The University of Nebraska

PRACTICAL SCIENCE

An Address Delivered on the Occasion of the Dedication of Plant Industry Hall, at the
University Farm, on Tuesday, June Tenth, Nineteen Hundred Thirteen

BY

JOHN M. COULTER, Ph. D.

Professor and Head of the Department of Botany
University of Chicago

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PLANT INDUSTRY HALL.

PRACTICAL SCIENCE

The dedication of a building devoted to Plant Industry, in connection with a university, calls for more than a passing notice. It is not a repetition of what has often happened; but it is a striking evidence of the progress of a great modern movement. It shows that the movement has reached a stage where the subject of plant industry deserves to become a part of the work of a university, which means that there is a *science* of plant industry as distinct from a *practice* of plant industry. This association does not seem so significant to those connected with state universities as to those who are living in the atmosphere of private universities. The pressure of a practical constituency is always felt at a state university, and practical community service is regarded rightly as a conspicuous part of the return that should be made for support.

The University of Nebraska is to be congratulated upon this visible pledge, given to its constituency, that it will serve the great material interests of the state, as well as the intellectual and moral interests to which all universities are pledged. The occasion is a fitting one for considering what this new building stands for; whether for a revolution in the old university ideals, or rather for a closer articulation of the university with the community.

Men who spend their lives in the older universities are apt to develop certain unfortunate peculiarities. These peculiarities may not make them less happy, or less useful to their professional students, but they diminish the appreciation of the community at large. In the life of such an instructor or investigator there is a peculiar kind of isolation that is bound to react.

It is partly the isolation of a subject which is more or less segregated from general human interests, at least in the aspects of it the university man is cultivating. As a consequence, he feels that his world is quite apart from that one in which the majority of men are living. He is conscious of an interest distinct from their interests, which seem to him therefore relatively trivial. This sense of intellectual aloofness does not result in a feeling of loneliness, but rather in a feeling of superiority, unconscious in many cases, but often naively expressed.

It is also the isolation of authority, which comes from mastery of a subject and association with students who recognize this mastery. To speak with authority in intellectual matters, to give the deciding word, to meet a constant succession of inferiors, is apt to affect any man's brain. Either he becomes dogmatic in expression, or he must hold himself in check with an effort. It is the same reaction that was observed in the case of the clergy, when acknowledged authority in position resulted in an assumption of authority in belief.

The larger the university, the more intense does this sense of the isolation of superiority and of authority become, for it is stimulated by association with its own kind. There is much honest effort to break down this barrier between the scholars who represent universities and the great host of men who represent the community. These men are not so isolated, but they are just as dogmatic in their own way, and they are immensely influential. Even when the two groups mingle, the scholar is often only a man of incidental interest, who possesses much curious information about many useless things. And the scholar usually enjoys being drawn out and made to display his curiosities, for it has the familiar flavor of the classroom, with its intellectually inferior students.

Of course such contact between scholar and community is not the effective one, for it is merely that of audience and entertainer. Here are two groups of men, both powerfully equipped, who should be mutually stimulating in all that makes for progress. Mutual stimulation can follow only after mutual understanding. It is not for me to explain the community to the scholar, but rather to explain the scholar to the community. Even this subject is far too large, for scholarship has many phases, all the way from artistic appreciation to scientific synthesis. I shall try to explain, in outline only, the scientific aspect of scholarship, and its significance to the community.

It is evident that the public is somewhat interested in scientific research. The most available index of the present interest is furnished probably by the newspapers and magazines, which try either to respond to the desires of their readers, or to cultivate desires. Even a cursory examination of the material they furnish which may be said to deal with research shows that it is scanty in amount, sensational in form, and usually wide of the mark. The fact that it is scanty in amount is a cause for congratulation if it must involve the other features. The sensational form is a concession to what is conceived to be public taste; and while to a scientific man this form seems to exhibit the worst possible taste, the serious objection

is that to secure the form truth is usually sacrificed. Some of the results of this kind of information are as follows:

Men engaged in research are looked upon in general as inoffensive but curious and useless members of the social order. If an investigator touches now and then upon something that the public regards as useful, he is singled out as a glaring exception. If an investigation lends itself to announcement in an exceedingly sensational form, as if it were uncovering deep mysteries, the investigator becomes a "wizard," and his lightest utterance is treated as an oracle. The result is that if the intelligent reading public were asked to recite the distinguished names in science, they would name perhaps one or two real investigators unfortunate enough to be in the public eye, several "wizards," and still more charlatans. The great body of real investigators would be known only to their colleagues, thankful that they were not included in any such public hall of fame. And yet the public is not to be blamed, for it is giving its best information, and the fact that it has even such information indicates an interest that would be wiser were it better directed. This better direction is dammed up behind a wall of professional pride, which makes an investigator look askance at any colleague who has broken through it. The intelligent public is certainly interested, but it is just as certainly not intelligently interested. I wish to analyze the situation briefly.

There is a conventional application of the term science which I will use for convenience. Thus applied, there has arisen a classification of science into two phases, called pure science and applied science. This distinction is one that not only exists in the public mind, but also is reinforced by published statements from colleges and universities. An attempt to define these two kinds of science reveals the fact that the distinction is a general impression rather than a clear statement. A general impression is usually sufficient for the public, but it ought not to be sufficient for the universities.

If the impression be analyzed, it seems that pure science is of no material service to mankind; and that applied science has to do with the mechanism of our civilization. The distinction, therefore, is based upon material output. In other words, pure science only knows things, while applied science knows how to do things. This impression, rather than distinction, has been unfortunate in several ways.

The public, as represented by the modern American community, believes in doing things; and therefore to them pure science seems useless, and its devotees appear as ornamental rather than as vital members of human society, to be admired

rather than used. The reaction of this sentiment upon opportunities for the cultivation of pure science is obvious.

On the other hand, the universities, as represented by their investigators, believe in knowing things; and therefore to them applied science seems to be a waste of investigative energy, and its devotees appear to be unscientific, very useful but not to be acknowledged as belonging to the scientific cult.

The reaction of this sentiment sometimes has been to avoid the investigation of problems that have an obvious practical application and to justify Lowell's definition of a university as "a place where nothing useful is taught."

In this atmosphere of mutual misunderstanding, the public and the universities have continued to exist and to make progress, all the time acknowledging their interdependence by mutual service.

In recent years, however, a new spirit is taking possession of the public and it has invaded the universities. In fact, so conspicuous have the universities become in the movement that they seem to be the leaders; certainly they furnish the trained leaders. The new spirit that is beginning to dominate increasingly is the spirit of mutual service. It is called by a variety of names, dependent upon the group that proclaims it; it is narrow or broad in its application, dependent upon the moral and intellectual equipment of its promoters; but it is the same enduring idea.

The university is no longer conceived of as a scholastic cloister, a refuge for the intellectually impractical; but as an organization whose mission is to serve society in the largest possible way. Furthermore, this service is conceived of not merely as the indirect contribution of trained minds, a contribution of inestimable value, as we believe, but also as the direct contribution of assistance in solving the problems that confront community life.

This new animating spirit is so attractive and inspiring, appealing to what seem to be our best impulses, that it threatens to become a real danger, not only to universities, but to the whole scheme of education down to the primary school. The reaction is natural, and therefore inevitable, but its demands must be recognized as representing the primary and extreme recoil stage of a new motive. The new motive must not eliminate all the old motives, but must adjust itself efficiently among them. For example, there is abroad an increasingly insistent demand that in the primary and secondary schools all instruction in pure science shall be discarded and various forms of applied science substituted, the imaginary distinction

being that which has been indicated. The same pressure ~~is~~ being felt in the colleges, not to the extent of substitution, but to the extent of adding impossible courses and weakening existing ones. My present thesis, however, is interested chiefly in the fact that the same pressure has begun to be applied to the research work at universities. This pressure is applied not only by public demand, which voices the supporting constituency of most universities, especially of the Middle West, but also by the extensive scientific work of state and federal governments, in which for the most part the immediate practical aspect must dominate. The more recent developments at our state universities are impressive illustrations of this pressure; and, as a result, in such universities scientific research in connection with the problems that do not seem to be related at present to the welfare of the community is living in a depressing atmosphere.

It is time for the public and for the managers of universities to understand the real relation that exists between what they have been pleased to call pure science and applied science. I cannot hope to make a statement that will appeal to all concerned, but it may serve some useful purpose.

As an introductory illustration, there may be outlined the usual steps that science has taken in the material service of mankind. An investigator, stimulated only by what has been called "the delirious but divine desire to know," is attracted by a problem. No thought of its usefulness in a material way is in his mind; he wishes simply to make a contribution to knowledge. No one can appreciate the labor, the patience, the intellectual equipment involved in such work unless he has undertaken it himself. The investigator succeeds in solving his problem, and is satisfied. Later, perhaps many years later, some other scientific man discovers that the results of the former may be used to revolutionize some process of manufacture, some method of transportation or communication, some empirical formula of agriculture, some practice in medicine or surgery. The application is made and the world applauds; but the applause is chiefly for the second man, the practical man. Any analysis of the situation, however, shows that to the practical result both men contributed, and in that sense both men, the first no less than the second, were of immense material service. The ratio that exists between scientific men of the first type and those of the second is not known, but there is very great disparity.

Another illustration is needed as a corollary. In this case an investigator, stimulated by the desire to serve the community, is attracted by a problem. He also wishes to make a contribution to knowledge. He succeeds in solving his prob-

lem, perhaps makes his own application, and is satisfied. Later, some other scientific man discovers that the results of the former may be used to revolutionize certain fundamental conceptions of science. His statement is made and the *scientific* world applauds; and this time also the applause is chiefly for the second man, the pure scientist. The analysis of this case shows, however, that to the scientific result both men contributed; and that both men were of large scientific service.

A third illustration is needed to complete the real historical picture of progress in scientific knowledge and in its material applications. A practical man, not trained as an investigator, faces the problem of obtaining some new and useful result. His only method is to apply empirically certain formulae that have been developed by science, but with ingenuity and patience he succeeds, although he is not able to analyze his results. And yet, his procedure reveals to a trained investigator a method or certain data that lead to a scientific synthesis of the first order.

With such illustrations taken to represent the actual historical situation, what may be some of the conclusions?

It is evident that responsibility for the material results of science is to be shared by those engaged in pure science, those engaged in applied science, and those not trained in science at all. The only distinction is not in the result, therefore, but in the intent. As one of my colleagues has aptly said, the difference between pure science and applied science, in their practical aspects, resolves itself into the difference between murder and manslaughter; it lies in the intention. So long as the world gets the results of science, it is not likely to trouble itself about the intention. In every end result of science that reaches the public, there is an inextricable tangle of contributions. Between the source of energy and the point of application, there may be much machinery, and perhaps none of it can be eliminated from the final estimate of values. And yet, the public is in danger of gazing at the practical electric light and forgetting the impractical power house; and schools are being asked to turn on the electric light and to shut off the power house.

Another conclusion is that all application must have something to apply, and that application alone would presently result in sterility. There must be perennial contributions to knowledge, with or without immediately useful intent, that application may possess a wide and fertile field for cultivation. It is just here that the menace to education is evident. When education in science becomes a series of

prescriptions to be followed without understanding and without perspective, it will train apprentices rather than intelligent thinkers. Of course there is a place for just this kind of training and there are individuals who need it; but the place does not seem to be the schools for general education, and the individuals are evidently not all those who pass through these schools, or even a majority of them.

A third conclusion is that there is nothing inherent in useful problems that would compel their avoidance by an investigator who wishes to contribute to knowledge. While such an investigator should never be handicapped by the utilitarian motive, at the same time he should never be perversely non-utilitarian. I feel free to make this statement, for perhaps no field, within the confines of my own general subject, seems to be more non-utilitarian than the special one I have chosen to cultivate. There is no reason why a university, especially one dominated by research, should not include among its investigations some that are of immediate concern to the public welfare.

A final conclusion may be that all science is one; that pure science is often immensely practical; that applied science is often very pure science; and that between the two there is no dividing line. They are like end members of a long and intergrading series; very distinct in their isolated and extreme expression, but completely connected. If distinction must be expressed in terms where no sharp distinction exists, what seems to me to be a happy suggestion, made by one of my colleagues, is the distinction expressed by the terms *fundamental* and *superficial*. They are terms of comparison and admit of every intergrade. In general, a university devoted to research should be interested in the fundamental things of science, the larger truths, that increase the general perspective of knowledge and may underlie the possibilities of material progress in many directions. On the other hand, the immediate material needs of the community are to be met by the superficial things of science, the external touch of more fundamental things. The series may move in either direction, but its end members must always hold the same relative positions. The first stimulus may be our need, and a superficial science meets it, but in so doing it may put us on the trail that leads to the fundamentals of science. On the other hand, the fundamentals may be gripped first, and only later find some superficial expression. The series is often attacked first in some intermediate region, and probably most of the research in pure science may be so placed; that is, it is relatively fundamental; but it is also relatively superficial. The real progress of science is away from the superficial toward the fundamental;

and the more fundamental our results, the more extensive may be their superficial expression. In short, my subject, "practical science," is no subject at all if it implies a special kind of science, for all science is practical.

In conclusion, I wish to illustrate this general statement concerning pure science and applied science by a single example taken from my own material, a phase of botany represented by this new building.

The science of botany has had a remarkable history. Beginning with the investigation of plants for what were called their medicinal virtues, it developed with various progressions and retrogressions, until the botanist came to be regarded as about the most useless intelligent member of society. His chief concern seemed to remove him so far from the general human interest that he was regarded as a harmless crank, at best a man of only ephemeral interest. No such opinion could have developed unless there had been some basis for it. It is entirely foreign to my purpose to discover this basis; the situation is simply to be recognized as a fact.

The most unfortunate result of this public estimation of botany was that it lingered much longer than it was deserved; and consequently, when the other so-called sciences had won public esteem either through their services or their appeal to the wonder-instinct, botany lagged behind in public recognition, and in most educational institutions was the latest born into the family of sciences. But finally, it also began to render signal service and to appeal to the wonder-instinct.

Without attempting to disparage the wonderful recent development of several phases of botanical activity, phases that have become so developed as to endanger the federal interests of botany as a unified science, there is certainly no one that is attracting more attention at this time, both in its scientific and in its practical aspects, than plant-breeding.

It is not my purpose to recite the notable achievements that are to be grouped under this title, for most of them have been widely published, and are the common property of the scientifically intelligent. I simply wish to use the subject as an illustration.

The practical aspect of plant-breeding, in a certain sense, is as old as the culture of plants. Long experience in the practical handling of plants slowly developed a kind of knowledge that became formulated in empirical practice. The general purpose was to improve old forms and to develop new ones. The improvements were numerous, and apparently were possible in any direction determined

by the need or taste of man. It was learned that improvements must be kept improved; in other words, that they would not remain constant if left freely to nature. This was a laborious but profitable method of plant breeding, the method known in general as mass culture. The most desirable individuals were selected and guarded through a series of generations, until the desired character was built up sufficiently for commercial purposes. This is the oldest and still the most widely used method of practical plant-breeding, begun by unconscious selection and merging into intelligent selection.

During all this period of plant improvement by mass culture and continuous selection, the so-called science of botany was cultivating a singularly distant field. In short, botany was not practical, and plant-breeding was not scientific. Therefore, botanists on the one hand, and agriculturists, horticulturists, floriculturists, etc., on the other hand, were as distinct from one another as if they had nothing in common. It so happened that the botanists were dealing with very superficial problems in a scientific way, and that the plant-breeders were dealing with the most fundamental problems in an empirical way.

As in any other practice, plant-breeding developed now and then a very successful practitioner, who made distinct contributions in the form of important results; but this represented no more of an advance than does the fact that one cook can surpass another cook in the art of making bread. This caution is necessary, for the results obtained empirically by skillful plant-breeders are too often ascribed to unusual scientific insight. The result is important enough without reading into it what it does not contain.

What may be called the second period of plant-breeding was ushered in when organic evolution began to be put upon an experimental basis. Plant-breeding had been practical, but with no scientific basis; now a new plant-breeding was established, which was scientific, and with no practical motive. The new motive was the accumulation of data bearing upon the problems of inheritance and the origin of species, probably to be regarded as the most important and most difficult of the biological problems.

The third phase of plant-breeding can hardly be called a third period, for it is practically synchronous with the second. As a by-product of the work on inheritance and evolution, some of the scientific results have been applied to practical plant-breeding; and the result has been an expansion of its possibilities that may well be called marvellous. In short, practical plant-breeding is now on a scientific

basis; and botany has at last attacked the fundamental problems and may be of some practical service, for it includes plant-breeding.

Perhaps it may not be out of place to remind you of the large importance of this combination, for it underlies the welfare of human society. It is a combination of scientific research and its practical application in maintaining an ever increasing food supply over ever extending areas. If it is the function of medical research and its application to provide for the welfare of a certain per cent of the population, it is one of the functions of botanical research and its application to provide for the welfare of the whole population. Nor is scientific plant-breeding, in its restricted definition, the sole contributor to this end, but bound up with it are physiology, ecology, soil investigations, pathology, and the whole round of interests that touch living plants. In short, there is now possible, for the first time, such a cooperation of scientific results towards a definite end as to make rapid progress possible.

In presenting this fleeting glimpse of the problems and the accomplishments of plant-breeding, I have intended to emphasize not only its fundamental importance to both biological science and agricultural practice but also the inextricable entanglement of the two. Any result of scientific plant-breeding, representing as it must additional knowledge of the processes of evolution and of heredity, may become of practical service; and any result of practical plant-breeding, involving as it does extensive experiments with plants, may prove to be of great scientific importance. They are mutually stimulating, and both are necessary to the most rapid development of knowledge.

It is the proper balance between the two that must be maintained. The physical needs of man, great as they may be, must never obscure the intellectual needs of man; especially as the trained intellect is the speediest agent in meeting physical need. On the other hand, the intellectual needs of man, noble as they may be, must never lose sight of the fact that the speediest results are obtained by the enormous increase of experimental work under the pressure of physical necessity.

I am confident that this building is dedicated to practical science in its largest sense; a practice based on science, and a science that illuminates and extends practice. And beneath it all is that finest of all impulses, the impulse to serve the community that has expressed its confidence in giving this building, and that has a right to expect large things.