THE TEACHING OF BIOCHEMISTRY[1]

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Your Chairman has asked me to lead the discussion of the subject indicated by the title of this paper and, in this connection, to develop further some of the issues that were raised by the committee consisting of Professors Gortner, Read, and Kraybill, which committee reported on the teaching of agricultural chemistry at the Washington meeting last spring. In the report of this committee particular emphasis has been laid upon the desirability of modifying the teaching of general chemistry to students in agricultural courses in such a manner as to draw the illustrations largely from the field of agricultural sciences. I wish to further stress the observation that students who matriculate in agriculture do so because of their keen interest in that subdivision of applied science. They have a definite objective in pursuing their college course, and this can well be taken advantage of in developing the outlines of the various subject matter courses, including chemistry. This does not imply that the fundamentals of science need be neglected in the slightest. The committee evidently feels, however, that the instructors who handle the courses in general chemistry should have a certain familiarity with the problems of agriculture and a distinct sympathy with those problems and the objective of the students in the courses.

The title of my paper implies a little more general treatment of the subject, since biochemistry is of interest not alone to students of agriculture but to numerous other groups, including particularly medical students. There is a principle in biology that ontogeny repeats phylogeny, that is, that the history of the development of the individual is essentially that of the development of the race. May it not be that the same principle can be borrowed by the biochemical pedagogue in outlining a program of the chemical sciences for his students? Looking back over the development of biochemistry during the past fifty years we note that when it first emerged as a separate branch of the chemical sciences particular stress was laid upon organic chemistry. This was due to the fact that this was the heyday of the organic chemist, who was startling the world by the variety and complexity of the substances which he was able to synthesize and purify. Now biological substances are largely made up of organic material in a water sol or gel, and no well-trained biochemist can get very far without a fairly comprehensive knowledge of the characteristics of certain of these organic materials with which he is forced to deal. Whether he needs all the training in organic chemistry which is required of the student who proposes to restrict his activities to the field of organic chem-

[1] Read in the Division of Chemical Education of the American Chemical Society, at the Ithaca Meeting, Sept. 11 (1924), during the discussion of the Report by the Committee on "The Teaching of Agricultural Chemistry." See THIS JOURNAL, 1, 177 (1924).

istry is doubtful, but certainly he must make a comprehensive survey of the carbon compounds. In such a course the instructor should draw his illustrations, so far as possible, from the materials with which the biochemist will later be concerned, and can substantially reduce the content of the extensive courses in organic chemistry to the extent of eliminating many of the detailed considerations of benzene derivatives. In discussing the benzene series much more advantage would accrue from the presentation of a few of the fundamental principles which appear to govern the reactions of typical carbocyclic compounds, rather than an extended consideration of the synthesis of various dyes and the like. One exception to this general statement should be noted. Those biochemists who propose to engage in pharmacological research need a more extensive knowledge of the carbocyclic compounds, and in many chemistry departments advanced courses in this subdivision of organic chemistry are already provided.

In the phylogeny of biochemistry the physical chemist made his appearance after the organic chemist, and, similarly, in developing a course for the present generation of biochemists a course in physical chemistry should be fitted, if possible, into the third year of the curriculum. Now there is a fine opportunity for argument as to which should precede, organic or physical chemistry. If we survey the average curriculum we find it is difficult to give the student the necessary training in mathematics to enable him to pursue a course in physical chemistry to advantage much before the beginning of the third year of university work, however, while the student can get along without this mathematics in the development of the work in organic chemistry. It is perhaps more difficult at the present time to find an instructional staff capable of teaching physical chemistry and at the same time familiar with the interests of the biologists. Recognizing this fact, we must turn our attention to the development of a corps of instructors adequate to this task. Certainly with the numerous physico-chemical phenomena which determine the progress of biochemical changes in living matter, no biochemist can consider himself adequately trained until he acquires a familiarity with the physico-chemical principles that are involved.

And finally we have the latest development in the field of physical chemistry known as chemistry of the colloidal state. The same remarks respecting the scarcity of trained physical chemists who are sympathetic with the problems of biology apply equally well to the present generation of colloid chemists. Certain schools are gradually training a group of instructors who will shortly be available in developing this subdivision of the science. A consideration of the colloidal state of matter should precede the usual consideration of the biochemistry of proteins, carbohydrates, and lipoids, since these materials occur in living tissue either in that state, or in solution in the aqueous phase of a sol or gel. Their significance and behavior are consequently largely determined either by their colloidal nature, or by their effect upon the colloidal material with which they are in contact.

In one of the later stages of the phylogeny of biochemistry there was a period of intense interest in enzyme phenomena. Many of the supposed facts developed in this earlier period of interest are now regarded with some skepticism, however, and it appears quite probable that the subdivision of the chemistry of enzyme action is about due to be worked over, in the light of the increasing knowledge of physico-chemical principles and the behavior of material in the colloidal state. The rising generation of biochemists can undoubtedly bring their more extensive training to bear on the solution of some of these problems, and I feel that this constitutes one of the most fruitful fields of research now open to the young research worker. Likewise, the instructional staff must give careful attention to discoveries that are made in this field and be alert to add new facts to the content of his courses.