric acid,	.1661	4,983	.146	4,380
Potassium oxide,	.1731	5,193	.149	4,470
Calcium oxide,	.3640	10,920	.638	19,140
Sodium oxide,	.1608	4,824	-	-
Magnesium oxide,	.0537	1,611	-	-

TABLE 8. — *Water Soluble Constituents in Average Normal and Abnormal Tobacco Soils.*

	Average Analysis of 5 Normal Tobacco Soils.		Average Analysis of 4 Abnormal Tobacco Soils.	
	Parts per 100 Parts of Soil.	Pounds per Acre.	Parts per 100 Parts of Soil.	Pounds per Acre.
Total solids,	.1043	3,129	.1981	5,943
Nitrogen,	.0109	327	.0193	579
Potassium oxide,	.0122	366	.0205	615
Phosphoric acid,	.0013	39	.0002	6
Calcium oxide,	.0148	444	.0326	978
Sodium oxide,	.0102	306	.0161	483
Magnesium oxide,	.0063	189	.0116	348
Sulfuric acid (SO_3),	.0118	354	.0209	627
Total salines,	-	1,698	-	3,057

The results of analysis of the different soils indicate that the injurious effect upon the growing plants, if due to the accumulation of plant food elements, must have resulted from the water soluble salines present. The soluble matter in the three normal soils was very much less than in the soils which had given trouble, although the normal soils had been used for the continuous growing of tobacco for as long a term of years, and had been as liberally fertilized, as the soils giving poor results.

It is impossible to say just how large an accumulation of soluble constituents may take place before the plants will be injuriously affected. The data at hand, however, would indicate that a relatively wide latitude may be allowed on at least some of the constituents. It is believed that the combined effect of the total *soluble mineral constituents* in the soil is responsible for the injurious effect on the growing plants rather than an accumulation of any *one* of the soluble elements. It is probable, also, that the rainfall has an important influence in this connection, plenty of rain having a tendency to keep the soluble matter well below the surface, while the absence of a normal rainfall would tend to draw the soluble salts to the surface.

It will be seen from Table 8, giving the average composition of the two types of soil, that nearly twice the amount of soluble salines was found in the abnormal solids as was present in the normal ones. A tobacco soil examined but not reported here has shown as high as .18 per cent. water soluble salines (equivalent to 5,448 pounds per acre), and yet has produced a fair crop of tobacco. On the other hand, serious injury to the crop has been noted on soil which tested only .14 per cent. soluble salines (equivalent to 4,152 pounds per acre). Another fact should not be lost sight of, namely, that the abnormal soils in all cases were underlaid with an impervious or hardpan subsoil which prevented the free circulation of the soil water. It seems probable, therefore, that the trouble is due to, or is most likely to occur on, soils underlaid with hardpan and in the absence of a normal rainfall, the accumulated soluble saline matter being brought to the surface.

The investigation brings out one fact of unusual interest, namely, the large amount of water soluble potash as compared with the total potash content of the abnormal soil. The average total acid soluble potash present in the three abnormal soils was .149 per cent., of which .0205 per cent. (or nearly 14 per cent. of the total amount) was present in water soluble form. The writer is aware that these facts are not in accordance with the usual teachings, it being generally held that potash does not remain in solution for any great length of time, but is soon fixed as basic compounds in the soil, only to be liberated gradually by chemical action. It does not seem improbable that the concentration of the soluble salines may in a measure be responsible for the large proportion of soluble potash present, and possibly even tends to dissolve greater quantities of the fixed potash. The proportion of water soluble potash in the normal tobacco soils bears out this theory, as out of a total of .1731 per cent., only .0122 per cent. (about 7 per cent. of the total amount) was present in water soluble form.

The results in Table 8 are of interest in connection with the question of the proper concentration of soil solutions most favorable to plant development. Numerous investigators have demonstrated that one part of mineral matter in 1,000 parts of water furnishes the best conditions.[1] The average analysis of the five normal soils shows the presence of 1.04 parts per 1,000, whereas in the abnormal soils nearly twice this amount was present. It is well known that some plants stand a greater concentration of soil solutions than others; for instance, corn and grass showed a wonderful development on soils which were so unfavorable for tobacco. Onions, on the other hand, seem to be quite as susceptible to injury as is tobacco. The same difference has been noticed in connection with the accumulation of soluble mineral constituents in greenhouse soils. Soil solutions too concentrated for cucumbers seem to be quite favorable for tomatoes. Little data is available in connection with this whole subject of the concentration of soil solutions, and further study with different plants is needed before any sweeping conclusions can be drawn. It is not improbable that if the amounts of the various soluble constituents in the soil are present in certain proportions the plant may be able to with-

[1] Pfeffer, Vol. 1, p. 420; Stockbridge, Rocks and Soils, p. 206.

stand a more concentrated soil solution. Pfeffer, in speaking of the concentration of cultural solutions, says, "The concentration of the cultural fluid is always important, for when its osmotic concentration passes a certain limit growth becomes impossible, though no poisonous effect is exercised, while when the fluid is too dilute, *or when a single essential salt is present in insufficient amount, the development of the plant is retarded.*"

As a remedy for the trouble under consideration the rotation of crops is advised. Corn seems to be a good hoed crop to be grown on soils in this condition. It requires a liberal amount of potash and other plant food constituents, and it appears to withstand the effect of the concentrated soil solution. The writer has known of some tremendous yields of corn, grown on tobacco soils evidently suffering from overfertilization, without the addition of any fertilizer whatever. Grass can follow corn with satisfactory results, and after three or four years of such treatment the soil can be used again for tobacco.

It is needless to say that if possible such land as has been described would be greatly benefited by underdraining, and it is strongly advised.

DIGESTION EXPERIMENTS WITH CATTLE FEEDS.

BY J. B. LINDSEY.

The term "digestibility" refers to that portion of food that an animal can actually make use of for nutritive purposes; the undigested portion is represented by the solid manure (feces) which is excreted by the animal as so much worthless material.

The unit of measurement is termed "digestion coefficient." Thus, experiments have shown that out of 100 pounds of bran 62 pounds, or 62 per cent., are digestible, and this figure is termed the digestion coefficient for bran. Again, experiments have shown that 77 per cent. of the protein and only 39 per cent. of the fiber in bran are digestible, and these two figures represent, respectively, the digestion coefficients for the protein and fiber in bran. Coefficients are used in figuring out balanced rations and in determining the relative nutritive values of different feedstuffs. A single illustration as to the method employed in calculating the actual digestible material in a foodstuff may suffice: —

One Hundred Pounds Timothy Hay.

	Contains (Per Cent.).	Per Cent. Digestible (Coefficient).	Pounds Digestible.
Water,	15.00	-	-
Ash,	4.30	-	-
Protein,	6.30	48	3.0
Fiber,	28.40	58	16.5
Starchy matter,	43.60	63	27.5
Fat,	2.40	61	1.5
Total,	100.00	-	48.5

It thus appears that 100 pounds of hay contain 48.5 pounds of material available for the purposes of nutrition. In case of corn meal 76.2 pounds are available, so that a definite amount of the latter food is more valuable than a like amount of the former.

In Part I. of this report detailed data of numerous digestion experiments with a variety of cattle foods are presented. In this article a résumé only is given of the results secured.

1. Corn Fodders (Varieties).

(*a*) Pride of the North, a medium dent that will mature its ears in Massachusetts.

(*b*) Rustler white dent, a corn of medium growth that will mature its ears in this State.

(*c*) Leaming, a dent that usually is not quite mature by September 15, in many sections of Massachusetts.

(*d*) Early Mastodon, a large growing dent that brings its ears to the milk stage by September 15.

(*e*) Brewer's dent, a large growing dent that may mature its ears in southern and southeastern Massachusetts in a favorable corn year.

(*f*) Wing's improved white dent, a large growing variety that is spoken of highly in Ohio, but will not mature with us.

Results secured.

	Coefficients.					
	Dry Matter.	Ash.	Protein.	Fiber.	Extract or Starchy Matter.	Fat.
Pride of the North,	77	36	63	66	84	84
Rustler Dent,	69	27	43	59	78	76
Leaming,	70	36	60	61	77	76
Early Mastodon,	72	36	57	60	79	80
Brewer's Dent,	72	46	69	69	77	68
Wing's Improved,	70	39	63	65	76	70
Average,	72	37	59	63	78	76
Average all trials, mature dents,	69	34	54	59	75	75
Average all trials, immature dents,	68	42	66	65	71	68

The results of the several experiments as expressed in the above coefficients when studied by themselves, without taking into consideration the chemical composition of the plant, would not reveal much of interest.

In general it may be said that those varieties that will bring their ears to maturity will have a higher degree of digestibility than those coarser, less mature varieties. This is due to the relatively larger proportion of grain to stalk. The Pride of the North shows a total digestibility of 77 as against 72 for the average of the others. It is not entirely clear why the Rustler dent did not show approximately as high a degree of digestibility as the Pride of the North. This may be due to the fact that the animals were fed rather more than they could eat, and probably did not digest quite as thoroughly as though they had received a less amount. The last four — Leaming, Mastodon, Brewer's and Wing's — representing the less mature dent varieties, show about the same degree of digestibility.

Mature dents (whole plant) will have a digestibility of from 70 to 75 per cent., while in case of the less mature dents the digestion coefficient will fall somewhat below that figure.

2. Proprietary Grain Mixtures.

The highest grades of unmixed concentrates have the following digestion coefficients: —

	Dry Matter.	Ash.	Protein.	Fiber.	Extract or Starchy Matter.	Fat.
Corn meal,	88	-	67	-	92	90
Gluten feed,	88	-	85	87	90	81
Cottonseed meal,	79	-	84	35	78	94

In experiments conducted with a number of proprietary mixtures the following coefficients were secured: —

	Dry Matter.	Ash.	Protein.	Fiber.	Starchy or Extract Matter.	Fat.
Schumacher's stock food,	71	–	70	52	79	88
Biles union grains,	75	24	71	80	79	96
Buffalo creamery feed,	69	23	81	55	71	87
Unicorn dairy ration,	83	25	76	72	89	96

It will be seen that the sample of Unicorn dairy ration had a relatively high total digestibility. Biles union grains were also well digested, while Schumacher's stock food and Buffalo creamery feed were fairly well utilized. None of these feeds had what would be termed a relatively low degree of digestibility. From a nutritive standpoint, therefore, the feeder could safely purchase these mixtures and feel that he was not buying inferior articles, provided, of course, that the manufacturers continued to maintain the standards represented by those samples. The questions of cost and suitability for definite purposes would also have to be considered before purchasing. These items are discussed in our annual feed bulletins.

3. Alfalfa Hay.

The alfalfa hay used in these experiments was grown on the college farm. It was cut while in early blossom and was quite free from weeds and grass. Owing to different weather conditions which prevailed at the time of cutting, and which necessitated different methods of handling, the amount of leaves lost in curing was not uniform; hence a strictly fair comparison could not be made between the different cuttings. The results of the several trials are therefore reported, and the average given for the several lots. In order to draw accurate conclusions between cuttings, the crop should either be fed green or cured under uniform conditions. Owing to frequent weather changes this is often not possible in New England.

Summary of Coefficients (Per Cent.), Periods III., IV. and V.

Sheep.	Cutting.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1[1]	1	1	63.27	57.43	78.33	53.82	77.30	44.76
Sheep I.,	1[2]	1	1	55.40	39.14	70.22	42.94	64.78	23.56
Sheep II.,	1[1]	1	1	62.77	47.24	75.93	44.68	73.86	40.88
Sheep II.,	1[2]	1	1	59.76	45.47	73.06	48.68	68.24	25.67
Sheep III.,	2[1]	1	1	54.29	35.40	69.46	42.20	64.79	13.83
Sheep IV.,	2[1]	1	1	59.49	42.56	74.39	48.39	68.80	19.29
Average,	-	3	6	60.00	44.54	73.57	46.79	69.63	28.00
Average of all trials, alfalfa hay for comparison,	-	42	80	62.00	50.00	74.00	46.00	72.00	40.00
Average of all trials, red clover for comparison,	-	12	25	58.00	36.00	58.00	54.00	65.00	56.00

[1] Third-year growth. [2] First-year growth.

Unfortunately an exact record of the weather conditions during the curing process of the several lots was not kept. It would appear that the first cutting of the *third year growth* was cured without the loss of a great deal of leafy matter. This is shown by the relatively low fiber percentage and the high digestibility. The second cutting of the *third year growth* evidently lost a considerable portion of its leaves, as indicated by its high fiber percentage and lessened digestibility. The first cutting of the *first year growth* also must have lost an excess of leaves, as it also shows excessive fiber and low digestion coefficients. It is possible that the markings of the first cutting third-year growth and the first cutting first-year growth were reversed, although we have not the slightest evidence to that effect.

While the coefficients obtained vary considerably the average is about the same as the average for all trials, except that the coefficient for fat is somewhat lower. It is believed that the average coefficients obtained in our several trials show fairly the digestibility of eastern-grown alfalfa under the adverse conditions due to the loss of leaves in the process of curing.

4. Red Clover Hay.

The clover was seeded in early August. It yielded well, was in early blossom when cut, and was cured in cocks. The first cutting did not cure out well, owing to a rainy spell during the curing process. It had a black appearance when taken to the barn, and later had to be spread in the sun for further drying. It did not lose its leaves to any extent; the lot was lacking in a satisfactory odor and was slightly musty. The conditions during the curing of the second cutting were more favorable. Both lots were rich in protein (15.28 and 17.82 per cent. in dry matter), and comparatively low in fiber (29.76 and 28.30 per cent. in dry matter).

Summary of Coefficients (Per Cent.), Periods VI. and VII.

Sheep.	Cutting.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	1	1	1	64.48	61.19	63.94	62.00	67.93	52.52
Sheep II.,	1	1	1	62.57	59.49	63.81	57.08	67.19	52.23
Sheep III.,	2	1	1	57.94	53.68	59.32	43.27	68.36	55.02
Sheep IV.,	2	1	1	61.31	57.99	60.60	49.38	70.51	55.77
Average,	–	2	4	61.58	58.09	61.92	52.93	68.50	53.89
Average alfalfa hay (our trials),	–	3	6	60.46	45.39	73.77	47.55	69.92	28.32
Average of all trials, clover hay for comparison,	–	12	25	58.00	36.00	58.00	54.00	65.00	56.00
Average of all trials, alfalfa hay for comparison,	–	42	80	62.00	50.00	74.00	46.00	72.00	40.00

The most noticeable difference in the four single trials with clover hay consists in the variation in the digestion coefficients obtained for the fiber (43 to 62). This is evidently due in part, at least, to the individuality of the several animals. The fiber in the second cutting was apparently not as digestible as in the first cutting. The other coefficients — excepting the ash, which is found to vary widely in most all experiments —

may be considered fairly uniform. The coefficients secured by us are higher than the average for all other experiments, probably due to the early cutting of the crop.

When the average of the clover coefficients is compared with the average of our reported coefficients for alfalfa, it is noted that in case of the total dry matter the former shows to advantage, although the reverse is true in a comparison of the experiments reported for all trials. The protein in the clover is shown to be substantially 12 per cent. less digestible than in the alfalfa; in case of the average for all trials the difference is 16 per cent. In case of the fiber the conditions are reversed, — differences of from 5 to 8 points being noted in favor of the clover. The comparative digestibility of the extract matter is about the same, although the average figures show 7 points in favor of the alfalfa. In making a comparison of the two plants from the standpoint of digestibility, two important differences are noted: (1) the protein in the alfalfa is noticeably more digestible than in the clover (12 to 16 points), and (2) the fiber from 5 to 8 points less so. In total digestibility the two plants approach each other, showing an average of about 60 per cent. as against 55 per cent. for timothy, 60 per cent. for early cut fine hay, 65 per cent. for rowen, 70 per cent. for the entire corn plant, and 85 per cent. for corn meal.

It is evident that the relative value of the two crops cannot be determined from their digestibility alone; other important factors to be considered are cost of production and yield and adaptability to Massachusetts conditions. Taking all the evidence into consideration it would appear that although the cost of seed and preparation of land is somewhat against the alfalfa, yet its much greater length of life, its larger average yearly yield, and its rather superior nutritive value are all in its favor. The conditions governing its successful cultivation must be carefully studied by all interested in its production. To the lack of attention to these conditions by the average farmer is due, in no small measure, the failures reported.

BRONZING OF MAPLE LEAVES.

G. E. STONE.

A somewhat common and peculiar effect on rock maple leaves, especially noticeable in very hot and dry summers, was brought to our attention this past summer. We have noticed this trouble many times before, particularly on rock maples growing in certain characteristic soils or habitats. It is most commonly seen on maples growing in dry soil where there is insufficient soil-moisture during periods of extreme drought.

The trouble is characterized by an absence of the typical maple leaf green. The leaves are more or less rigid, and in color are light, with a reddish brown tinge. An examination of the surface of the leaf with a hand lens, or even with the naked eye plainly shows that many of the cells of the leaf blade or lamina are dead and reddish brown in color. These dead cells are confined to certain areas of the laminæ, mainly between the minute veinlets, whereas those cells near the veinlets are green and alive.

Repeated examination of the leaves has demonstrated that the trouble is caused by no pathogenic organism, but is purely functional in nature. On the other hand, it is quite distinct from the so-called sun scorch so commonly affecting the rock maple, although both are induced by similar conditions. The typical sun scorch is characterized by more or less irregular blotches of dead tissue more often on the edges of the leaves, which are usually more susceptible to the scorching and are often lacerated severely. This sun scorch, like the "bronzing," also affects maples growing in very dry soil, on dry, windy days, when the roots cannot supply the foliage with sufficient water. Since transpiration under such conditions is very active and root absorption limited, wilting and death of the leaf tissues result.

Sun scorch is common to many plants, and is referred to under different names such as "topburn" in lettuce, "tip-burn" of potatoes, "leaf burn," "wilt," etc. It may result from the presence of certain chemical substances in the soil, or from some individual peculiarity in the root-absorptive capacity of the organism. The peculiar drying and reddening of the cells of the maple leaves which we have previously referred to as "bronzing" is not necessarily caused by wind; the principal factors necessary being a soil deficient in moisture, and excessive transpiration.

As already stated, "bronzing" occurs on very hot, dry days, in periods of severe drought, and this last summer we have succeeded in producing many excellent examples of it in the greenhouse. The trouble was very common this season, our attention often being called to it, and we have been observing very severe cases of it in certain maple trees for many years.

COARSE NOZZLE VERSUS MIST NOZZLE SPRAYING.

G. E. STONE.

At the present time much thought is being given to the general technique of spraying. The subject is an important one and is by no means settled, either as regards equipment or methods. Our own State has done its share in this respect since the important economic problems involved in handling the gypsy and brown-tail moths have made it necessary to originate and utilize the most modern and efficient spraying machinery.

For the perfection of modern spraying on a large scale great credit should be given to Mr. A. H. Kirkland, a graduate of this college and former superintendent of the Gypsy Moth Commission, whose handling of economic problems of this nature has been unexcelled, and particularly to Mr. L. H. Worthley, the present superintendent. The former methods of spraying advocated and used by the old commission were considered revolutionary in those days, and great credit should be given to Mr. E. C. Ware, the mechanic associated with the former commission, for developing an improved outfit and for originating the best fine mist nozzle as yet devised. The old method, however, has been practically discarded, since the modern method is much cheaper and about as effective.

This makes use of the powerful high pressure machine and coarse nozzle, which is capable of throwing a stream to a great height, this breaking up into a more or less fine mist. The first attempt to use engines in spraying dates back some years.[1] Most of the devices were very crude in construction. Mr. J.

[1] L. O. Howard, Year Book, Department of Agriculture, 1895, pp. 361–394, and 1896, pp. 69–88.

W. Pettigrew, superintendent of the Boston park system, was one of the first to construct a really effective spraying equipment provided with high-pressure gasoline engines and modern coarse spray nozzles. This was used with much satisfaction some years ago in spraying woodlands for the gypsy moth and for park work, and on this model were constructed the later and more improved types of machines. In 1896 he employed a more or less cumbersome outfit for spraying in the public parks of Brooklyn, N. Y., consisting of an ordinary road sprinkler and a 10-horse power portable steam boiler fitted to a large pump. He made use of a ¾-inch hose provided with 3/16 or ¼ inch nozzle.

About the same time Mr. Christopher Clark, the veteran city forester of Northampton, Mass., made use of a similar machine for spraying elm trees. Mr. Clark's equipment consisted of a small steam boiler which used coal for fuel, and a Duplex pump mounted on a truck. The pressure he obtained from this equipment was something over 100 pounds. He used an ordinary garden hose nozzle of ⅛-inch aperture and obtained a coarse spray, not in any way comparable, however, with that obtained from the use of modern equipment. Other makeshifts, which used steam for power, were employed here and there about the same time, but these were all crude affairs compared with the modern outfit.

Those who have had opportunity to make extensive comparisons of the high-pressure, coarse-nozzle spraying and the fine mist spray under low pressure are generally convinced that, considering the cost and efficiency, the former method is far superior to the latter for certain work. The question therefore arises to-day whether or not high-pressure coarse-nozzle spraying cannot be applied to orchards with the same results that have followed its use in other ways. Recent experiments made in Virginia [1] have shown that for the control of the codling moth the high-pressure, coarse-nozzle spray has proved superior to the low-pressure mist spray. The best high-power sprayers in use at the present time have reached a high degree of perfection, especially the machines manufactured for and

[1] Spraying for the Codling Moth, West Vir. Agr. Exp. Sta., Bul. No. 127.

used by the Gypsy Moth Commission. But there are many others, of both high and low power, which are thrown together in an altogether haphazard fashion. A machine which is to develop and maintain 250 pounds pressure with a 1-inch hose and 1.8 and 3.16 inch nozzle should be provided with an engine which will develop 5 or 6 horse power at the least. A machine of this type would be suitable for small towns where it is necessary to spray only 500 or 1,000 trees each year, or it would be suitable for large orchardists. When the spraying to be done is extensive, however, the larger machines, at least 10 or 15 horse power, are the more economical in the end, even if the first cost is greater, since some allowance should be made for deterioration and loss of power in any machine.

It is a question whether we are using the best methods in some of our spraying work. A 5 or 6 horse power pressure machine can be depended upon to handle a stream of from 40 to 60 feet high, and this is sufficient if a ladder is used; but if it is necessary to throw the spray 100 feet, or to the tops of the trees, larger machines must be used.

At the present time less attention is being given to nozzles than to machines, and in our opinion there is ample room for improvement on the nozzles in use to-day. The various mist-spray nozzles are good for short distances, and those in use at the present time are an improvement over the old spray nozzles. But we need wide-angled spray nozzles that will give a spray of uniform density which will throw a relatively fine mist at least 20 or 30 feet. To obtain such a spray high pressure is one of the necessities, and a new type of nozzle another. By the use of nozzles adapted to high-pressure machines which can be adjusted to different distances we are of the opinion that the spraying of orchards can be done as effectively and more cheaply than at present. Instead of employing 70 pounds pressure and forcing the spray through ½-inch hose provided with a mist nozzle with a limited carrying capacity, we shall come to the use of high pressure and larger hose provided with nozzles of great carrying capacity. In our opinion spraying will be developed along these lines in the future, since the process will be rendered cheaper and practically as effective as at the present time by the use of high pressures and nozzles of better carrying power.

The writer has devised a number of spray nozzles adapted to high-pressure machines, some of which have been constructed and tested. The aim has been in constructing the nozzles to get a good carrying power, and still to maintain a fairly fine mist.

EXPERIMENTS WITH ROSE SOILS.

G. E. STONE.

Although requiring exceptional skill, the management of green-houses has reached such a high degree of perfection in the United States that it seems somewhat presumptuous for an amateur to attempt serious experimentation with the idea of its being of value to the remarkably trained men who make a profession of growing roses and carnations under glass. Nevertheless, for two years we experimented with roses, and during this time freely consulted the best experts in the line. The experiments were undertaken largely to determine the effects of different soil textures on the growth of roses, to study their diseases, and in general to ascertain the limitations of the plant under different methods of treatment. Such crops as lettuce, tobacco, roses and others are quite susceptible to differences in soil texture, which often produce quite different types of tissues and of growth. Tobacco, for example, will bring $0.30 a pound when grown in certain soils, while the same plants, when grown in other soils even by the same grower, will often not be worth $0.10 a pound. Likewise lettuce grown in the light, porous soils about Boston is quite different from that grown in the heavy, inland soils.

For the best growth of roses it is essential that the soil have a more or less definite texture, and in these experiments it was our purpose to observe the effect of different soils on the development of roses. We selected the American Beauty rose for the experiments, as it is considered the most susceptible to soil texture. It has even been maintained that a soil suitable for its growth is rare in this State, whereas in Pennsylvania the soils appear to be ideal for this variety.

Mechanical analyses of some of the best rose soils in this country demonstrate that they contain a large percentage of finer particles, clay, etc., than is generally found here in our soils. In our experiments we selected soils which resembled as much as possible the best types. Some of the soils in the Connecticut valley seemed to be excellent substitutes for the real rose soils, and these were tested in order to obtain some idea of their relative value. Most of the Connecticut valley soils run low in coarser materials and high in the finer materials such as very fine sand, and occasionally silts predominate. These fine sands and silts give a compact character to the soil, with a large water retaining capacity. Very fine sand predominates in many of these soils, as high as ·75 per cent. being found in some samples, but nearer the river we often find samples in which the coarser silt predominates.

These experiments were continued for two years in a greenhouse provided with 5 beds, one-half of each bed containing a typical Amherst loam which had been used for some years in growing cucumbers, tomatoes and melons, and to which no commercial fertilizer had been added, although horse manure had been applied freely. The other half of each bed was filled with specially selected soil of different textures for the purpose of comparison. These benches were 1 foot deep and the bottoms were filled with brick placed on end, leaving about 7 inches depth of soil in each bed. Seventeen plants were used in each section, or in the whole house a total of 170 plants. Since five of these sections contained soil of the same types, only five were used for other types, and these were all different.

TABLE 1. — *Showing Mechanical Analysis of Soils used in Rose Experiments.*

Number.	Section.	Bed.	Per Cent. of Organic Matter, Gravel, Sand, Silt, and Clay in 20 Grams of Soil.								
			Organic Matter.	Gravel (2-1 mm.).	Coarse Sand (1-.5 mm.).	Medium Sand (.5-.25 mm.)	Fine Sand (.25-.1 mm.).	Very Fine Sand (.1-.05 mm.).	Silt (.05-.01 mm.).	Fine Silt (.01-.005 mm.).	Clay. (.005-.0001 mm.).
20, ...	I.	A	8.22	0.10	9.45	1.44	4.35	40.01	29.67	0.46	5.65
69, ...	I.	B	18.21	1.45	4.40	3.85	12.93	38.13	1.50	0.51	12.26
68, ...	I.	C	6.58	0.99	1.48	1.53	12.51	28.02	14.51	14.11	10.41
67, ...	I.	D	8.96	3.51	3.25	3.87	9.75	45.42	14.49	0.99	3.86
66, ...	I.	E	9.80	0.69	3.86	3.63	6.51	36.53	14.27	12.25	9.43
71, ...	II.	A-E	7.54	1.24	3.62	3.48	11.64	49.01	10.85	1.55	1.71

The mechanical analysis of the soils used in our experiments with roses is shown in the preceding table. Five of the beds in section II., beds A to E, contained soils represented by No. 71, which is a fairly typical Amherst loam, the analysis being made from a composite sample taken from each of the five beds, and contains 1.71 per cent. of clay. The remaining five beds, section I., were filled with selected soil of different textures. These were all obtained from the vicinity of the experiment station, but were different in texture and appearance from our typical loams. All were thoroughly mixed with about one-third cow manure. The character of the soils in beds A to E, section I., was as follows: —

Soil No. 70, bed A, was obtained from near the banks of the Connecticut River, and was higher in clay than No. 71. Silt and very fine sand, however, predominated in this type.

Soil No. 69, bed B, was obtained from a forest near by and was rich in vegetable matter as a result of many years' accumulation of decayed roots, leaves and twigs, and was very dark in appearance. It was characterized by considerable amounts of clay and very fine sand, which was the result of wash from higher elevations.

Soil No. 68, bed C, procured 6 feet below the surface, was very compact, containing little organic matter, and would be designated as hardpan. Very fine sand predominated in this soil, which also contained 10 per cent. of clay.

Soil No. 67, bed C, was a modified local soil obtained from what was originally a muck meadow which at one time was overflowed with water, but later reclaimed. It had received some wash in times past, was dark in appearance, and more or less compact. For some years it had been growing excellent crops of grass, but the year before we obtained it had been ploughed up and reseeded. Our sample was taken from the surface and contained the old and new seeded soil, well decomposed. Fine sand and silt predominated and the soil contained a little more clay than No. 71.

Soil No. 66, bed E, was the same as No. 68, except that besides the one-third cow manure, one-third finely pulverized sod was added.

All of the soils in section I. contained more clay than our regular greenhouse soils shown in section II., the clay ranging from 3.86 per cent. to 12.26 per cent. The plants were set out in October and removed the following June. Besides the above treatment all of the beds were freely supplied every week or two with liquid cow manure. The steam pipes were painted with sulphur and oil, and there was little or no mildew or black spot. The plants were quite free from diseases caused by pathogenic organisms, although much variation occurred in the vigor and growth of the plants in the different soils, as was anticipated from the dissimilar conditions. In most cases they were not what would be called vigorous. The following table gives the height of the plants at two different periods in their growth; viz., at March 17 and June 19.

TABLE 2. — *Showing the Average Height in Inches of Rose Plants grown in Different Soils, in Beds A to E, Section I.*

	Beds.				
	A.	B.	C.	D.	E.
Soil number,	70	69	68	67	66
Average height of plants March 17 (inches),	37	38	22	46	36
Average height of plants June 19 (inches),	50	68	39	72	66

The average height of plants in section I., beds A to E, which contained a variety of new soils, was 36 inches for March 17, and 29 inches for corresponding plants in section II., beds A to E. At the second period of measurement, June 19, the average height of the plants in beds A to E, section I., was 59 inches, while that for beds A to E, section II. was only 34 inches, showing that the new soils produced plants of greater average height than the old greenhouse soil. If we take the averages of the final measurements made on June 19 of the plants grown in new soils, that is, in beds A to E, section I., we find that the highest average growth in height is shown by soil No. 67, or in bed D. (See Table 2.) Soil No. 67 contained nearly 4 per cent. of clay and considerable fine sand and silt, and constituted one of the best soils for roses in the house. Soil No. 69, bed B, produced the next highest average of plants, but they were abnormal, developing small leaves and a spindling growth. The soil in this case was very dark colored and rich in organic matter.

The plants in soil No. 66, bed E, closely resembled in height those in the preceding one. The soil in this case was heavy and compact, but contained besides the cow manure considerable pulverized sod. Soil No. 70 in bed A and No. 68 in bed C gave the lowest average growth in height. The latter soil was the same as No. 66, bed E, except that it contained no pulverized sod. This soil contained the least organic matter of any, was heavy and compact, and contained 10 per cent. of clay. When pulverized sod was added, as in No. 66, far better results were obtained. No. 70 was also lacking in organic matter. The heavier, more compact soil developed better leaves and blossoms than the lighter soil. Soil No. 67 produced the best developed plants, while the most slender canes were produced by soil No. 69.

The largest number of flowers developed on the plants which made the best growth, but the quality was the best in No. 67. The most normally developed plants were grown in soils No. 67 and No. 66, the latter being the only soil to which was added pulverized sod, and the former contained a fairly good supply of well decomposed sod incorporated with the soil when brought from the field into the greenhouse. The addition of sod to some of the other soils would no doubt have given better results. The superior plants produced by soil No. 67 were undoubtedly due to the large amount of well decomposed sod it contained; in other words, the humus was in a condition to make it more available, whereas in soil No. 66 this was not so, as the sod was applied fresh and was not in the least decomposed, and in Nos. 70 and 68 there was too little humus. Soil No. 69, obtained from the woods and containing large amounts of decomposed roots, leaves and branches of shrubs and other plants, was not suitable for growing stocky plants, although rich in humus.

The soil in the different beds remained undisturbed during the summer, and a second crop of roses was set out the following fall. However, before setting out the plants each bed in both sections received a fairly good application of cow manure, this being thoroughly incorporated in the soil. The new plants during the second year started very poorly, became sickly, and in the course of three months half of them died. This experiment was conducted purposely along this line, although we knew we were violating the customs of the best growers. Nevertheless, we wished to learn what the result would be. The sickly plants showed no indications of being affected by pathogenic fungi or eel worms, but the roots were abnormal, indicating that the trouble was in the soil. We therefore flooded each bed while the plants were "in situ" for a period of two hours, washing out the soil very thoroughly. The first water that came through the soil was exceptionally turbid, but that which came through later was very clear. The percolated water was collected at intervals and chemical tests made of it for acidity, etc. These tests gave surprising results, as they showed that the soil was in very abnormal condition for root growth. These soils had been given, the year before, the customary treatment, consisting of a liberal supply of cow manure, both in the solid and liquid form, but this had so filled up the soils with injurious chemical compounds as to prevent root development. Rose growers have found by experience that good results can be obtained only by changing their soils each year, and this experiment verifies the wisdom of the practice.[1] On the other hand, lettuce growers seldom if ever change their soil, experience showing that for lettuce the older the soil the better. In the former case cow manure is used, and in the latter, horse manure, mixed with a large percentage of straw, is used exclusively, the effects on the soil being quite different.

Carnation soils are treated in the same way as rose soils, the soil being changed each year. Roses and carnations, therefore, require a new soil each year, while most market garden crops are grown year after year in the same soil enriched with horse manure and straw. Repeated applications of horse manure improve such soils, and there is little danger of over manuring; whereas cow manure has a quite different effect and cannot be used in the same way, as there is danger of root injury and malnutrition.

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[1] At the present time rose growers use Manetti stock for grafting and do not change the soil more than once in two or three years. This stock is said to be more immune to eel worms.

Most of the lettuce soils in the greenhouses in this State have never been changed, and some of them are very old. The older such soils are the better for lettuce and market-garden crops in general although tomatoes do the best when the soil is changed occasionally.

After the rose soils were washed out no further dying of the plants occurred; on the other hand, they developed quite rapidly and the crop matured. The trouble was with the roots and was caused by an abnormal chemical condition of the soil. When this occurs, as it does quite commonly in greenhouses, washing out the soil is a corrective. Sometimes the trouble can be remedied by placing a new layer of soil on top of the bed, in which case new roots will form in the top layer of soil.

The development of the plants in the second crop was not as good as in the first, but the same characteristic growth in the different beds was noticeable. The washing out of the soil improved the condition of the plants to quite a remarkable degree, especially in soil No. 69, which appeared to be more acid than that in the other beds. The plants in soil No. 67, however, as in the preceding experiments, showed the best development.

At this point it might be well to compare the texture of other rose soils with that of those with which we experimented. The following table gives the results of the analyses of some of the best and most typical rose soils found in the eastern States.

TABLE 3. — *Showing Mechanical Analysis of some of the Best Rose Soils obtainable from the Rose Houses of the Eastern United States*

States.	Number.	Per Cent. of Organic Matter, Gravel, Sand, Silt, and Clay in 20 Grams of Soil.								
		Organic Matter.	Gravel (2–1 mm.).	Coarse Sand (1–.5 mm.).	Medium Sand (.5–.25 mm.).	Fine Sand (.25–.1 mm.).	Very Fine Sand (.1–.05 mm.).	Silt (.05–.01 mm.).	Fine Silt (.01–.005 mm.).	Clay (.005–.0001 mm.).
New Hampshire,	109	4.58	0.13	0.16	0.25	6.62	36.80	16.34	12.74	9.11
	110	7.90	1.35	1.25	2.22	3.72	13.18	32.25	23.59	13.73
	105	4.69	0.41	0.13	0.49	0.89	14.05	29.46	15.36	29.28
New York,	106	4.69	0.74	0.73	2.09	8.57	32.25	26.84	12.76	8.53
	108	3.15	0.21	0.13	0.56	2.82	43.15	14.56	19.40	10.15
Pennsylvania,	107	7.28	2.87	1.73	3.33	9.55	39.44	20.09	3.37	6.73
	118	5.12	5.10	2.62	4.52	12.09	26.20	31.04	3.52	6.42
	111	4.60	0.62	0.60	2.04	3.98	23.15	25.52	19.10	11.01
	112	5.19	0.35	0.42	1.34	2.48	32.26	5.15	36.10	11.80

TABLE 4. — *Showing the Percentage of Coarse and Fine Material in Rose Soils.*

Bed.	Number of Soil.	Percentage of Soil Constituents in—	
		Gravel through Fine Sand.	Very Fine Sand through Clay.
A,	70	15.34	75.70
B,	69	22.63	52.40
C,	68	16.51	67.05
D,	67	20.38	64.76
E,	66	14.69	72.48
A-E,	71	19.98	63.12
	109	71.17	74.98
	110	8.54	82.75
	105	1.92	88.15
	106	12.13	80.38
	108	3.72	87.26
	107	17.48	69.63
	118	24.33	67.18
	111	7.24	78.78
	112	4.59	85.31
Average,	70-66	17.91	66.49
Average,	109-112	9.68	79.36

All the soils shown in this table are from locations where roses are grown to perfection. A casual glance, however, at the mechanical analyses of these soils given in Tables 3 and 4 shows that they are somewhat higher in the finer particles than most of the Massachusetts soils. The clay runs from 6 to 29 per cent. in the soils shown in Table 3, while the very fine sand, silt and clay run from 67.18 to 88.15 per cent. The gravel, coarse and medium and fine sand run from 1.92 to 24.33 per cent. (See Table 4.) In our experiment soil the very fine sand, silt and clays run from 52.40 to 75.79 per cent., while the coarse particles, namely the gravel, coarse, medium and fine sand, run from 14.69 to 22.63 per cent. In most of the types the silts run higher than in our typical Massachusetts soils, although in some cases the very fine sand and silt are less than those found in some Connecticut valley soils.

The average percentage of coarse particles is 19.98 in our experiment soils, and 9.68 in typical rose soils, while the average for the finer particles is 66.49 in our soils and 79.36 for the typical rose soils; in other words, the percentage of coarse material averages highest in the soils with which we experimented, and the percentage of finer particles averaged less than in the typical rose soils. The average percentage for silt is 14.88, and for fine silt 5.66 in our experiment soils, while the typical rose soils give 22.36 for the silt and 16.21 for the fine silt, the typical rose soils showing a larger percentage of silts than our experiment soils. This also holds true for the clays. We are of the opinion that the larger percentage of silt and very fine sand makes a compact soil of good water-retaining capacity. Our experiments were not carried on extensively enough to determine, except in a general way, the textural effect on roses, and it would require considerable experimenting to determine the specific effects of each group of soil particles on the development of this plant. Numerous mechanical analyses of a large number of our best rose soils which have been made for many years throw some light on the problem of soil texture, but the problem, like many others, is complicated by the undoubted presence of other factors which may play a part here in the development of a crop.

The best rose soils appear to be those which possess from 8 to 12 per cent. or more of clay, and which are well supplied with other grades of the finer particles. The percentage of very fine sand, silt and clay should exceed 75 per cent.

Our experiments with roses were not continued as long as we should have liked, and the results have a limited value. Neither were our soils treated with fresh pulverized sod, as is customary, except in one case, where the addition of sod proved a great benefit. The presence of organic matter is important, and our best soil was the one in which the organic matter was well incorporated and decomposed. The soils which produced the most normal growth were those of a compact nature, and the freshly prepared soils gave better results than the old ones which had been used for growing various crops.

A NOTABLE ELM TREE.

G. E. STONE.

The American elm, as found growing in New England, is a tree unsurpassed in grace and beauty. It reaches its highest state of perfection in the river valleys where the soil conditions are well suited to its growth, and especially in the Connecticut valley, where the soil is largely composed of very fine sand and silt, and has considerable water-retaining capacity. The elm, however, will grow in very moist soil, although requiring for its best development a well-drained surface soil. While it makes good growth in almost any type of Connecticut valley soil, it reaches its best development in a soil in which coarse silt predominates rather than very fine sand. Our many years' observations on the elm have convinced us that it is quite susceptible to soil texture, and its freedom from various troubles is equally marked when growing under ideal conditions.

A somewhat notable elm growing near the college was recently cut down, and the opportunity was taken advantage of to make careful observations in regard to its age and growth. This tree is illustrated in the third edition of Emerson's "Trees and Shrubs of Massachusetts," published in 1878, and was at that time considered an exceptionally large and symmetrical tree. At the time of its removal, in 1911, it had lost none of its beauty and symmetry.

Measurements of the tree after it was cut down showed it to be 19 feet in circumference 1 foot above the ground; 17 feet 4 feet from the ground, and 8 feet above the ground, at a point just below the larger branches, it measured 21 feet 7 inches. Fourteen feet from the ground it measured 25 feet 5 inches.

The age of the tree, obtained by counting the annual rings, was found to be one hundred and thirty-one years, and the height, which was estimated after the tree was felled, was between 115 and 125 feet. The south and east radii showed the greatest development. This is not surprising, since the light conditions are 10 or 15 per cent. more favorable in the morning than in the afternoon, and there naturally occurs more photosynthetic activity and therefore more growth on the south-east side of the tree than on any other side. Careful measurements were made of the annual rings in decades by Sumner C. Brooks, and the results of these measurements, showing the grand period of growth, are shown in Fig. 1. By studying the

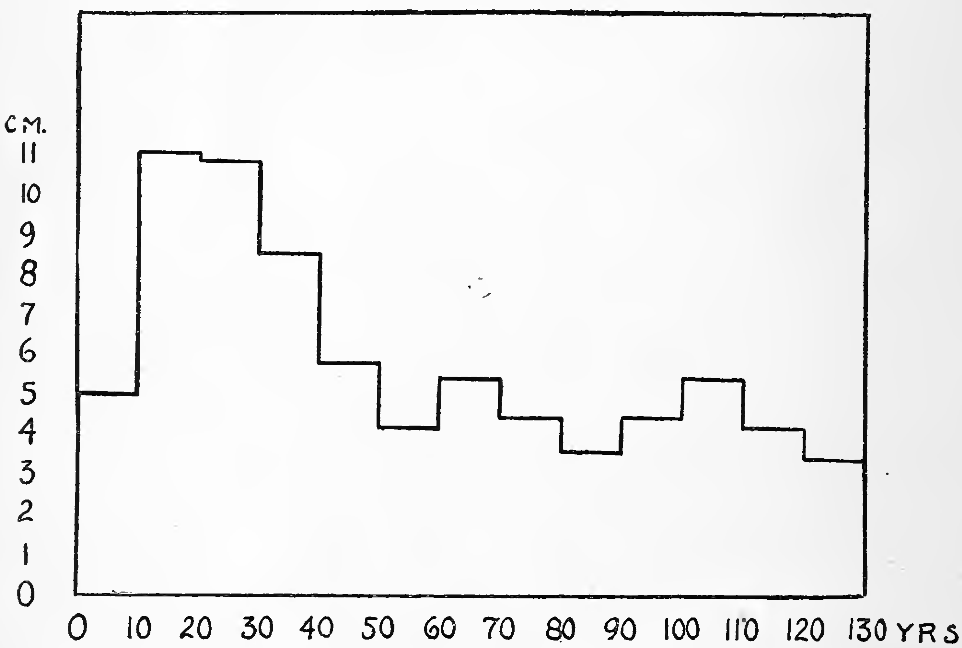

Fig. 1. — Showing grand period of growth of elm tree, *Ulmus Americana*, L. The figures on the ordinates represent centimeters, and those in the abscissæ, years.

curve it will be seen that the maximum period of growth occurred between the tenth and thirtieth years, following which there is a gradual decline in the decade growth, as might be expected. Even between the one hundred and twentieth and one hundred and thirtieth year the growth in thickness of the trunk indicated considerable vigor and was about two-thirds that which occurred between the first and tenth year.

There were a few small, dead branches on the tree, and a small split in one of the crotches of the larger branches. One of the largest branches also showed a more or less decayed interior resulting from lack of proper treatment, which should have been given years before; but the tree was practically intact at the time of its removal, and providing its root system was normal it was certainly capable of growth for many years to come, as was shown by its vigor at the time it was cut down. By the aid of modern tree surgery what few defects the tree possessed could easily have been remedied.

Table showing the Growth in Thickness of an Elm Tree, Ulmus Americana, L. Measurements represent the Growth of the Annual Rings in Decades.

Decades.	Growth in Centimeters.	Decades.	Growth in Centimeters.
0-10, ...	5.0	70-80, ...	4.4
10-20, ...	11.0	80-90, ...	3.6
20-30, ...	10.8	90-100, ...	4.4
30-40, ...	8.5	100-110, ...	5.4
40-50, ...	5.8	110-120, ...	4.2
50-60, ...	4.2	120-130, ...	3.4
60-70, ...	5.4		76.1

SOME OBSERVATIONS ON THE GROWTH OF ELM TREES.

G. E. STONE.

Trees like most plants, make different growths in soils of different natures, and many of them respond noticeably to cultivation. While no extensive experiments have been made to determine the effects of specific fertilizers on shade trees, it is well known that many varieties respond to such treatment. The elm is especially susceptible to variations in soil texture, requiring certain conditions for its best development. Dry, gravelly soil causes a spindling growth, and it is very often difficult to make young trees live in soils of this nature. Mowings are not at all favorable locations for elm trees, as the grass robs them of considerable moisture; and here young trees often succumb in the struggle for existence.

There are many elm trees on the college grounds which have been for the most part set out by the different classes, and in this immediate vicinity we have for some years had opportunity to carefully observe the growth these elms have made. For some time we have been making series of measurements at frequent intervals to determine the rate of growth under various conditions, and the results of some of these observations are presented here.

In two rows of elm trees running north and south and growing in soils of similar texture we find quite marked differences in the rate of growth. On one side of the road the trees have been in mowing land ever since they were set out, about thirty-two years ago, and on the other side they have been growing in lawn conditions for the same length of time. As the road was not very wide the roots of both rows of trees extended into the roadway, giving some of the roots similar conditions.

The rate of growth in circumference 4 feet from the ground of the trees growing on the lawn side of the road was 9 per cent. greater than of those on the mowing side for the same period, thirty-two years.

In another case, where the roadway was wider and the trees smaller, the difference was 36 per cent. in favor of the trees on the lawn for a period of twenty-two years. Here the soil was much drier than in the preceding instance, and the trees showed the effects of occasional applications of fertilizer to the lawn. However, there was a marked difference not only in the growth, but in the color and amount of foliage in the two groups of elms. The difference between lawn and mowing conditions is more prominent in dry than in moist soil, although it is possible for elms to receive too much water, as is proved by the following instance: —

Two rows of elms running north and south on either side of a wider highway were under practically the same conditions, except that one row was in a good soil underdrained and the other in a wet soil where the drainage was very insufficient. The difference in the growth in circumference of these 4 feet from the ground for a period of thirty years was 10 per cent. It should also be noted that the soil with the poor drainage had been cultivated a few times, while the other had not, but the drainage in the former soil was so poor that the trees made little growth and were stunted in appearance.

Elms growing in wet soils are invariably poorly formed, and seldom develop into good ornamental or street trees.

Exposure to light, as might be expected, materially affects the growth of trees. A row of trees located in mowing soil on either side of a narrow roadway running southeast, in thirty-two years showed a difference of 11 per cent. in their circumference 4 feet from the ground, in favor of the south or sunny side of the radii. No differences would occur with small trees when first set out, but when they grow large enough to shade each other there are differences in the rate of growth. Since these trees were planted close together and the roadbed is narrow, they shade each other at the present time, and have for some years past.

Trees grow in proportion to the amount of foliage they develop, as well as to the amount of light they receive. Those growing on the east side of mountains develop most on the east side, and those on the west side will develop most on that side of the trunk. We found 28 per cent. difference in favor of the east radii of some stumps growing on the east side of a mountain, and 8 per cent. difference between the east and west radii of trees growing on the west side of mountains. The growth of trees differs greatly according to the exposure; as, for example, on the edge of forests the growth is greater than in the middle of the forest, proving that light affects growth materially.

In the case of the trees on the east and west sides of mountains, they will receive sunlight during only part of the day, and their development will coincide with the amount of light they receive, as well as depending also on the side of the tree exposed. Since morning light is more intense than afternoon light, the east side of a tree will show the greatest growth, and a great many measurements of trees and of light intensity at different times during the day have shown us that the growth of the tree in one direction or another is directly in proportion to the light they receive.

In conclusion we might repeat that elms thrive better in pastures where the grass is likely to be scant, than in mowings, and lawn conditions are more or less favorable. They also respond to cultivation and treatment with fertilizers like any other crop.

DO WE NEED A SEED LAW IN MASSACHUSETTS?

G. E. STONE.

There has been considerable agitation during the past two or three years over a seed law for the State, interest in which has been shown by farmers and citizens in general. Some States have passed laws relating to seeds and have established standards for seed germination and purity, while others are seriously considering the matter of purity of seeds, and are attempting to establish laws to this end. The standards for purity and germination adopted by our different States are similar, but are so high that it is impossible for any seed dealer or extensive importer to live up to the law under the present system of handling seeds. The presence of laws on our statute books which no one can live up to is conducive to the best interests of no one; nor is it wise to bring seed dealers before the courts for selling as good quality seeds as can be obtained, and brand them as criminals or law-breakers. A law which cannot be enforced is worse than none, since it has a tendency to breed contempt for all law. A seed law which cannot be conformed to is bound to be broken, as certain crops have to be grown whether the seed complies with some arbitrary standard or not.

It is most unfortunate that the majority of the laws are drawn up from the seed analyst's point of view and not from that of the dealer or retailer. Too rigid seed laws are bound to prove very unsatisfactory in the end to seed importers and dealers, and if strictly enforced will prove of great disadvantage to the farmer. The best process of cleaning seed is not known, and it is also a difficult matter to grow clean seed.

The germination of seeds is greatly influenced by climatic conditions, and the percentage is by no means a constant factor from year to year. It is often impossible to obtain seeds anywhere in the world that will come up to the standard required for germination by these arbitrary laws, and the question is, "What are the farmer and seedsman going to do in such cases?" We are strongly of the opinion that the time is not ripe for a severe seed law, at least in this section, and we question whether it would not be better at present to restrain by publicity the dealer who persists in selling poor seeds rather than hold him to a standard impossible to comply with.

The seed situation in a nutshell is this: the purchaser has a right to know what he is buying, therefore the seedsman should give some guarantee of what he is selling. The sale of adulterated seeds should be prohibited by law, and if all packages of the more important varieties of seeds containing over 5 pounds were to have a guarantee label, and if samples were tested each year and the results made public through some official publication, the moral effect would be good.

Many of the State seed laws which have been adopted at the present time appear to us to be failures. A glance at the results of official analyses of seeds of various States which have these laws shows that a very large percentage do not come up to the standard, many being far from it, and prosecutions in these States are so rare that it is difficult to find them. We question very much whether the purity of seeds or the standard of germination have been very much improved in those States where these laws have been passed. If some of these laws were strictly enforced it would drive most of the seed dealers out of business, and many of them are of course very reliable and honest men. A great many, as we know from personal experience, take the greatest pains in selecting the best and highest grade seeds on the market, although of course there are many dealers who care little about the grade of seed they sell. They buy the poorest seed obtainable, catering to the farmer who wants to get seed as cheaply as possible, regardless of its quality. Here the farmer is largely to blame.

The seed laws passed up to this time expressly emphasize seed purity and germination. It is well known that these are by no means the most essential factors, and cannot be compared with such important considerations as strain, etc. The seed of a certain strain, even if it contains 10 per cent. impurities, is better than one that is pure and of an inferior variety.

The writer has studied the seed question from various points of view, — from that of the seed importer, the seed dealer and the farmer, — and is well aware that there are a great many difficulties associated with the seed problem which cannot be overcome by legislation. The importer, retailer and farmer are interested in the seed question, and the reliable dealer is anxious to put on the market as good seed as possible. We are of the opinion, however, that the matter is a delicate one, and whatever is accomplished in the line of legislation must be done cautiously and in a spirit of co-operation.

As already stated, the collecting of seed samples in the open market or from dealers each year would greatly improve conditions if these samples were analyzed and tested for purity and germination and the results published. A law requiring an approximate guarantee concerning the germination and purity of certain seeds, especially those sold in packages of over 5 pounds, would also have a salutary effect. We repeat that we do not consider it wise to load our statute books, however, with impractical laws; any restrictions relating to the sale of seed should conform to common sense. We cannot compel nature, by any form of legislation, to produce a definite quality of seeds each year; neither have we the right to ask dealers to accomplish what is impossible. Publicity, in our opinion, would constitute the best corrective for abuses.

DISEASES MORE OR LESS COMMON DURING THE YEAR.

G. E. STONE.

Like the preceding one the past summer has been exceptionally dry, and the heat has been intense at times. This drought, coming as it did after three or four previous dry seasons has affected vegetation to a considerable extent, and will result in later injury, especially to trees.

Some of the diseases which have been more or less common during the summer are as follows: black rot of cabbage and cauliflower (Pseudomonas), asparagus rust (Puccinia), bean Anthracnose (Colletotrichum) and celery rot. The cucumber Fusarium wilt described in our last report has caused much damage to greenhouse cucumbers, in many cases destroying the whole crop, and is serious at the present time. Experiments relating to the control of this disease are now being carried on, but the nature of the trouble makes considerable study necessary. A similar disease of tomatoes is also becoming troublesome, but it does not cause so much damage to the tomato as to cucumbers.

A new disease of tomatoes characterized by bacterial infection of the leaves has recently been brought to our attention, but at present we have found only one variety of tomatoes affected.

Many dahlias made a stunted growth this summer, and others were deficient in flower production. From our observations we should say that this condition was not associated with attacks of either fungi or insects, but was due to some abnormal feature causing a slow and stunted growth.

A peculiar instance of malnutrition was observed on corn. This was caused either by too heavy applications of fertilizer or wrong methods of applying it; or it may possibly have occurred from lack of rain needed to dilute or wash out the fertilizer; at any rate, the plants were yellow and sickly and the tissues were abnormally gorged with nitrates.

The epidemic of rust which has prevailed generally over the country during the past few years and which has affected plants usually immune in this region was not so severe this year. However, beans were affected to some extent, as were quinces and Vinca. The apple, ash and some other species were practically free from the trouble.

Some apple troubles have been somewhat common, while others have been less common than usual. The Baldwin fruit spot, which has been with us for so many years, and which has never been associated with pathogenic organisms, has apparently been superseded by a similar but more prominent and disastrous spot termed the "fruit spot." This has been very common not only on Baldwins but on Greenings and other varieties. The latter is characterized by much more conspicuous spots than the former, and a fungus termed Cylindrosporium is usually found associated with it. In one of the best orchards in the State we were able to find only two or three apples on a tree affected with this spot. In some other cases, however, it was much more common. On the whole, this trouble has proved rather serious this year, and as it appears to be controlled by spraying it may become necessary to resort to this in order to control it. Both spots seem to be associated with drought.

Many cases of sun scald were observed on apple trees during the year, both large and small trees being affected. Much of the scalding noticed was on the trunk near the ground. In some orchards which have been severely pruned, and the trees ploughed around and fertilized, more or less sun scalding occurred. This was noticed on unusually vigorous young shoots which are characteristic of trees handled in this way, and was due to the nonripening of the wood.

Potatoes were affected by the drought and to some extent by early blight. The severe fall rains caused attacks from late blight, and in some cases potato stem rot was reported.

Trees in general were affected to an unusual extent by a series of troubles.

Burning of conifers, including our native white pine, and various evergreens such as rhododendrons, arbor vitæs and others was the worst experienced in years. The loss to nurserymen and others from this cause was large, and it was very difficult to meet the demand for nursery stock of this class. Sun scorch was also common on the rock maple, and the young growth was generally affected by winter killing.

The chestnut disease, which has been with us now for four or five years, is spreading in some localities, but it should be borne in mind that every chestnut tree which appears sickly or dying is not necessarily affected with the so-called "blight." There are, in fact, many sickly chestnut trees as well as others which are showing no indications of blight, a feature which Dr. G. P. Clinton, of New Haven, has noted in Connecticut. The chestnut disease is the worst at present in the Connecticut valley so far as we can observe, and the question of preventive measures seems wellnigh hopeless, although not less so than the possibility of extermination in other ways. There is, however, some reason to believe that it will not prove as severe as further south.

Other trees, such as the elm, maple, some oaks and ashes, are at present in bad condition throughout the State. The large number of dying trees, particularly elms, which may be seen here and there is surprising even to a casual observer. The elm, to be sure, has many enemies, such as the leopard moth and elm-leaf beetle, but there are other causes responsible for their present condition. It is questionable whether it is advisable at the present time to plant elms as shade trees, and a number of other varieties are doubtful, but after many years of close observation on trees we have found one species which has stood the effects of drought, winter killing and other troubles better than all others, and that is the red oak. Prof. C. S. Sargent of the Arnold Arboretum has recommended this for many years as a shade tree, and although little used there are a great many reasons why it should be used more than it is. Under good conditions the red oak will grow as rapidly as the elm and maple, and its habit of retaining its leaves, which it shares with other oaks, gives it a rugged and picturesque appearance in winter.

In conclusion we might repeat that the past few years have been very hard on vegetation. The summers have been dry and the falls wet. Vegetation needs water the most during the growing season, and a superabundance in the fall is a menace rather than a benefit, as it has a tendency to develop tender shoots and prevent the ripening of the tissue. When the wood of trees does not ripen properly and is subjected to even ordinary cold, it sun scalds or winter kills, with disastrous results. The exceptionally dry summer and rather wet fall which we have just experienced have furnished ideal conditions for winter injury this coming winter.

INSECTS OF THE YEAR 1911, IN MASSACHUSETTS.

H. T. FERNALD.

No unusual destruction by insects has been observed in Massachusetts during the year which has just closed. On the other hand, many different kinds have contributed toward the loss which has been experienced, and several not usually met with have been in evidence.

The unusually hot, dry summer was of course favorable to the rapid increase of plant lice and the San José scale. Cutworms were also very abundant and did much damage, and the elm-leaf beetle was unusually destructive, though in most towns this pest is now quite well kept in check by spraying. It was first found in Nantucket this summer in small numbers, on five or six elms, near the center of the town, not, as perhaps might have been expected, on the trees nearest the wharves.

The leopard moth, *Zeuzera pyrina* L., is now present almost everywhere in eastern Massachusetts near the coast, and has even reached Nantucket. It does not seem to have worked its way far inland, however, and, as in other States, its injuries are most pronounced in the cities and larger towns.

The 12-spotted asparagus beetle, *Crioceris 12-punctata* L., which has been working its way northward, was taken at Concord and Roslindale near Boston in 1909. It was not observed at Amherst until last summer, which might indicate a more rapid dispersal along the coast than inward.

The cottony maple scale, *Pulvinaria innumerabilis* Rathv., has been unusually abundant in the Connecticut valley this year, many of the soft maples being so thoroughly covered with it as to have made little or no growth. This is the first time for several years that this insect has attracted any attention in the State.

In 1910 the white birches throughout New England were attacked by the birch-leaf skeletonizer, *Bucculatrix canadensisella* Chamb., and almost without exception the leaf tissues were entirely consumed. As scrub birch is so abundant everywhere in this part of the country much attention was directed to this insect, and many inquiries as to the likelihood of the destruction of the trees were received. During the past fall the insect was again in evidence, but to a less degree, only a small portion of the foliage being destroyed, and as a whole the greatest injury appears to have been in localities where the pest was least abundant last year.

The cut-leaved birches, so much favored as ornamental trees, have had a different experience. They have suffered equally with the native varieties, but in addition, for the last three years in the Connecticut valley at least, they have also been attacked by the bronze birch borer, *Agrilus anxius* Gory, and in nearly every case where this insect has entered a tree the death of the latter has followed, while the native birches have thus far appeared to be exempt.

The latter part of May some large chestnut trees in Amherst were reported as dying. An examination showed that they had been nearly girdled close to the ground, and full grown larvæ, pupæ, and adults of *Leptura zebra* Oliv. were found in the burrows.

For several years the elm-leaf miner, *Kaliosyphinga ulmi* Sund., has been present in considerable abundance. Last year this insect was less noticeable than in 1909, but during the past summer its work on Camperdown and European elms has been very noticeable. In many cases the parenchyma of all the leaves of the trees has been almost entirely consumed, and the trees have made little or no growth. Some facts which have been noted would seem to indicate that there are two generations a year of this sawfly in Massachusetts.

The work of the maple-leaf stem sawfly, *Priophorus acericaulis* MacGill., was quite noticeable in some parts of the State last spring. It had previously been noticed, but has evidently become much more abundant during the last year or two.

A specimen of the roach *Panchlora hyalina* Sauss. was taken near Amherst in a field at least half a mile from the nearest store. It is of course to be presumed that it came in on some tropical fruit, but it is evidently liable to fly some distance, and may therefore be met with almost anywhere.

During June the members of an elementary class in entomology at the college, interested in collecting insects, obtained a trolley car headlight with the requisite apparatus, and took it to a point where the local car line passes through a densely wooded area. There they established connections with the feed wire of the line and used the headlight to attract insects. The resulting catch included about twenty *lunas,* several *polyphemus* and *io* moths, besides a large number of smaller Lepidoptera, in a little over an hour. Several trials of this method gave extremely good results, and suggest the possibility of using electricity at places where moths are most abundant when trolley lines are properly located for this purpose.

On the 5th, 10th and 23d of June blister beetles were received from correspondents in Stockbridge and Williamstown which were evidently of the genus *Pomphopœa,* and which were kindly identified by Mr. Charles Schaeffer of the Brooklyn Museum as *Pomphopœa sayi Lec.* This insect has never before been received by the experiment station, and the data sent with the insects were of such interest as to be worthy of record. The Williamstown correspondent, under date of June 5, writes: "On the mountain ash tree where they were found there were about a quart." One of the Stockbridge correspondents wrote, June 10: —

Yesterday morning on entering my garden I found that these beetles had taken possession of the place. Every flower stalk had been eaten down and the iris and roses were fast being devoured. Lupins seemed to be the favorite and not one was left. The beetles seem to be drunk with the nectar, for they stuck to the flowers and we could easily cut the stalk and drop it in a pail of kerosene. We caught hundreds in this way. Later, in the afternoon, they seemed to have taken flight. There was a flight of about 300 on June 12, eating lupin, roses, syringas, iris, etc., eating the flowers and not the foliage. They appeared suddenly, over night. There was no special wind or other climatic conditions noticed. They were exterminated by hand, and after a heavy rain at night none appeared next day.

The other Stockbridge correspondent, on June 23, wrote: —

Three days ago I found these beetles eating the roses in the garden. They lighted, half a dozen or so, on one rose and devoured it rapidly. They were either so sluggish or so hungry that they were easily caught and the gardener drowned several hundred in an hour. Since then I have seen only a few scattered individuals. They seem tenacious of life, as specimens have lived three days in a box.

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