THE RELATION OF PURE AND APPLIED SCIENCE TO THE PROGRESS OF KNOWLEDGE AND OF PRACTICAL AFFAIRS.

1. The Relation of Pure and Applied Biology.

Cornelius Betten.

It may be well to call attention to the fact that the subject set for discussion makes distinctions which, if they are convenient, are after all largely fictitious. The contrast between pure and applied science, as generally conceived, is that implied in the statement of the subject, namely, that applied science has to do with the practical affairs of life, while to pure science

we indefinitely ascribe the progress of knowledge. This distinction means little or nothing to us. If history teaches us anything, it teaches that the advance of knowledge is the most practical affair in which we may engage. It shows us that scientific investigation which seems farthest removed from the life of the people today, may before long have tremendous bearing upon the welfare of our own species. It is, of course, for us individually to decide where we can most advantageously help the cause and train and broaden ourselves in the doing of it; by remaining close to what is today the vital practical application of science, or to venture into studies whose ultimate bearing upon human life can only be conjectured. To those of us who are in the work of education it becomes a pressing problem also to decide this question for those who come under our guidance. There are certain apparent dangers in the introduction of vocational work in non-technical education, and so guarded have we been against them that the general attitude is to admit only the minimum that is needed to enlist the interest of the student. At present however, it is becoming more common to admit the maximum that will not conflict with well established educational principles. It seems to be becoming more clear that the practical bearing of a subject is a real asset. We should understand, however, that the aloofness of science from common affairs is obviously a matter of degree, and time generally wipes out that difference or not infrequently inverts its terms. We may hope that our pure science, in the pursuit of it or in its direct results, may some day bring benefit to mankind, and we may at the same time fervently believe that the immediate relation of applied science to the needs of the human race does not vitiate its educative value to him who engages in it.

It is obviously not possible in the time here allotted to review with any degree of care the multitudinous ways in which the biological sciences are today affecting the progress of the race. At the risk of dealing only in what may be platitudes to this audience, I limit myself to some of the more general aspects of the question.

Any science evidently affects the progress of the race in three ways: it trains men in methods of thought and work, it furnishes a body of directly useful information, and it establishes a few general concepts that have great influence in determining men's approach to the problems of life.

In method the sciences are fundamentally the same, though they may differ in the stage of their development. Thus today biology is only entering that phase in which physics has for a long time been and into which chemistry has more recently entered, namely the stage of experimentation. There still remains an inexhaustible supply of material for new descriptive work, and all of the old material will have to be worked over again and again with the old methods but with new points of view. But in addition, we are recognizing in all fields of research that significant advance must now come from the adoption of the experimental method rather than from the older method on either old or new material.

It is probably a difficult matter to get an estimate of the results which scientific work, whether in the schools or in the shop and factory, is having in improving the habitual methods of thought and action in those pursuing it. I know of no reason for discouragement in this respect, though we may all regret that the results are not more marked, and may welcome such sympathetic criticism as Dewey has recently given in this connection. (Science Jan. 28, 1910.)

As to what biological science is doing in amassing information directly useful to man, it is hopeless to attempt a categorical account. In agriculture, horticulture, in plant and animal breeding, in relation to the cure and prevention of disease, and in allied fields, biological investigation is transforming our world. It is not too much to say that the advances in these lines are among the most significant facts of contemporary history. The work centering about the subject of heredity and plant and animal breeding is perhaps just now in the center of interest. On the theoretical side this work has of course raised about as many questions as it has answered, but the practical results of the careful study of hybridization and selec-

tion will soon be universally felt, and the possibilities now seem enormous. I mention this subject of heredity especially because it is such a capital illustration of the way in which years of independent and apparently unrelated work in taxonomy, morphology, cytology and embryology may come to converge sharply upon a definite problem of universal human interest.

Finally, what has biology done in giving us fundamental concepts which may dominate in our mental habits? We often say that great questions are likely to be decided by relatively trivial things, by the feelings of the moment, determined perhaps by the last previous meal or by the nature of our night's rest. In saying this we are doubtless taking the interesting exception as the rule. The educated man views his problems and determines his course largely by a few fundamental principles that have become part of his mental make-up. The special field of one's work may therefore readily affect one's general attitude by making its peculiar basic principles pronounced in him, quite as well as by the method with which it equips him. These broad principles naturally overlap in other fields, and the danger of not appreciating the differences in their applications to different materials is very great. It is the fortune of biology to have as its dominating concept the idea of genetic continuity in the forms which which it deals, a concept which after it has been vitalized by biological investigation has become quite as dominant in many other fields. The man who has once seen the organic world as the biologist sees it, who has some conception of the intricacies of phylogenetic relations and the factors concerned in development, is not likely ever to lose the dynamic point of view. He may not know as much as he would like to know of the political, social, or religious movements of the world, or of the philosophical systems which have held their sway, but his approach to all of these will be immeasurably improved if he regards this world in its forms and its activities as a "stage" in more than one sense of that term. In spite of the misconceptions arising from superficial contact with the facts, we shall not likely overestimate the beneficent results of the

general adoption of the dynamic view of the world and of our own ideas and activities. The adoption of that point of view may be obtained in any subject; it cannot well be missed in biology.