complete equipment to be secured. In addition to this provision for annual support, the institute has recently received from Dr. Norman Bridge the promise of $200,000 for an extension of the physics laboratory and of $50,000 for its library.

It is also announced that the Southern California Edison Company will immediately erect at a cost of $75,000 on the campus of the California institute a high-tension laboratory where an extensive investigation on the transmission of power at high voltages will be made by the staffs of the company and of the physics and electrical engineering departments of the institute under the direction of Professor R. A. Millikan and R. W. Sorensen, and where other scientific researches will be carried on by the professors of the institute in cooperation with the Mt. Wilson Observatory.

A large project of research work will be at once undertaken, involving the close cooperation of the Mt. Wilson Observatory, the Norman Bridge Laboratory of Physics, and the Gates Chemical Laboratory of the institute. This research project will consist in a systematic attack on the most fundamental problem of physical science to-day—that of the constitution of matter and its relation to the phenomena of radiation. Further advance in these fields is to be expected, on the one hand, largely through the utilization of the most powerful agencies, such as enormously high temperatures and pressures, high-voltage discharges and intense magnetic fields; and, on the other hand, through the active cooperation of physicists, astrophysicists, mathematicians and chemists, whose combined viewpoints, knowledge, and experimental skill will contribute. These conditions already exist in large measure at Pasadena, but the scientific staff and the experimental facilities are to be so extended that the opportunities for the investigation of this fundamental problem will be exceptional.

It is also announced that, in order to supplement the work in mathematical physics now carried on by Professor Harry Bateman, Profesor H. A. Lorentz, of the University of Leiden, will be in residence as lecturer and research associate of the institute during two months of the winter term, and that Dr. C. G. Darwin, of the Univerity of Cambridge, has been appointed professor of mathematical physics at the institute for the college year of 1922–23.

THE COURSE IN GENERAL ZOOLOGY: METHODS OF TEACHING

Professor Shull has done a signal service to the teaching of general zoology by calling attention to the defects of the one-time prevalent "type course" and to certain advantages to be gained by basing the course on general principles. The kind of course deemed best by Professor Shull is indicated in his papers in Science[1, 2] and his recent "Principles of Animal Biology"[3] and "Laboratory Directions."[3] Professor Nichols[4] has discussed the relative merits of a course in general biology as compared with separate courses in botany and zoology, and Professor Henderson[5] has made a plea for the substitution of the study of human physiology for the study of animals and plants. Professor Colton[6] has discussed aim and incentive from the standpoint of the attitude of the student toward the subject. In none of these papers, however, has much been said as to fundamental *purpose* or *method.* Professor McClung[7] in his appeal for a discussion of the general course in zoology indicated that these subjects should receive predominant attention in any effort to arrive at a satisfactory conclusion as to how the course should be given. It is to the subjects of purpose and method, and especially the latter that the writer desires to invite attention.

It would seem to be self-evident that matters of content, arrangement and method should be determined by the aim or purpose

1 Science, December 27, 1918.
2 Science, March 26, 1920.
3 New York, McGraw-Hill Book Co.
4 Science, December 5, 1919.
5 Science, January 16, 1920.
6 Science, April 16, 1920.
7 Science, April 11, 1919.

for which the course is given. To a certain degree, also, the purpose should be influenced by the character and prospective careers of the students taking the course.

With regard to the latter consideration it may be assumed that in a majority of college classes in general zoology there are roughly two groups, one composed of those who will take no other courses in the subject but who are destined to enter upon a great variety of walks of life, and the other composed of those who will pursue the subject further, to prepare themselves to become physicians; teachers in high schools, colleges and universities; investigators or other kind of professional workers.

It may properly be asked whether it is possible to give a single course which will satisfy the needs of these different groups of students. The writer believes that an affirmative answer can be given. The general purposes in teaching zoology are necessarily identical with the aims of all education, namely, to make life more worth while for those who attend the schools by developing and training their mental faculties and by extending their knowledge of themselves and the world in which they live. The purposes thus include giving information of a valuable nature, and giving training. Nearly all of the scientific work being done in the world to-day is accomplished by persons trained in scientific methods; and it is the trained mind and hand that employers everywhere are demanding. Consequently training of the right kind should be of value to all classes of students while information or content may be varied to meet the more special needs of each class.

As to the nature of the training that should be given Professor Nichols has given an admirable statement:[4]

> The value to the student of biology or zoology as a cultural study lies quite as much in methods acquired and in facts observed as it does in information received. First and foremost the student should be taught to be careful in his technique, to be precise in his observation, to be thorough in his attention to details, to be keen in finding things for himself, to be accurate in his conclusions.

To these may be added—to make effective use of the English language. Surely no student, no matter how he may be planning his future, could fail to profit by a course which gave training in the qualities enumerated.

Is it not therefore necessary to select with care the method of teaching which will give the best results in accomplishing the kind of training indicated? The too-prevalent method of confirmation or verification, when used exclusively or combined with purely informative methods, can scarcely give the desired results. The so-called scientific method, involving so far as is practicable the method of discovery, must be employed if training for individual initiative or independence of thought is to be acquired. And unless the student does learn to think independently he can never take the leadership in the community for which his education should be his preparation.

The scientific method has been called the method of common sense extended and systematized. It involves the inductive process of drawing conclusions from observed facts. It is not only the basic method for all scientific work but it is applicable to almost every field of human activity requiring thought and judgment. In applying it there is assumed a purpose or goal to be reached or problem to be solved which is stated or described as clearly as possible. Then observations are made which may or may not be based on experiment. The observations are made with great care and as extensive as time and material will permit. The observations are recorded in some permanent and convenient form by the use of notes, drawings, models, charts, graphs, maps, or photographs, depending upon the nature of the material. The data thus secured are correlated and coordinated (synthesized) so that a conclusion may be drawn. Should not every course in a science give training in the scientific method?

As a further amplification of the views of the writer with regard to the use of this method in the course in general zoology, extensive references will be made to the course given at the University of Pennsylvania since the plans for this illustrate in a concrete way the ideas that the writer desires to convey. With reference to this course it should be said that it was established upon the basis of "general principles" about twenty years ago when Professor Conklin was head of the department. The instructors concerned are therefore in hearty accord with Professor Shull's efforts to extend the employment of such a plan. For the past few years also a serious effort has been made to apply the scientific method throughout the part of the course devoted to laboratory studies and the results have more than justified the efforts in this direction. The laboratory work, occupying more than two thirds of the time devoted to the course is, consequently, presented to the student in the form of a series of problems framed as far as is practicable upon the method outlined above.

In deciding how the course should begin a number of purposes have been kept in mind. An effort has been made to lessen as much as possible the difficulties that students have in getting started on a new subject under entirely novel conditions. Contrary to the rather widespread practise of beginning with the cell or a protozoon, an animal is used at the start which is large enough to be seen without special equipment, since to get acquainted with the compound microscope constitutes no small task in itself. Another reason for taking a larger animal is that it is much more likely to fall within the range of the student's experience, and, further, since the student is accustomed to look at animals as individual entities, it is more desirable to present an entire animal than any part of it such as a cell or tissue. It is an open question whether it is better pedagogy to begin with the simple (cell—protozoa) and proceed to the complex (entire animal—metazoa) or to proceed from the more familiar (entire animal) to the less familiar (tissues and cells). As a result of their teaching experience the instructors giving this course have adopted the latter alternative. They are furthermore in agreement with Professor Nichols when he says:[4]

> Let the student learn to be analytic before he attempts synthesis.

In choosing the first animal it has also seemed desirable to select one which is definite in its morphological characters and complex enough to afford a good test of the student's powers of observation.

With the foregoing considerations in mind an Arthropod, such as a grasshopper or crayfish, has frequently been chosen and used with much success. At the beginning the student is asked to study carefully a specimen of the chosen animal and to make two pictures of it; a word picture, thus permitting him to use his most familiar tool of expression, his language; second, a picture in the form of a drawing. He is asked to organize his description carefully, make an outline of it and then write it out, using the best English at his command. He is asked to compare his two pictures and decide which is the more accurate: this is the problem set for him to solve. Almost without exception the student perceives that the drawing furnishes a much more accurate picture of the animal than does his description and thus some of the objections that students are accustomed to make to the requirement of drawings are met and disarmed at the very outset.

Then through a series of problems the student is asked to determine in an analytical way the external anatomy of the animal, recording his observations in the form of fully labelled drawings. At the end he is asked to integrate his information into an essay upon the specimen as a whole animal.

This study is followed by an exercise on classification most of the material for which the student collects for himself. Next a vertebrate, such as a frog, is introduced to give a better basis for the subject of general physiology, which is presented primarily from the standpoint of human physiology, but also with reference to the animal which is being dissected. The student is thus introduced to the more general morphological and physiological characteristics of living things, is brought to see the application of these principles to his own body and mind, and perceives the fundamental similarities between himself and the lower organisms, the latter represented by his laboratory specimens.

Next the student is given an "unknown" vertebrate to study. For the most part the student is placed on his own responsibility and judgment in handling the new specimen, his problem being to determine and record facts in the best possible manner, and to make intelligible to any one unfamiliar with it, the appearance and organization of the new animal. Having been given a method with the earlier specimen he is expected to apply it to the second. A large majority of the students give a ready response to this appeal to their individual initiative and to the opportunity for making discoveries for themselves. In some cases an interest which may have been lagging is stimulated into renewed and sustained activity.

The compound microscope is next introduced by a special problem on the use of the microscope, and this is followed by the study of cells and tissues. Then follow in succession studies on embryology, cell division, maturation and fertilization, with especial attention to the behavior of the chromosomes. But since the complex behavior of the chromosomes in mitosis, maturation, and fertilization is most satisfactorily explained as the mechanism for the behavior of mendelian factors, the subject of heredity, and especially mendelism, is considered along with these morphological studies. A book on heredity, such as that of Conklin[8] or that of Guyer[9] is read by the student and he also carries out a breeding experiment with *Drosophila.*

Next an evolutionary series is presented consisting of representatives of the protozoa, cœlenterates, flat worms and annelids, followed by other studies illustrating evolution. In addition to furnishing evidences for organic evolution, the series is made to illustrate a variety of biological principles, further details about which will, for the sake of brevity, be omitted here.

These objective studies are handled in the form of problems based upon the scientific method previously outlined. As the course develops and the student gains in experience he is placed more and more on his own responsibility as to methods of procedure and record, thus permitting him to apply the lessons in method that have been learned. In addition to training in method, the student gains through these studies much of the information that he is supposed to acquire, and gains it in a way that will make it of the most value and permanency for him. Additional information is conveyed through lectures, quizzes, and assigned readings, so selected and arranged as to emphasize general principles and to contribute to the "unity and balance" of the course.

Since the scientific method is more time-consuming than other methods, its use imposes rather definite limitations upon the amount of ground which may be covered in any given time. But the results have been so much more satisfactory than those secured by other methods that the instructors giving the course feel that its use is thoroughly justified.

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8 "Heredity and Environment," Princeton, Princeton University Press.

9 "Being Well Born," Indianapolis, Bobbs-Merrill Co.

LOUIS ALBERT FISCHER

LOUIS ALBERT FISCHER, physicist and chief of the Division of Weights and Measures of the United States Bureau of Standards, died at his home in Washington on July 25, aged fifty-seven years. Early in life he joined the old weights and measures office of the U. S. Coast and Geodetic Survey. During this period he compared the standards of length in the custody of the national government with the standards submitted for test by manufacturers, educational institutions, and the various state weights and measures bureaus. The duties of this position also included the standardization of weights, the ordinary weights of commerce as well as the weights