

TRAINING RESEARCH CHEMISTS IN INDIANA.

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During the few years just past we have heard it stated, and many times reiterated, that scientific research is the one all important activity for national progress, national achievement and national self-preservation. The lessons of the great war pointed unmistakably to this conclusion and an impetus has been given to research in a multitude of fields. One result of this has been a growth of confidence on the part of scientific leaders and a feeling that this one great lesson of the war would never be forgotten. But a similar confidence has been felt that other lessons of the war would not be forgotten. It was said that we were learning thrift, self-denial and self-sacrifice, economical habits of living, altruism and other splendid things. And yet with the relaxation of tension after the close of the great international struggle we, as a nation, plunged into a riot of extravagance and wastefulness such as we had probably never before known. It has even seemed probable that we were relapsing into a permanent state of national selfishness and aloofness from the troubles of the rest of the world. Can it be that we are now to lose also the research spirit, to lapse into the mere "business as usual" habit of considering of value only the investigation that makes for immediate profit?

Whatever the answer to this question may be, it is generally conceded that scientific research cannot go on, either with or without material support, unless we can somehow continue to give to an intelligent and able body of men and women who have shown special aptitude for this kind of work, special training in the necessary methods of scientific investigation and, at the same time, to inspire them with enthusiasm for this high sort of endeavor. Quoting from a recent circular issued by the National Research Council, "It" (the Council) "hopes - - - to encourage the interest of universities and colleges in research work and workers so that the inspiration and training of American youth for scientific work may never fall so low as to threaten to interrupt the constantly needed output of well-trained and devoted scientific talent in the land".

This brings us, at once, to the examination of the question of what things are necessary to provide opportunity for such training and of what we in Indiana are now doing in the way of providing this opportunity.

I have a notion that what I am here to say will apply in considerable measure to nearly all branches of pure and applied science. But in order to forestall, if possible, certain criticisms that I might, through ignorance, be unable to meet, I shall confine myself to the one matter covered by the subject of this paper: the training of *chemists* for research.

My first proposition is that such procedure must be based upon a very broad and thorough drill in the fundamentals of the science. No chemical research problem, however narrow or limited in its application it may seem to be, can be investigated with efficiency and thoroughness by one who has only a smattering of basic laws and facts, of this and of related sciences. He will almost immediately find himself balked by ignorance of scientific principles, following false trails or endeavoring to obtain experi-

mental proof of matters that are already well known and of common knowledge to better informed researchers. With this training in fundamental facts, laws and theories of modern chemistry and, indeed, as a necessary part of it, must be a good knowledge of chemical literature and a familiarity with the important journals containing original papers on subjects of chemistry and, so far as possible, physics, biology, medicine, engineering, etc.—subjects closely allied to or involving the applications of chemistry.

This thorough knowledge of the science and of the recorded labors of a multitude of investigators cannot come from necessarily brief and circumscribed courses of lectures and laboratory work involved in a four-year course in a college. No matter how enthusiastic, intelligent or industrious the student may be, or how able and inspiring the professor, it is a human impossibility to absorb *and assimilate* even a major fragment of the complex material of a science as highly developed as is chemistry, in the time that is allotted to this subject in a well balanced college curriculum. This is recognized by practically every one who has been through the undergraduate work of the liberal arts or science courses of the college, and who has later gone out to apply his knowledge to practical purposes, and every good teacher knows that his courses, wisely administered, can at best provide a moderately good training in the outstanding fundamentals of specified and limited fields of the science and teach the student something of the methods of independent and effective study. Real accomplishment, on the part of the student, usually comes some years after graduation and then only in case patient study and clear thinking have produced a certain maturity of mind,—which comes to a too small number of college graduates at any period.

As looking toward the development of research chemists, the great work of the college is then to teach the main fabric of the science as well as possible and to develop industrious habits and logical, orderly minds, capable of clear and independent thinking. This effort usually encounters many obstacles. The student must necessarily pursue a number of studies in addition to his major work and this does not make for concentration of thought and energy. We do not, by any means, propose that undergraduate work should be limited to a single science or that entirely unrelated studies should be ignored. At this period in his education the student is not prepared for specialization to any considerable extent and the broadening influence of the study of mathematics, English literature and foreign languages, and of other sciences than his own, is too well understood and too universally conceded to require any detailed argument.

In addition to this impracticability of concentration upon a single science, one may remark the great multitude of "activities" which serve to divert the attention of the student and to generate in him an attitude toward his studies which does not promote concentration or tend toward clear and profound thinking, which we have recognized as essential to the efficient investigator, or toward a recognition of comparative values of men and things. Many of these activities are in themselves harmless, or even wholesome and desirable but their influence is, undeniably, as I have stated and this has been a subject of frequent comment. A single example may be cited. Our own college daily (*The Purdue Exponent*) carries a feature

column headed "The Inquiring Reporter". This curious individual daily asks of five students, chosen at random, a given question and the answers are published, verbatim. On a certain day the question was "What, in your opinion, would serve as the best advertisement for our college?" (or words to that effect). With one accord the five answers stated that winning athletic teams would be the best possible advertisement. One answer included also a successful body of alumni as a second best advertising medium but this was the nearest approach to a recognition of the possibility of any other fine thing, the heralding of which might serve to attract a desirable class of prospective students, or to win the support of public opinion and public purses. Apparently no one thought of a high class, devoted faculty, whose members can not only know and teach, but *do* also; or (with one exception) of a great body of graduating students who take an important and dignified place in the work of the world, or of increased equipment for the administration of high grade scientific work. These five answers may possibly not be considered as representative of student opinion but I am inclined to think that they are. I do not mean that our students look down upon the other things or hold them in contempt. They simply ignore them when the great question is to be considered. I do not even particularly blame them for their attitude. It is perhaps natural, under the circumstances. It is certainly almost universal and this is a fact that must be considered,—explain, excuse or condemn it as we will. Also it is an attitude that persists after graduation. The average body of college alumni, desiring in their hearts above all things to "boost" their alma mater, will give the major portion of their discussions to the problems of improving athletic conditions and of developing winning teams.

If I have made myself at all clear in what has been said, my next proposition seems a logical conclusion. It is this, that it is not only a difficult matter to give college undergraduates proper training and drill in the methods of chemical research, but it may also be undesirable to attempt such training, in the majority of cases. Real research is a long, hard, troublesome business, rich in rewards but calling for preparation, energy and application such as the average undergraduate does not possess. Far better to keep him on the fundamentals of pure and applied science, of which he will absorb a woefully small amount under the best conditions, than to give him the false notion that after a matter of three or three and a half years of intermittent study of an intricate and complex science, he is prepared to solve scientific problems that have baffled others, or even to know how to try to solve them.

The undergraduate thesis, in the large majority of cases, is little more than a piece of more or less mechanical following of directions given by the supervising professor, and it rarely develops any dependable results that may be considered as new. It is conceded that the material may be new to the student and that the psychological effect may thus be desirable. But so are all of his studies new to him. They are all, for him, original research in practically the same sense that the the is investigation is original research and if, in his regular studies, he is properly directed in the use of the library and if the inspiration to real study is provided, there is little real difference between the thesis and the regular study, so far as this sort of training is concerned.

It may be objected that a large proportion of our undergraduates will then never have any training at all in the methods of research and will never enter this field, since a comparatively small number ever pursue graduate studies. Well, we might, with equally good logic, conclude that a large proportion of these undergraduates will never be physicians or professional actors, or will go to China or be bank presidents. We do not expect large numbers to do any one of these things. On the contrary we know that only a comparatively small number could be efficient and successful if their work were confined to chemical research, rather than to the hundred other lines of endeavor in pure or applied chemistry. But we do desire that a certain respectable minority of the men and women who leave us shall distinguish themselves, in at least a modest way, by carrying on successful work in scientific investigation and that, being effective in this work, they shall continue it through their best years and thus aid in the development of science and bring some reward of honor to themselves and to their college. How this can best be done is the question before us.

If we leave out of consideration a comparatively small minority of college men who develop notable research ability in their technical work after graduation, we may say that the great bulk of our important research work is being done by men who have had graduate training in the universities or, to be strictly accurate, by graduate students or industrial fellows working under the direction of such men. One is not to suppose that the end of the senior year in college marks a sharp division between completed mastery of the science, on the one hand, and development of research ability, on the other. But the recent graduate has at least had fair scientific training in theory and manipulation and he is now free from the necessity of carrying other studies. Also he should have an attitude of more complete devotion to the one absorbing subject of chemical investigation. Given the proper research atmosphere, an inspiring and able director and the will to work, he can now begin to know something of the meaning of research.

In addition to the benefit to be derived by the graduate student from devotion to the work of scientific investigation under proper direction, there is to be considered the reaction of this upon the undergraduates of the same school. For the undergraduate to be denied the opportunity to carry on research is not then in the nature of a discouragement. Rather, it should be a constant source of inspiration to him to see a relatively small but enthusiastic body of graduate students doing effective research work and providing material suitable for presentation before critical scientific bodies and for publication in important scientific journals. This kind of work is kept before the undergraduate as a possible and desirable future activity for him as an individual and he is likely better to appreciate the necessity for a thorough preparation in the necessary foundation for such work.

When we inquire what Indiana is doing to provide facilities for graduate work in chemistry, we are led to see why it is that our Indiana colleges are turning out so few chemists who are prepared to do independent research work of an enduring character. Apparently neither of the two major State colleges is prepared, in equipment, buildings or professorial staff, to give extensive or serious graduate courses in chemistry, leading beyond the degree of Master of Science. At Purdue we are, candidly, not attempting to do it. We have no organized graduate school and we have

never conferred the degree of Doctor of Philosophy or any other doctorate, excepting an honorary degree on two or three occasions. It is recognized that the existing limitations in available funds makes it difficult to provide instructional staff, buildings and equipment to meet the needs of the ever growing undergraduate departments and that it would be impossible, under the circumstances, to conduct a creditable graduate school which would attract any considerable number of students. As a result we have available for experimental research, practically no one except graduate assistants who are proceeding to the Master's degree.

At our sister institution (Indiana University) a graduate organization is maintained but examination of most of the catalogues for a dozen years back fails to show that any one has ever received the degree of Doctor of Philosophy, with major work in chemistry, from that institution. I have not discussed this matter with any member of the chemical faculty of Indiana University but I have an idea that their story would be about the same as ours,—that they are unable to provide adequate facilities for the administration of high grade graduate work in chemistry and so choose to devote their energies to undergraduate training.

The State is losing, incalculably, as a result of this policy. Compared with the important universities of other states, our state colleges are accomplishing a painfully small amount of chemical research. The time and energies of our professors are consumed in routine teaching of large classes of undergraduates. Even at that, many of our more ambitious professors could and would be productive researchers if they could have a reasonable number of graduate students available for doing the experimental work of research problems under their personal direction. Every one who is at all informed on this subject knows that the great mass of university research work of today is done in this manner. The directing professor, through his extensive knowledge and experience, originates the basic idea and plans the research, in the main. The graduate student carries out these plans in the experimental laboratory, makes observations and obtains necessary data. Also, if he is the right sort and has the "stuff" in him, he catches the inspiration of his teacher and, through intimate contact and numerous discussions, learns his methods of reasoning, of planning investigations and of arriving at conclusions.

As a State we therefore lose, also, the opportunity to send forth into useful service a body of young men and women, trained in the methods and inspired with the purposes of scientific research. Our chemical graduates are a splendid asset to the State and to the nation but their work, for the most part, lies elsewhere than in the lines of research.

It is my personal belief that Indiana has not yet awakened to the needs of higher education. We deal in a niggardly fashion with the only institutions that we have legally provided for keeping the lamp of education burning. I have been reliably informed that the President of the University of Michigan is asking his state, this year, to furnish over eight million dollars, merely to provide for immediate and pressing needs, and that there is every prospect that this money will be given. What might out two State universities do with half, or even one quarter of this amount?

I should like to close this brief discussion by stating it as my firm conviction that, do what we will or try what plan we may, Indiana will never

succeed in training any considerable number of chemists for research, or in accomplishing any very large amount of research in her colleges until really adequate provision is made for the best modern graduate departments. And may I recall the statement made at the beginning of this paper, to the effect that this conclusion may possibly apply, in a measure, to sciences other than chemistry.