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DEVELOPMENT OF AGRICULTURAL EDUCATION

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The pioneer farmers of America had a double interest in life. First and foremost, they were pioneers, with all of the dangers and excitements of that pioneer life. Secondarily, they were farmers. It was hard and rude and unskilful, the farming in which they were engaged, but it gave them the necessities of life. When the first dull opposition of nature was overcome, when cabins had been built and woodlands cleared and the plow had in some way done its first work, the soil showed itself responsive and fertile enough. For a time, at least, life was easier. But the zest of pioneering was gone, and the more adventurous of our people soon moved on to the West, where they might feel the thin edge of civilization still cutting its earliest way through raw nature and barbarism, and know that that keen edge was their own life and endeavor. The farmers who remained behind were now farmers only and no longer pioneers. They saw the first rank fertility of the soil fall back into more moderate bounds. Their life became tame and binding. New wants arose with the rise of new social relations. A few in every community were able, by insight and energy, to keep still in the forefront of things in that new age, but for many the occupation which made up the greater part of their life had become an unpromising, uninspiring, unenlightened servitude. In this jubilee today we are to recall the ways in which new zest has been brought into the depressed life of the American farmer, the ways in which his farm has been made part of a new frontier, and he has been made once more a pioneer.

At first the improvement of our husbandry was the work of a

few men, and these were men whose interest in farming was, in large part, a public interest. George Washington was one of the earliest and one of the most influential of these. First in war and first in peace, he was also, it would seem, the first American farmer of his day. His outlook over the educational needs of the new nation included proposals for the establishment of boards of agriculture, a military academy, and a national university. Other statesmen with a care for agriculture and other farmers who were statesmen in their view urged that practical provision be made for the collection and dissemination of agricultural information. In the opinion of these men it was information that was chiefly needed—information regarding the experience and experiments of those who were already most advanced in the practice of agriculture—to insure the general improvement of the farming industry. The new awakening in European agriculture had great influence among the leaders of American agriculture at this time.

It was while we were still under the Articles of Confederation that a beginning was made in the formation of agricultural societies. Pennsylvania and South Carolina had established such societies before the adoption of the Constitution. New York, Massachusetts, and Connecticut followed during Washington's administration. The publications of these societies had begun to appear before the close of the eighteenth century, and agricultural fairs came into being in the first decades of the nineteenth century. Various endeavors to secure the establishment of a national board of agriculture had led, before the day that we here celebrate, to the first seed distributions through the national Patent Office, and to the first separate agricultural appropriation, in 1854.

Through these several movements, supplemented by a comparatively early development of an agricultural periodical literature, and through many later developments of agricultural organization, the growth of interest in the improvement of

rural conditions has long been actively fostered. But our attention today must be centered upon the development of organized agricultural education, and to that subject we will turn without any further delay.

Let us first note some bearings of agricultural education which have often been discussed, but must be considered here again in the interest of true educational perspective. Historically it has been found extremely difficult to bring the subject of agriculture into any manageable pedagogic form. The fact that everybody in the country knows something about it is at first a hindrance rather than a help. It is difficult to treat the subject in such manner as to avoid, on the one hand, an excess of platitude, a repetition of what everyone knows or thinks he knows, and, on the other hand, an excess of unutilized natural science, deeply interesting in itself but hard to apply on the farm. Certain other subjects, of which education itself is one, share in this handicap. It is a difficulty met with in European schools of agriculture, and it had not been overcome in Europe or America when the Michigan State Agricultural College came into being. The most effective training for manual occupations was still some form of apprenticeship, apart from schools, while the school had long held the foremost place in preparation for literary pursuits. How to combine, in one educative process, the advantages of the school and the advantages of the apprentice system was the problem of agricultural education. In one form or another it has been the problem of all our education for special occupations in the past half-century. For the student of educational history, then, this problem of agricultural education appears as one phase, and a peculiarly difficult phase, of the larger problem of training for any particular vocation in life. You will not look to me to contribute anything to the special history of this institution, which others, here on the ground, may be expected to treat so much more effectively than I could treat it. But my theme deals rather with the broader move-

ment of which the notable history of this institution forms a part.

It would be difficult to say just where and how systematic instruction in the principles of agriculture took its rise in this country. Such instruction was given in some sort in Moor's Indian school, out of which Dartmouth College arose, back even in colonial days. Benjamin Franklin proposed such instruction for the academy at Philadelphia, the forerunner of the University of Pennsylvania, but it does not appear that this part of his plan was realized. In the 20's and 30's of the nineteenth century great interest was excited in the so-called manual-labor schools. It was proposed that a farm be attached to the schools, and that those who were studying during a part of the day should engage in ordinary farm labor during another part of the day. The purpose, to be sure, was primarily to provide a way by which students might "pay their way" through school. But there was a thought, too, of instruction in the better methods of farming, and at least a vague dream of something better yet, the vital union of thought and manual toil. Some of the old-line colleges showed at least good-will toward the scientific aspects of agriculture, Columbia even establishing a professorship under which agriculture was ranged alongside of other sciences. Then just at the middle of the century, the state of Michigan provided in its constitution of 1850 for the establishment of an agricultural school, and seven years later this institution, the first of its kind and grade in the United States, was ready to enrol its first students. Pennsylvania had already incorporated its Farmers' High School, but it was preceded by two years in the actual opening by this State Agricultural College of Michigan. A little later in that same notable year, 1857, Justin S. Morrill of Vermont first introduced his measure for the endowment of agricultural and mechanical colleges in the several states by the national government.

What is especially worthy of note at this point is the fact that

this movement, which was primarily a movement of the people or rather of the leaders of the people, found parallel embodiment in both state and national legislation. At first both the states and the nation moved but slowly and tentatively. But within a few years large beginnings had been made. In this, as in other public interests, within the broad limitations of the national constitution, working adjustments of state and national agencies to each other have been made from time to time, in view of practical needs rather than of academic theories.

The great, epoch-making act of this whole movement was undoubtedly the Morrill Act, which finally reached its passage when civil war had lent new power to the spirit of nationality in the national legislature. In signing this act, on July 2, 1862, Abraham Lincoln, that "new birth of our new soil," that surveyor of western lands, who was to drive the labor of slaves from our American fields, now joined his work with that of Washington, to make our American tillage the doing of men made free by knowledge and enlightened skill.

By the Morrill Act of 1862 the national government gave aid to the states, in the way of liberal grants of lands; it encouraged the states to do in their own several ways the work of higher education in the domain of agriculture and the mechanic arts. While technical studies were brought to the front in this act, it refused to draw a line of opposition between those technical subjects and the training which makes for liberal culture. And both technical and liberal training were joined with preparation for the defense of the nation's life.

Other important acts soon followed: That establishing a national department of agriculture, in 1862, which department was raised to cabinet rank in 1889; and that establishing a department of education in 1867, which department was reduced to the rank of a bureau in 1869. In their different ways, these two government offices have both had to do with the administration of the later acts for agricultural education; and

I think I may add that on their effective co-operation depends the full realization in the future of the high purposes for which those acts were passed.

After the Civil War the establishment of agricultural colleges went steadily forward till such institutions, aided by the land grants of the general government, had been erected in all of the states, with eventually sixteen schools for colored students added in the southern states. The association of these colleges was organized, the Hatch acts brought new aid from the general government for the maintenance of experiment stations, the second Morrill Act added its large federal appropriations for the furtherance of the ordinary work of the colleges, the summer graduate school was organized, the Adams Act provided for advanced research in agriculture, and finally the Nelson amendment to the agricultural appropriation bill of 1907 has brought still larger financial support to the colleges, together with permissive provision for the use of a part of the federal grant in the training of teachers of agriculture. It is a record of notable advance, and we can hardly doubt that the great heart of Washington would have been glad to see the results that we may see today.

When we attempt to interpret the course of this educational development and to plan for further advance, we need the help of some general conceptions relating to our social organization. For it is evident that agricultural education cannot be a thing apart and alone. Its real and lasting strength is to be found in its connection with general education. And the strength of general education and of all of its special developments is to be found in the connection of the schools with the real life of our people.

Passing over all other views of our democracy, however essential and interesting they may be, permit me to call attention just now to the function of those who are called leaders in a democratic society. For we now commonly recognize the fact

that democracy does not dispense with leaders, but rather makes the strongest demand for positive leadership. But in such a society it is not for one individual or one class simply to lead, while another class simply follows. The true leader in a democracy is one who, while leading in all reality, is capable of learning from his followers. And the followers of such a leader in a true democracy are not those who follow because they do not think, but those who follow because they think and are able to recognize their leader. They follow because they are convinced. So our whole social fabric is made up of leaders who must learn if they would continue to lead, and their peculiarly restless and skittish constituencies. Here as everywhere the relation of leaders to constituencies is permanent and essential, but within that permanent relationship there is continual interplay and shifting of parts. It is a normal condition with us that those who have the subordinate part should be increasingly intelligent, critical, and ready to assume the actual leadership.

This is the state of things that our system of education fosters and must continue to foster. It must bring forth scientific experts who shall be able to teach the people the principles underlying the arts of life, and it must train up a people to make for the expert an intelligent constituency, quick to seize on all that he may offer for the betterment of their practice, and quick to reject those suggestions that they cannot put to use. So our public health rests upon the co-operation of highly trained experts in medicine and sanitation and a people who can act intelligently upon their directions and regulations. So our public and domestic architecture is improving slowly—very slowly—through the co-operation of architects who know their art and a building people who know their architects, and who follow them in part and frustrate them in part. So, too, our agricultural education must proceed. There must be training of the highest sort for our agricultural experts. More than that, at the topmost reach of our agricultural education there must be that which is not

commonly recognized as education at all, the pure research of the pure scientist. For no education can continue to be really alive unless it draws directly, from some source of new and abounding knowledge, a fresh supply, never yet handled and made common among mankind. It may be very little that any year or any age may have to give that is altogether new, but that little will sweeten all the rest. Then our system of education must reach down to schools of the lowest grade, the little country schools, in which the capable constituency of the great experts is to be trained; and there, too, some of the future leaders are to make their first beginnings. The most of those in such schools are to live by the practical art of farming. But in these days they are to have the skill to take the science of the scientist and transform it into the art of their lives. They are to read agricultural bulletins and understand and use them. They are to pick their way and keep from being mired in the mass of such literature now provided for their reading. They are to attend institutes and conventions, where they will listen with discrimination to long and learned papers, and make short and pertinent speeches of their own. They are to find the farm interesting in the highest degree, because of new hopes of profitable production which it offers and because of its connection with the great world of ideas.

When we grow more skilful, we shall make elementary schools of a better-rounded type, in which the book-learning that has long been the distinctive province of the school shall join to itself the best things in the old system of apprenticeship; and from that combination shall arise something better than either one in its lonesome isolation. Already we are beginning to make institutions somewhat of this order, and it will be done much better yet as time goes on.

This, then, is what we may see as the ideal, in agricultural education and equally in education of other kinds, and perhaps of every kind: A system of schools complete in its sequence

from the lowest to the highest, in which the study of books is closely joined with training for some of the practical arts of life; in which all practical training is kept in vital touch with general education; in which the ability to form sound and stable judgment is sought throughout as a thing of very great price; in which the higher schools send into the lower schools an unbroken succession of teachers who both know the truth and are able to bring others to a knowledge of the truth; and in which, finally, the stream of knowledge fresh and new, from some department of pure research, shall never fail to keep fresh and bright the old wisdom of the ages gone before. Or, in more concrete statement, our elementary schools and high schools in country communities are still to be primarily schools of general education, but with much more of training in the arts of the farm, and the sciences lying near to those arts; our state colleges of agriculture and mechanic arts are to prepare young men and young women to read intelligently the literature of scientific agriculture, to form independent judgments in agricultural matters, and to bring their new knowledge into connection with the real work of the farm; these state colleges, moreover, are to provide well-trained teachers of agriculture and related subjects for the elementary and secondary schools; the colleges of agriculture, still further, are to be co-operative educational institutions and not merely special and local institutions—they are to co-operate with similar institutions in other states, in order that the work of one may be strengthened by the work of all, and co-operate with the universities of their several states for the innumerable advantages to both which may come from such united effort. The National Department of Agriculture is undoubtedly to continue its remarkably wide and influential work, its expert investigations, the issuance of manifold and vastly useful publications, and its furtherance of all manner of agricultural education and research in the several states. Finally, the Bureau of Education is to do as thoroughly as possible the part of this work

assigned to it. I venture the hope that with enlarged resources it may do more than it is now expected to do, and that without trespassing on the proper field of other institutions.

Let me speak a little more particularly of the part of this program which falls to the education office of the general government. It can do its best work, I think, as a co-ordinating influence. It can bring to the notice of the less favored institutions information concerning the experience of more advanced institutions. It can call attention from time to time to the relation of agricultural education to general education. It can survey the educational field and possibly point out dangers to be averted or weak places to be strengthened. It can, finally, discover things that need the doing and are not attended to by any other agency, and can see that some part of such lack is supplied. So much as this I hope the Bureau of Education may be able to do for our agricultural education. And so much as this I may say it will undertake to do as far as its resources will permit.

Just at this time, a survey of the field seems to show that the paramount need is the need of a supply of qualified teachers. Arrangements have already been made for the publication in the fall of an issue of the *Bulletin of the Bureau of Education* devoted to the present condition of the agricultural and mechanical colleges, and particularly to the ways by which teachers may be trained in those colleges to meet the needs of high schools and normal schools in which agricultural subjects are taught. A preliminary account of the history and present condition of agricultural education throughout the world is to appear in the near future, in another issue of the *Bulletin*, which will, it is hoped, be of help in such training of teachers and a help to those teachers who are already in the field.

In conclusion, the view cannot be too strongly stressed that all of this agricultural education is a contribution to the general education of the American people and to the betterment of

American life. You who celebrate the fiftieth anniversary of this institution realize, as the history of this College has shown, that it is not simply larger crops and better breeds of stock and a more profitable output of farm manufacture for which you are laboring; but through these means and through all other interests of the modern farm, you are working for the improvement of American citizenship, and that with special reference to the needs of this great state of Michigan. May you long continue to serve the commonwealth and the larger republic as faithfully and as successfully. And may every good cause in this land feel the reinforcement of a wholesome and vigorous life in the homes of our country communities, which have been made more prosperous homes and better homes because of the work that you are doing here.

THE DEVELOPMENT OF ENGINEERING EDUCATION IN THE LAND-GRANT COLLEGES

WINTHROP ELLSWORTH STONE

It is matter of conjecture as to how far Senator Morrill and his colleagues foresaw the great and true significance of the now famous act of Congress establishing the land-grant colleges. That it was to become the actuating force in a new educational movement, and that it was to influence the industrial and commercial growth of the nation profoundly, were generalities in which its advocates undoubtedly believed without being able to conceive of the details of their operation. The rapidity with which these institutions have sprung into commanding positions, have overcome prejudiced opposition, and have won public confidence and respect must have been beyond the comprehension of these men, for never in the previous annals of education has anything of equal or similar character or extent been recorded.

But now, after the passing of little more than a generation, he who would chronicle the manner and extent to which these land-grant colleges have developed in respect of the single department of engineering education finds himself—so extensive is the subject—dealing with the leading facts of the times in regard to education, applied science, and industrial and commercial progress.

The impulses set in motion by the passage of the Morrill Act have developed, in a remarkably short time, a new education; have achieved great popularity and influence; have appealed to the democracy; and have proved its inestimable value to the industries. As is well known, the act, while remarkably broad in its scope, specifically emphasizes two principal lines of educational effort, viz., in "agriculture and the mechanic arts," and,

properly, these colleges have from the beginning in accordance therewith expended their energies mainly in these two industrial fields.

My duty at this time is to set forth what has been accomplished by the land-grant colleges in the sphere of mechanic arts. In this discussion I shall broadly include all of those institutions receiving state or federal support, in which engineering is taught, since with few exceptions the state universities and colleges engaged in engineering instruction are also beneficiaries of the Morrill Act.

It is worthy of note that, in nearly every instance, the demands upon these colleges for instruction in "mechanic arts," especially in the earlier days, have greatly exceeded those for "agriculture." The aggregate enrolment of students of collegiate grade in engineering courses in these institutions has been many times greater than in courses in agriculture. Frequently the representatives of agriculture have shown impatience at these conditions, ascribing the inequality of attendance in these departments to unfair discrimination on the part of the college management. The real causes, however, seem to lie elsewhere. Instruction in engineering was earlier and better organized as regards pedagogical form; the industries included under mechanic arts have had a better appreciation of the value of technical training; there has been and is a tendency among young people to regard agriculture unfavorably as compared with other pursuits; and, finally, the recent extraordinary developments in manufacturing, mining, and transportation have created a great demand for men trained in the mechanic arts, which no inducements in the field of agriculture could match. The rapid development of engineering education, therefore, has obeyed the influence of distinct public needs and demands to meet which has given college authorities no end of difficulty and which, under these conditions, they certainly have had neither power nor desire to stimulate.

The conditions which have been less favorable to agricultural education are now, happily, disappearing and there can be no doubt that the agricultural courses in the land-grant colleges are soon to become quite as popular, attractive, and effective as those in engineering; a situation which I am sure will be welcomed by everyone who desires to see these colleges fulfilling their original purpose to the highest possible degree.

In endeavoring to trace the development and present status of these engineering schools, one soon is impressed with the fact that he is dealing with practically the whole history of engineering instruction in America, and, next, he realizes that this record constitutes an important part of the world's progress in this field. In fact in the essential development of engineering education the land-grant colleges, in their various forms of organization, have always been foremost and in the aggregate are today the principal exponents of this phase of education.

Systematic instruction in engineering science is a recent thing; it is a constituent part of the remarkable development of industrial and technological training which is recognized as the principal educational event of the last half-century. It is true that some isolated and vague experiments in this field were undertaken nearly a hundred years ago, but an estimate of the scope and value of these efforts may be had by considering how imperfect was the existing knowledge of pure science until well into the nineteenth century, while the applications of these sciences to the arts and industries were scarcely recognized, much less organized into any pedagogical system, until very recently. With two or three exceptions[1] there was in America no organized attempt at engineering instruction prior to the Civil War. Contemporaneous with, or following, this period came three epoch-making events, each of which was in itself of great importance but which, in conjunction, have wrought an extraordinary national

[1] Rensselaer Polytechnic Institute, founded in 1824; the Lawrence Scientific School, in 1846; the Sheffield Scientific School, in 1847.

influence upon education and industry. These events were: the establishment of the land-grant colleges; the great wave of scientific discovery and invention; and the remarkable commercial and industrial development of the country. Under these conditions the growth of engineering schools has been little less than remarkable.

In claiming thus for the land-grant colleges a considerable degree of prestige on account of the development of engineering education, I am not unmindful of the great contributions to progress in this field made by other institutions. For this all due credit should be given. Nevertheless, if one could conceive of the annihilation of what has been done and is being done in the land-grant colleges in engineering science, the loss would involve, I am sure, a very large part of the present possessions of engineering education in America, if not of the entire world.

That this should be so is, after all, quite natural. If anything less had been achieved upon this special foundation and in the stimulating industrial atmosphere of America, our institutions would be blameworthy indeed. The conditions have been unusually favorable and, in general, they have been utilized with marked success.

This development has been on characteristic and, in some respects, unique lines. Because these institutions were new foundations—for the most part—they were free to build new structures untrammeled by conventionalities and free from useless imitations. Just as our engineers are notable for their initiative, adaptability, and resourcefulness, so our engineering schools have met and solved problems on the ground, in a practical way. Without ignoring what was of value in previously existing systems, they have been free to strike out in new lines. Wisely, they have from the first endeavored to adapt their methods and scope of instruction to the distinct needs and conditions of our industries. This policy has evoked much sharp criticism

as to its real educational value, but the schools have gone steadily on, creating a new education with a new spirit; winning the confidence of the commercial world; and becoming the chief bulwark against the growing prejudice against "the college graduate." Recognizing that engineering is an intensely practical profession, they have sought to impart a training which should develop in their students the power to do things effectively, in the belief that this is the modern criterion of education. To these established characteristics of originality, adaptability, thoroughness, and efficiency, our engineering schools undoubtedly owe their high standing, popularity, and the confidence of the professional and technical world.

Since these institutions by reason of their origin and functions form a class by themselves, it is important to classify and enumerate their features of organization, method, and curriculum, which constitute the present basis of engineering education in this country.

The institutions are for the most part of collegiate grade, receiving students from the secondary schools and administering a full four-years' course upon the completion of which a variety of degrees of the bachelor's rank are conferred. With few exceptions, the land-grant colleges are coeducational and women students are occasionally found in the engineering courses. A few have been known to graduate, but of their subsequent careers the engineering chronicles are significantly silent.

Measured by the conventional standards established by schools of liberal arts, the requirements for entrance are not high, varying in different parts of the country from six to sixteen high-school units. In many instances these requirements are higher than for the agricultural school in the same institution. As a rule, in any given part of the country admission to the engineering school is practically on the same basis as to the college of liberal arts, although usually not identical. The authorities are agreed, for the most part, that in state institutions

it is unwise to require preparation which the average public schools of the community cannot supply. Nor is it the practice to include Greek or Latin in these requirements. Weight is laid chiefly upon English, mathematics, and the sciences, as being directly necessary to the work of the engineering courses. In other matters, the engineering schools have not been bound by the practices of others, but in their entrance requirements have given consideration to the educational opportunities and needs of the industrial classes. On the other hand, they recognize elements of training and preparation which are quite ignored in the purely academic requirements for colleges of liberal arts. It may be claimed, consistently, that entrance requirements to engineering schools should differ from but not be of lower grade than those of colleges of liberal arts. Everyone knows that book knowledge alone does not give power and efficiency, and it would seem that in standardizing entrance requirements to engineering colleges some weight should be given to the maturity and experience of the applicant. In short, our engineering schools are coming to recognize that a valuable part of the preparation for an engineering course may be obtained in the field, shop, or office, and cannot be measured in high-school units alone.

The curriculum of our engineering schools is characterized by the weight given to mathematical, scientific, and technical subjects in contradistinction to the classics and humanities, although in all of these there is an evident purpose to retain in the course of study as much as possible of the cultural elements. English, the modern languages, history, and economics are for this reason given much weight. The physical and chemical sciences, mathematics, shop practice, and drawing are the fundamentals of engineering education, and following these in sequence come the subjects of mechanics, machine design, thermo-dynamics, hydraulics, and the various specializations pertaining to the different branches of engineering practice.

The student has little choice of subjects in any given course, for the elective system is unsuited to the mastery of a logical sequence of facts and principles. The curricula of engineering courses are, therefore, almost exclusively prescribed. There is, moreover, a characteristic blending of the theoretical and practical. A knowledge of the hypotheses and theories of pure science is fundamental to the training of an engineer, but they are valueless to him unless their applications are traced. Naturally the laboratory has a large place in this scheme of instruction. It is necessary that the student have contact with and an intimate knowledge of the machines and materials with which he is later to deal. The laboratory courses and equipment are, therefore, striking characteristics of our engineering schools. In chemistry, physics, electricity, steam engineering, shop practice, material testing, hydraulics, and drawing each student must be supplied with a work place and equipment for the study of the actual phenomenon or object under consideration. The shops and laboratories of a modern engineering college have all of the aspects of a commercial establishment, and contain types of the real machines and materials of commerce. These methods and equipments are responsible for the costliness of engineering education in marked contrast to courses in liberal arts.

From the nature of the subjects taught, the standard of scholarship in our engineering schools is high. The predominance of mathematical subjects; the accuracy of observation and statement required; the analytical character of much of the work render it impossible for a dull man to succeed. These schools are not training mechanics or skilled workmen. Manual dexterity is important and a knowledge of practical operations is essential to the engineer, but his power lies in his capacity to organize and utilize forces and materials, and his training is intellectual rather than manual. The actual expenditure of mental effort required of the engineering student is, I believe, quite exceptional, for the successive steps of advancement to

which he must attain are fixed and absolute; they involve the exercise of opinion and criticism but slightly; they require rather a definite knowledge of facts and their application which permits of no error or half-knowledge. High standards must be maintained, for the graduate must, ultimately, sustain the most exacting tests in practical experience. Nothing would more speedily destroy the efficiency of engineering training than low standards of scholarship.

The scope of engineering instruction is as broad as the country itself. In all of the schools the general principles and fundamentals are taught, but beyond this is a wide variety of development into special lines related to sectional or local interests. Civil, mechanical, and electrical engineering are the subjects most commonly presented, but several institutions offer courses in mining engineering, while sanitary, municipal, and chemical engineering and architecture all have honorable place in the list. Certain institutions offer instruction also in engineering principles as specially applied to sugar-making, irrigation, forestry; marine engineering is also taught in one or two schools, and there is an interesting and increasing development of engineering instruction as applied to farm machinery and operations—which is perhaps best designated as farm mechanics.

The extent of the courses of instruction in engineering is, in point of time, usually four years, of which the first two are spent upon the fundamental and general subjects, and the last two upon those which are special and technical. Among other usual requirements for graduation is the completion of an original study or investigation, the results of which are presented in a "thesis." The graduate receives in most cases the degree of "Bachelor of Science," which is frequently further qualified with reference to the particular line of study pursued. A few institutions give professional degrees, such as "Electrical Engineer," "Civil Engineer," etc., for the completion of undergraduate courses; the larger and better equipped colleges also administer

graduate courses, for which advanced degrees are granted. In a few instances, the honorary degree of "Doctor of Engineering" has been given.

By no means a minor phase of the work of these institutions is that of research and investigation. Countless problems present themselves in connection with every industry, in regard to the improvement of methods, designing of apparatus, use of materials, fixing of standards, etc., and for information on these matters the public applies with confidence to the engineering schools. Scientific and technical literature teems with articles from teachers and students of engineering, and many of the contributions to knowledge from this source are of national, or, indeed, world-wide fame.

Having thus briefly outlined the present methods and work of the engineering schools, I would broadly characterize their distinguishing features to be: First, an adaptation of instruction in theory and practice into a course of training which is at once of high educational value, and of special application to practical affairs; and, second, the high efficiency in turning out a product which commends itself to practical men, and which is ready for immediate participation in the work of the world.

WHAT HAS BEEN ACCOMPLISHED

The immediate products of these schools are thousands of young men trained in accurate, scientific methods of thought and study; skilled in the application of scientific principles to practical affairs; and grounded in the fundamental principles of engineering work. That there exists a great demand for young men of this type in all kinds of manufacturing and productional enterprises immediately makes clear that to the individual this kind of education is profitable because of the good market for his accomplishments, and not only is the immediate opportunity for the young graduate exceptionally good but the way is open to a career of great responsibility, influence, and remuneration.

On the other hand, the value of these trained forces to the industrial and commercial interests of the country cannot be overestimated. There could be no continuous development or progress without these trained men and, though the graduates of these schools are still young, their influence upon methods, practice, and operation is already an important factor in our country's development.

A further result of this breeding of trained engineers is to educate the public to a better appreciation of the value of the application of scientific study and methods to all business and industrial operations. The development of this understanding is altogether significant. A few years since, any young man who based an application for a business position on the fact that he was a college graduate would probably have been treated with contumely. Now all of this has been changed, and it is the ordinary experience of engineering schools that all of the members of their graduating classes are sought for professional positions before they have received their diplomas. This broader appreciation of the value of trained men and of the application of scientific methods means true progress in our industrial and commercial development. It means better public utilities; higher factors of safety and health; and cleaner, saner, and safer living for the whole people.

Still further, and quite aside from the professional and technical influence of the graduates of these schools, I regard it as not presumptuous to claim for them a citizenship of high quality. I claim that no other training is likely to breed so genuine a contempt for shams and hatred of dishonesty as the engineering training, and that no other class of men are so likely to stand for right principles in the administration of public offices as well as for private honor and honesty. Of course there will be exceptions to this rule, but if there is anything in dealing with the immutable laws of nature; anything in the engineer's conception of accuracy likely to develop respect for law and sincerity

of purpose, then the training which the engineer receives cannot but have its corresponding effect upon character.

Finally, among other results of the work of engineering schools, we may not ignore the actual contribution to technical and scientific knowledge made through investigations and researches carried on in the laboratories of their institutions. These investigations relate to every possible phase of the production and utilization of power, the performance of machines, and the characterization of the physical properties of materials of construction. To illustrate more fully what is meant by this statement, I may point out that a generation ago it was the exception that any machine was constructed or purchased on a specification as to its efficiency of performance, or for any material of construction to be supplied on a specification of qualities. Now the effort is to base all transactions upon a specification of quality or efficiency based upon accurate scientific tests. For instance, no one now buys a steam boiler except on specification of its evaporative efficiency, or steel, except upon specification of its strength, or paint, or coal, or cement, except upon certain guarantees of quality, and even the physical characteristics and qualities of timber are now being determined and fixed in engineering laboratories as a possible basis for future use in this way. The work of determining these standards, of devising methods of testing, of accumulating the vast data of reference, and of actually carrying on these tests and determinations has been the contribution of our engineering laboratories. How vast this is and to what an extent it controls and improves engineering practice can be imagined, but scarcely comprehended. In the great engineering societies, engaged in promoting and fixing engineering standards, the teachers and graduates of engineering colleges are prominent and, through these channels, exercise their influence on professional practice. Another important contribution from the teachers of engineering has been the development and organization of the material of instruction.

A generation since, scarcely anything had been done toward systematizing engineering instruction, but during this time curricula have been perfected, texts written, laboratory experiments devised, and the entire plan of teaching brought to a high degree of efficiency.

These facts indicate that the work of the engineering schools of the land-grant colleges has been quite as extensive, valuable, and useful in its way as has ever been accomplished in any educational field in a like time. Indeed, in view of their rapid development and the extraordinary contemporary interest in technical affairs, probably no other schools have exerted so great an influence in so short a time.

WHAT IS TO BE THE FUTURE DEVELOPMENT OF OUR ENGINEERING SCHOOLS?

Up to this time, engineering instruction as an organized force of education has been occupied with laying foundations; with systematizing and developing its teaching; with preparing texts and lectures; and with the adaptation into teachable form of an enormous mass of material. It has been burdened with the demands for practical men. It has been called upon to solve problems; to supply men; and to meet the exacting demands of an unparalleled commercial and material development. Much of this work has been, of necessity, of an elementary character because of the absence of any other agency to perform it. The requirements growing out of these conditions are now being fairly well met in the various engineering colleges. We shall probably next see a differentiation of this instructional work by which the elements of engineering and industrial training will be administered in industrial, trade, and manual-training schools. In this way, the opportunities for this kind of training will be greatly multiplied and made available to far greater numbers of students than at present, and the general effect of this upon the public will be vastly beneficial. The engineering schools

will then be free to devote their resources to instruction and research in the higher branches of technology.

A logical step in this direction will be the establishment of bureaus or laboratories devoted entirely to investigations of engineering problems and the fixing of standards. I believe we shall come in this way to the engineering experiment station, the analogue of what has now become so important an adjunct of agricultural instruction, namely, the agricultural experiment station. One state[1] has already established such a research station with generous financial support. There can be no logical argument advanced for the agricultural experiment station which will not apply with equal force to the engineering station, be it on account of the important interests involved, the problems inviting solution, or the industrial value of such an institution.

In conclusion, one cannot contemplate the developments of these institutions without a feeling of pride in their achievements and a conviction that the phase of education which they typify is destined to become more and more important in America. The essential basis and foundation of a nation's welfare is to be found in its industrial conditions. It is true that those abstract qualities which contribute to national greatness and patriotic citizenship are the offspring of ideals rather than of material things, but these can never come to their fullest fruitage without that substantial foundation afforded by rational and well-balanced industrial forces. The highest development of national ideas is like a flower whose beauty is unfolded in a clear atmosphere, while its roots find anchorage and nourishment in the fertile stratum of an intelligent industrial democracy. True industrial progress consists in utilizing with ever-increasing economy and accuracy natural forces and materials, in more scientific methods of operation and management, in securing

[1] The University of Illinois established an engineering experimental station in 1903.

better conditions of life for industrial workers, in furnishing products of better quality at lower cost, and in narrowing the gap between the employer and the employee. Education alone can accomplish these things, but it must be an education which reaches the industrial classes and applies to industrial conditions, and this is the true aim and spirit of our land-grant colleges.

THE AUTHORITY OF SCIENCE

WHITMAN H. JORDAN

As a prologue to the subject that I have assigned myself, permit me to present to the officers and students of the institution whose guests we are, my greetings and felicitations. This is, indeed, an occasion for well-deserved congratulation and praise. We are assembled within the borders of an institution that for fifty years has rendered distinguished service in a new field of education, and there are some features of this service which merit generous and grateful recognition.

To the trustees and faculty of this College, I would say that it is a notable achievement to have taken a leading part in building new avenues along which knowledge has approached more closely to human needs, especially when to do this in the face of unbelief or of dogmatic opposition has required on your part a tenacious faith and an abiding courage. At the same time you and your predecessors have manifested a spirit of rational and safe conservatism. While your College has departed widely from the curricula of the older institutions, it has held fast to the great truth, the soundness of which can never be successfully assailed, that the only way to uplift any industry is to develop among those who are engaged in it not only technical knowledge and skill, but intellectual and moral force. To this end the vagaries and educational poverty of extreme specialization have not been allowed to seize upon your courses of study. Evidently you have not believed that "intensive knowledge" of one subject compensates for "extensive ignorance" of everything else. It is clear that you have not been willing wholly to subordinate to his vocational skill a man's intellectual and social well-being. This

much of the faith and practice of the fathers has remained with you. May you never lose it!

I suspect that your wise conservatism has been due partly to the fact that you have had among your number great leaders and teachers who have been both expounders of truth and centers of inspiration. Two of these I came to know a quarter of a century ago, one of whom, ripe in years and full of honor, has entered into his rest. The other with unabated zeal for truth and undiminished loyalty to your interests is still your beloved associate. Evidence of the influence of these men and of the policy that they helped to sustain is seen in the remarkable number of the sons of this College who, in all parts of the United States, are occupying positions of honor in the field of agricultural science as teachers and investigators.

I congratulate you on the record of fifty years. As a fitting commemoration of the spirit and influence of your honored institution and as pointing to the true philosophy of all education, I would that in passing we might pause to erect a wayside altar and, in characters so bold that he who runs may read, leave on it this inscription: *What man is determines what man achieves.*

The suggestive title of a recent book written by a distinguished graduate of this College is *The Outlook to Nature.* This volume, that fifty years ago would not have been well understood, is symptomatic. It worthily expresses a trend of thought in education and in practical affairs that is one of the most noteworthy features of the present time. Man is just now very busy discovering himself and his relations to the physical world. He is studying and mastering his environment as never before. The rise of institutions of investigation, the crowded state of university and college courses in the sciences and their applications, university-extension courses along popular scientific lines, the wide attention given to nature-study, the many assemblages of farmers for the consideration of subjects semi-scientific in their character, and indeed the knowledge applied to our whole

economic progress, are convincing evidences that the outlook to Nature's methods is earnest and widespread.

The serious side of this world-wide movement is the conviction that science is a trustworthy guide in directing our activities. In all ages man has been prone to seek the guidance of authority. He listened in faith to the prophets, sought the counsel of the ancient oracles, accepted the dogmas of the church as arbitrating all truth, both temporal and spiritual, and has been the dupe of the necromancer and the faker. But now we have turned to science and, excepting in things spiritual, it utters the final word. To be sure there are still those who scoff at the scientific man as unworthy of confidence, sometimes with good reason, but on the other hand, many trust him over much and behave toward his utterances as though they are infallible. Comparatively few use knowledge in a discriminating way; indeed few are qualified to do so, for in this, as in many other weighty matters, the masses walk by faith and not by sight. If, then, science is the oracle of today, what a grave responsibility attends its teachings! He who assumes to interpret Nature must reckon not only with truth but with his fellow-man whose welfare is to be safeguarded.

This is more than a fancied obligation. Science has come to be closely concerned with the large affairs of human life and activity. It lays its compelling hands upon Nature's great forces, directs agriculture and the industries, designs machinery, builds bridges, protects health and prolongs life, feeds the intellect, is a theme for literature, and essays to invade the great mysteries of religion and the future life. Its conclusions guide our vocations, are the dicta of the classroom, and are proclaimed as truth from the platform and pulpit.

How intimately, too, has science laid hold upon our individual lives! It has greatly increased our comforts and intensified our pleasures. Whether we travel abroad or abide at home, we are the subjects of its beneficence. Indeed, it has also entered into our anxieties concerning our most serious relations. When we

survey our morning meal, we consider in terms of chemistry whether the repast is nutritively sufficient and what our chances are in a physiological contest with its germs and germicides. A glass of water on the railroad train is taken with proper scientific reservations as to our future prospects in the hands of the doctor and the nurse. The wisdom of the crucible and the microscope have even been invoked in the domain of our religious thought, sometimes to assure us concerning the verities of the Christian religion and sometimes to assuage our fears as to the certainties of divine retribution.

But what is science and from whence comes its authority? On what grounds may it rationally appeal to our confidence? Those of us who accept its verdicts as a part of our intellectual equipment, to whose activities truth is a blessing and error a disaster, whose personal and material well-being may be jeopardized by unsound conclusions, have a right to ask these questions and ask them insistently. I crave your indulgence while I attempt to answer them.

Concise definitions of science are, "knowledge amassed, severely tested, co-ordinated and systematized, specially regarding those wide generalizations called the laws of nature." Or, what is simpler, "knowledge gained and verified by exact observation and correct thinking." The specifications, "knowledge severely tested," and "knowledge gained and verified by exact observation and correct thinking," clearly indicate, not only what science is, but what it is not. It is not opinion, it is not platform speculation, however eloquent, it is not truth diluted or distorted by much repetition, it is not magazine exploitations of the new and wonderful in a way that fires the imagination but deceives the understanding, it is not theories partially supported by data, it is not dangerous conclusions vitiated by confessed errors or propped up on all sides by "ifs" and "provided," it is not a "report of progress" that shows little more than what the investigator hopes some time to prove and will take up again

when he has opportunity—true science is none of these things. Some of them may be steps in its direction, but they do not constitute "severely tested" or "verified" knowledge. So obvious a truth would scarcely need stating, were it not for the fact that our scientific literature is submerged with increasing records of imcomplete and inconclusive observations. It is a sobering thought that only a minor proportion of the mass of generalizations that are published endures severe scrutiny and becomes permanently incorporated into the body of science.

Scientific generalizations at their best are far from infallible. Every spot of truth is so surrounded by unpenetrated, and therefore unknown, regions, that many conclusions are properly held to be tentative. Even some deductions, the result of researches apparently most exhaustive, that are stated without reservation or modification, are abandoned as larger knowledge is gained. A most striking example of this is furnished by the investigations as to the sources of nitrogen to the plant. In 1857–58, Lawes, Gilbert, and Pugh carried on at Rothamstead, England, what has been pointed to many times as a classical research on the question of the use by plants of the free nitrogen of the air. The inquiry was most severe. All available knowledge was brought to bear on it, and the conclusion was reached that uncombined atmospheric nitrogen is not available plant food. This verdict is now reversed by later evidence of the soundest and most incontrovertible kind. In 1857 knowledge of the biological activities of the soil was very meager. The Rothamstead investigators worked with sterilized earth, not realizing that they were thus destroying the germ life which, as we now know, somehow functions in aiding the legumes to utilize atmospheric nitrogen. While the plants did not acquire free nitrogen under the conditions involved in the investigation, these conditions were made greatly unlike those prevailing in nature. Science will always be subject to such reversals. Its progress has been, and always will be,

a series of advances and retrogressions, with the outposts of knowledge steadily advancing. All this but emphasizes the supreme importance of organizing inquiry on a thoroughgoing basis, coupled with a judicious conservatism in the formulation of conclusions.

If, then, what we call science is a mixture of truth and error, of the enduring and the transient, by what standards shall we measure its reliability? You will agree with me, I am sure, when I state that wise critics estimate the value of scientific deductions by their authorship. When new conclusions are brought to our attention our first inquiry is for the name of the author, and three factors enter into our judgment of him and consequently of his work. These factors are, (1) his personal equipment for investigation, (2) his motives or point of view, and (3) his environment.

The primary consideration is the man. It is a fundamental fact which should receive greater emphasis, that what is presented to us for truth takes form in the human mind and the quality of what we are asked to believe bears a close relation to the development and equipment of the producing intellect. Unripe minds will inevitably produce unripe science, and while intellectual conquests are won of which we are proud and that bear ripened fruit, much so-called science is being forced upon our attention today that is as unripe and unassimilable as the proverbial green persimmon.

The man-side of research is emphasized at this time because, in my judgment, it is not sufficiently considered in our development and support of the work of inquiry. This development must begin with the preparation of men properly fitted to conduct research that is worthy of the name, and until this is accomplished other means, such as money, buildings, and apparatus, are inefficiently and wastefully applied. Material equipment is subsidiary to the intellectual. The normal and only successful order of procedure in this, as in every other effort, is first an

efficient instrument and then the means for utilizing it. Any other sequence is irrational and unsafe.

Again, an investigator in science should be judged by his controlling motives or point of view. It has been said, with what accuracy I do not know and shall not inquire, that an English university once wrote over its portals: "No useful knowledge taught here." One of our own scientists is absurdly reported to have expressed a regret that chemistry was ever put to money-making uses. Those of us who are devotees of applied science repel such sentiments and, having right on our side, declare with great fervor that we will have nothing to do with knowledge that cannot be brought into the service of humanity. We are glad that learning has escaped from the monastery into a throbbing, busy world. We have no sympathy, either, with the modern monastic spirit sometimes manifested by those who claim to be working in the field of what is designated as pure science and affect contempt for the utilitarian.

But, on the other hand, it is time for us to give practical recognition to the fact that great victories never have been won in science, and never will be, when knowledge is sought merely that it may be weighed in the balance as bullion. The investigator whose foremost thought is financial advantage, either to himself or to others, has an inferior point of view and is devoid of the highest inspirations. I know that some good people of an ultra-practical frame of mind take exception to the statement that the investigator should "seek truth for truth's sake," and declare that the controlling point of view should be that of utility. Granting that knowledge reaches its best estate when it serves human needs, it is still to be said that inquiry is not on safe ground unless the dominant impulse is to know the truth. The true scientific mind is the truth-loving, truth-seeking mind. He who possesses it is dominated by a desire for knowledge that leads him to sacrifice, if necessary, opportunities for power, distinction, wealth, or pleasure. In these days of money-making invention,

rather than of a desire for larger intellectual vision, when the imaginations of ambitious men are dazzled by the opportunities for financial gain, we need a renaissance of the spirit which inspired and upheld the fathers of science in the classic researches that have laid the foundations of modern knowledge. Until this comes in a greater measure than we now have it, we may not reasonably hope for the solution of many of the great unsolved problems of agriculture.

In the third place, research efforts take color and value from the environment in which they are carried on. No investigator is likely to be immune to the influences that surround him, and there are modifying conditions, the presence of which must be regarded as essential to the highest type of inquiry. If, as is obviously true, science is an individual product, the initiative and liberty of the individual should be safeguarded. The research worker must be allowed, within reasonable limits, to follow his inspirations and enthusiasms in his own way. Investigation that is too highly organized into a mechanical system, so that duties are assigned as in the routine of an administrative department, is infertile. It is a station worker's inspirations rather than his director's commands that are fruitful. Science that is worth anything will never be ground out by machinery, however costly and elaborate the mechanism may be. Neither should the investigating mind be subject to the coercion of public sentiment or the demands of expediency. Its operation should be carefully guarded in an atmosphere of quiet and unbiased reflection. This should also be an atmosphere of deliberation and not of haste. New knowledge that is reliable is reached with exceeding slowness for it is wrought out only by immense labor and with untiring patience. Perhaps what I have said concerning the authority of science may be summarized and made more specific by the statement that the knowledge most trustworthy is that which proceeds from the domain of conservative scholarship—such scholarship, if you please, as is bred in the atmosphere of

our best colleges and universities. Despite the dangers from academic dogmatism, it is in such surroundings that we now generally find the most critical and impartial judgments and the most careful deliberation in the formulation of conclusions.

The conditions essential to effective inquiry have been briefly outlined at this time in order that they may be compared with those under which agricultural research is undertaken in the United States. But before such a comparison is made, I would like to meet one thought that I suspect is already in your minds concerning what has been said. Doubtless your mental comment is that the specifications laid down are ideal and at present are unattainable by the institutions here represented. If this be true, then so much the worse for the prospects of scientific progress among us. When the temperature necessary for the hatching of eggs in an incubator is unattainable in a given instance, why, the eggs will not hatch. But I do not concede that there is anything extreme or impracticable in these specifications. They have existed, and they exist now, in some places and it is only where they are found that research is in its best estate.

In considering the present status of agricultural inquiry in the United States, we are impressed first of all by the great magnitude of the effort that, according to the language of the laws authorizing it, is known under a variety of terms such as "scientific investigation and experiment," "original researches," "diffusion of useful information," and similar phraseology. In 1906 the experiment stations expended nearly two million dollars. Assuming that of the seven million dollars appropriated to the United States Department of Agriculture, 60 per cent. was assigned to those bureaus engaged in the work of inquiry and demonstration, we find that in 1905–6 over six millions of dollars was applied by the federal and state governments to the promotion of agricultural science. This is outside the funds used by the land-grant colleges in the work of instruction. The number of persons now employed in the expenditure of this vast

sum of money is not less than four thousand. Millions of copies of bulletins and reports are now issued annually by the experiment stations, and the mass of literature sent out by the federal department is something prodigious. Department and station men are found frequently on the platform at agricultural conventions and farmers' institutes, and their contributions to agricultural literature in the way of books and newspaper discussion are extensive. History records no other instance of an organized attempt to aid agriculture or any other industry on a scale so magnificent in its proportions and so far-reaching in its results.

But in all candor it must be confessed that, whatever may have been the phraseology of law or of common speech in characterizing this movement, it has been mainly an effort, not of research, but of the exploitation of existing knowledge. We have not reached far into the unknown, and although important new truths have been brought to light, our efforts at inquiry have neither produced results nor commanded the respect of the scientific world to an extent commensurate with the generous means applied. During the past twenty-five years we have been busy instead with much agricultural speaking and writing. The chemist has been called from his crucible, the botanist from his microscope, the editor from his desk, and the farmer from his plow, to aid in spreading the gospel of an agriculture based on exact knowledge into almost every hamlet in the land. The unknown, but greatly inadequate, facts and principles of science have been exhibited with kaleidoscopic effects and have been turned inside out and upside down in order to meet conditions almost numberless in their variety.

Doubtless it may be argued in a way more or less convincing that the diffusion of existing knowledge was necessarily the first step in bringing the people in harmony with, and to the support of, the kind of educational and research work that is our goal. There is much to be said for this position, but we must not forget

that the largest asset of the priests of agriculture is their ignorance. Fifty years ago we began to import German science, and, with a due respect for a foreign product and because we didn't know any better, we accepted it all without modification or even *adulteration* as applicable to the agriculture of this new and rapidly developing nation. Some of us elder brethren remember with what confidence we advised the farmer as to rations for plants and animals, for had not the Herr Doctor *Namenlos* worked it all out and was he not authority? But since those days we have become one of the great powers and we now have a right to some things of our own, even our ignorance.

We are seeing with greater distinctness every year that the more complex and more important problems of agriculture are still unsolved, and that because of this our utterances to the practical man are still lame and halting. Do you doubt this statement and ask what these problems are? Who of us is able to stand on his feet and define fertility, or even demonstrate the relative value of its various factors? Do we not often quail before the simple and direct questions of the farmer when he seeks information as to the production of crops and sometimes return him answers bedecked with glittering generalities? We say much, and not too much, about the wonderful value of the legumes. Clover and alfalfa have been the most valuable asset of the institute speaker and yet we are in profound ignorance as to how much nitrogen they take from the atmosphere when they are grown under the ordinary conditions of farm practice. Once we had the German standard rations for farm animals and our *ex-cathedra* formulae were convenient and much admired. Now we have practically lost these standards in the misty mazes of new data and nutrition problems still harass our minds. Control of results in the breeding of plants and animals is still an unsolved riddle. (This statement should be made, I suppose, with an apology to the mathematical formulae of the disciples of Mendel.) Tuberculosis in farm animals is an unconquered

scourge. Do not say that there are no great agricultural problems left for us to attack. They are both great and many, and their successful study demands investigation of wide scope and masterful ability. We should not feel that because agricultural science deals with things common and familiar its problems are easy and may be solved by correspondingly easy methods. All that is required for progress in any other field of inquiry whatever in the way of efficiency of organization, scientific acumen, and severity of method is required here.

In repeating the assertion that we have failed to grapple with the large problems of agricultural science, as has been our privilege and opportunity, do not understand me as disparaging the results of your efforts. You and your predecessors have been engaged for the past thirty years in a noble enterprise which you have loyally sustained. It is a common remark from those who come in contact with this body for the first time that it is made up of men of unusually earnest endeavor, who are evidently seeking most conscientiously to do the work that they have in hand, and those who have frequented these meetings for many years know that such a comment is entirely just. Much has been accomplished. It is generally conceded that no instance is on record where technical knowledge has been brought into such close and practical touch with the people as has been done for our agriculture during the past twenty-five years. The comprehensive organization of the effort and the sympathetic relation of the various agencies involved, from the university to the home reading-course, are worthy of our admiration. The uplift of agricultural thought and practice has been great and has abundantly justified the new democracy of education. I am convinced, nevertheless, that, as was inevitable under new and untried conditions, some serious mistakes have been made in our attempts at research. But just now we are assuredly on the verge of substantial gain in the purposes and methods of our work and it may not be amiss to glance briefly at some of the

conditions, not yet entirely removed, that are inimical to scientific efficiency and progress.

The quality of work accomplished in agricultural science in the United States has been menaced, and still is, by the extraordinary growth of institutions for agricultural investigation. Comparatively few persons outside of those directly interested appreciate how remarkable this development has been. Up to 1887 there had been established in the United States only seventeen experiment stations, no one of which was receiving anything more than meager support. The passage, in 1887, of the Hatch Act, granting $15,000 to each state, or a total of upward of $600,000 for the maintenance of agricultural experiment stations, resulted in the prompt organization of twenty-nine more stations, making forty-six in all. This required the immediate employment by the Hatch stations of nearly four hundred men, a large part of whom had not previously been engaged in the work of inquiry. The number of stations is now fifty-five, which employ nearly eight hundred persons and expend annually nearly $2,000,000.

During this time the development of the United States Department of Agriculture has been even more remarkable. In 1888 the congressional appropriation to this department was $1,019,219; in 1900, $3,006,022, and in 1907, $7,175,690. From June 30, 1897, to July 1, 1906, the number of employees of this department has increased from 2,043 to 6,242. It is approximately accurate to say that over 4,000 men employed by the Department of Agriculture and the experiment stations are giving their time to the work of research and demonstration, in the support of which between six and seven million dollars are annually expended. This marvelous development along one line of effort has taken place within the past twenty years.

Unquestionably the quality, if not the integrity, of scientific conclusions, has been endangered by this unprecedented enlargement of funds. In the first place, research efforts of a high type

are not made to order. They are an evolution that is by no means rapid. We say, and with truth, that age alone brings to a college the atmosphere most congenial to educational results of the highest value, and institutions of research develop and ripen no less slowly. Moreover, a large body of real investigators is not summoned in a day or in a year from among the mass of educated men. The real investigator must have what we speak of as initiative, fundamentally a natural quality that has been trained and developed in an atmosphere of scientific inquiry. Such men are not abundant. They are slowly gathered about any given center and their selection calls for the divining-rod rather than the dragnet.

Again, investigators in certain fields of agricultural research should be something more than mere technicians in science. They should be ripened men who see relations broadly, men who know affairs as well as principles. To be sure, agricultural problems relate to the common things of everyday life, but this in no way lessens their depth and complexity or the severity and thoroughness of the methods necessary to correct conclusions.

The difficulty, then, where endowments for research have increased by million-dollar steps, has been to secure a corresponding equipment of men with a genius for observation, who have ripened into usefulness, especially when we have so few institutions that are giving adequate training for scientific inquiry in agricultural directions. The fact is, funds applied to agricultural research have at times been increased so fast and on such a tremendous scale, though never beyond the needs of agriculture, as to exceed the possibilities of a normal and sound scientific growth correspondingly rapid and extensive. It is my judgment, which you may estimate as a purely personal point of view if you like, that agriculture has no right to ask for larger sums of public money to be used in the study of its problems until there are available more men who are adequately equipped for the

work of inquiry. In our enthusiasms we have proceeded, I am convinced, to create a condition that is out of balance. We should bring the situation into balance by giving more attention to the development of men.

Another condition, more or less unfortunate, is that agricultural research work is largely dependent upon annual legislative appropriations, either national or state. The legislative mind, for most excellent reasons, is peculiarly sensitive to popular sentiment. It also very generally holds the *quid pro quo* point of view. The query in legislative halls is quite naturally apt to be, not "What is truth?" but "What is truth worth in commercial units?" A closely related fact is that the agricultural public is not always patient or discriminating. Only investigators themselves understand the length of time and the persistent effort necessary to the formulation of sound conclusions, and because a constituency that has no adequate conception of what research involves complains to its representatives in the legislature that the appropriations for agricultural investigation are not producing equivalent values, the investigator is placed in a position of defending himself before a jury that does not understand him. The condition of expectancy that prevails on the part of the public that it must have results of immediate value to practice, and on the part of various institutions that they must have public support, has been an element most dangerous to the quality and integrity of our work.

As among the remaining factors related to agricultural investigation in the United States, permit me to refer briefly to the much discussed adjustment of teaching and investigation in its bearing upon the efficiency of our experiment stations. There is an unquestioned advantage to an experiment station, we all admit, in locating it in a college or university environment, provided the relations established are of the right sort. The college atmosphere is essentially speculative and is conducive to reflection and inquiry, or should be, and in a community of

teachers and students we generally find a desirable intellectual and social stimulus.

But the record of the past twenty-five years does not justify us in expecting a fruitful research effort when teaching of the kind and amount that must be done in most of our land-grant colleges is a part of the duty of members of a station staff. It is conceivable that giving a few lectures on advanced subjects might be a distinct advantage to a research worker, but this cannot reasonably be claimed for routine instruction in fundamental subjects. Observation shows that classroom work of this character will inevitably claim the first place in the use of the teacher's time and energy. It is useless to ignore the plain results of experience. The fact that this combination of duties seems for the most part to have been unavoidable in our experiment station organization may excuse the situation but does not nullify its effects.

It is of little avail, however, to dwell on the past, excepting as we glean the wisdom of experience. Our problems are with the future. As I see it, the further development of agricultural research in the United States lies primarily with the colleges and universities in the preparation of men and, secondarily, with the extent and conditions of the endowment of such research. Concerning this secondary factor, little will be said at this time beyond the remark that it will be fortunate when our research efforts shall be farther removed from the disturbing influences of an indiscriminating public sentiment and the uncertainties of legislation. We have no assurance that either education or research will develop normally or symmetrically if the purposes and methods of the classroom and laboratory are to be standardized by a public conception of what is their immediate vocational or commercial value.

The present fundamental need, however, is for more young men endowed with a love of learning, of scholarly habit, and with integrity of mind and heart, whose ambition is not for

notoriety but for the conquest of truth, and who, with more thought for service than for salary, are anxious to aid in laying broad and deep the foundations of human thought and activity. For this reason, in the progress of agricultural knowledge, I place the influence of the teaching institutions as the primary factor, because, when there exists a body of men really possessed by the research impulse and with adequate training, inquiry will not wait on legislative authority and support, but will proceed even under adverse circumstances. Whether the land-grant colleges are to train such men sufficient in numbers and ability to meet the demand is yet to be determined. So far these institutions have appealed for public support, chiefly on the ground of educating farmers, and have pointed to farmer graduates and crowded short winter courses as a sure way of convincing the popular mind that public funds are successfully applied to the supposedly chiefest aim of agricultural education and are not being exhausted in the labyrinths of learning characterized as useless.

It is a serious question whether we are right in our educational plans when we place almost the entire emphasis upon the commercial or business side of agriculture and the industries, or whether in doing this we are promoting the highest utility of agricultural and industrial education. Is it not now the privilege and duty of at least some of the colleges and universities here represented more fully to nourish and develop the spirit of inquiry? Should you not deliberately set about recognizing and encouraging scientific initiative among your students and organizing courses of instruction that shall give a substantial preparation for the work of investigation?

A New England college president, having in mind, doubtless, the older institutions of learning, once expressed the half-formed conviction that "the college is farther from the market-place than is the church." It was evidently his thought that in the college, as

nowhere else, are nourished and cherished the highest intellectual and moral ideas.

But here are institutions with new purposes and new relations. On their doorposts is written the word "practical," and in their classrooms the student is asked to consider the vocational side of life and he learns of machinery and slaughter-houses and railroads and markets; in short, he learns of all that man is doing, rather than of what man is thinking and dreaming and hoping. Is the future investigator with his imagination fired by ambitions for larger knowledge to come out of such an environment? We may well be solicitous whether the spirit of learning can survive in centers of thought where facts and principles are so constantly weighed and measured with reference to their material or commercial value. It is a serious matter if the new education that is now attracting to it thousands of our young men is to serve chiefly in commercializing, rather than intellectualizing, the most virile manhood of a nation that is already grossly materialistic.

Friends and fellow-workers, these problems are your problems. Now that an apparent transition in the aims and methods of education is in progress, the institutions you represent, founded as they are upon the broadest possible basis of educational function and leading as they do an invasion into new and untried fields, occupy a position of critical responsibility. May you possess such wisdom, and such initiative tempered by the lessons of experience, that your efforts will advance the intelligence and prosperity of the farm and shop, promote the love of learning, and uphold the standards of the scholar.