sity, and will begin his duties December 1, 1914. The following additional full-time instructors began service this year: Henry O. Feiss, A.B., M.D. (Harvard), D.Sc. (Edinburgh), in experimental medicine; Gaius E. Harmon, M.D. (Boston), C.P.H. (Mass. Inst.), in hygiene; Bradley M. Patten, A.B., Ph.D. (Harvard), in histology and embryology; George E. Simpson, B.S. (Illinois) in organic and biochemistry.

The following appointments have been made in the department of psychology at the University of Illinois: Dr. Homer B. Reed, instructor; Dr. Joseph E. De Camp, assistant; Miss Anna Sophie Rogers, graduate assistant, and Miss Helen Clark, fellow.

Dr. Rudolf Rothe, professor of mathematics in the Technical School at Hanover, has been called to the Technical School at Charlottenburg to succeed the late Professor Hettner.

Dr. Peter Debye, professor of physics at Utrecht, has accepted a call to Göttingen.

DISCUSSION AND CORRESPONDENCE

THE HISTORY OF SCIENCE

To the Editor of Science: During the past months I have written a number of professors, deans and college presidents, as well as directors of institutes of technology, in reference to the value to American undergraduates of the study of the history of the sciences and industries. In each case the response received has been marked by cordiality and enthusiasm; so that I am now encouraged to seek a larger audience than can be reached by private correspondence. May I hope that the columns of your periodical will be open for a discussion of the matter?

Many of my correspondents (whose names, unfortunately, I have not yet sought permission to quote) feel that if in their undergraduate days they had been given a survey of the development of the sciences, or, better still, had been led to trace the evolution of scientific thought, their individual mental progress would thereby have been much stimulated and advanced. They feel, moreover, that such a course of study as I suggest would be of special value in America, where our life and institutions commit us to the ideals of a democratic culture.

It is of course widely recognized that the individual sciences would be better taught if presented on an historical background; we know most vividly what we know in its origins. An old-fashioned course in chemistry taught us that oxygen was a colorless, tasteless, odorless gas, non-combustible, but a supporter of combustion, and left it to later chance reading to disclose the thrilling story of the discovery of oxygen. Those fortunate enough (perhaps years after graduation) to read eventually of the men of genius, Scheele, Priestley, Lavoisier, who had agonized to attain the generalization that had seemed so tame and valueless to the undergraduate, realized the defectiveness of instruction that sought to give the results of scientific investigation without availing itself of the historical motive.

The practise of teaching the sciences in their evolution is a needed modification of Herbert Spencer's pedagogy, without which his theory is both inconsistent and rude. On the one hand, he, like a true follower of Auguste Comte, held that the development of the individual intellect should rehearse the course of the history of civilization; on the other hand, he attacked as too primitive what he called the esthetic and ornamental studies. If he had supplemented his devotion to the sciences (as he understood them) by a recognition of the sciences in their development he would have been more consistent, and perhaps have been less bellicose in his attitude toward those languages in which Archimedes, Lucretius and Galileo wrote. That the history of the sciences was the essential history of civilization and as such should be rehearsed by each developing mind he still could have maintained.

Another defect in the undergraduate curriculum that might be made good by the general history of science is the lack of connection between scientific studies. In the old-fashioned college the student was permitted to take up biology in the freshman year, physics and chemistry in the sophomore, mineralogy and crystallography in the junior, and geology, astronomy and psychology in the senior. Scarcely a word in reference to the mutual influences and interconnections of these sciences! Only the exceptional graduate was able to bring order out of the chaos of knowledge he bore away with his skeepskin.

Those who attend American institutions of higher learning might easily be made to see in the beginnings of science essential problems in their less complex forms, and realize that organized knowledge arose in connection with industry and human needs. They could be placed in a position to appreciate the present-day applications of science, and to welcome future inventions and discoveries. At the same time they would learn that some of the most abstract reasoners have contributed to racial progress through studies that were not obviously utilitarian. They could be made to understand that science is the constant pursuit of truth and not merely a treasure-house of truth already attained, and incidentally that it is no reproach to science that it does not teach to-day what it taught five hundred years ago, and that Darwin did not live in vain even if what he discovered is also in the process of evolution. As already indicated, our undergraduates through the example of the great scientists should be stimulated to research and independence, and weaned from the childlike notizenstolz of the academic classroom.

Of course in order to be truly cultural a course in the history of the sciences must rise to general ideas, discuss cause and effect, the constitution of matter, and the conceptions fundamental to all the sciences. In a word it must be interpretive and not merely narrative. In fact, the subject of study I am discussing first presented itself to my mind as an equivalent in this institution of the traditional history of philosophy, a means of deepening our culture without prejudice to our confessed practical, vocational aims. It was soon realized that the general history of science affords a unique approach to the history of general thought. The history of philosophy can be reread in the light of the history of science.

For example, we all learned at college that Thales saw in water, or the moist, the principles of all things; but we were not taught at the same time that twenty-three centuries elapsed before men discovered the constitution of water as we understand it, and before it was demonstrated that water could not be reduced to a solid by boiling; that Thales was dealing with what a later time called the states of aggregation of matter; and that liquid, or possibly fluid, might represent his conception. Similarly we studied the theory of the pneuma without knowing that it was late in the eighteenth century that a great chemist published his "experiments and observations on different kinds of air." The nature of the elements, the reality of the concept, the permanence of species, the transmigration of souls and genetic psychology, these topics will suggest to my readers points at which the history of science throws light on the history of philosophy. Indeed whole periods, like the scholastic (with its insistent question: What is the difference between this and that?), assume a new value as seen from the standpoint of the history of science.

Dannemann's work "Die Naturwissenschaften in ihrer Entwicklung und in ihrem Zusammenhange" has the merit of offering a wealth of material on the subject it treats. The fourth volume gives excellent bibliographies of the general history of the sciences, as well as of astronomy, physics, chemistry, mineralogy, geology, zoology, botany, general biology, medicine and hygiene, technology, mathematics, etc. It is far from being an ideal text-book, but it affords a fascinating survey and leaves no doubt in the mind of the experienced instructor that the history of the sciences could be treated in a way highly acceptable to the American undergraduate. It would interest the humblest intelligence, and stimulate the exceptional minds to the heights to which they might be capable of attaining. The tactful instructor would emphasize the narrative or interpretative factors, the practical or philosophical aspects, of the subject, according to the abilities of the students. I can think of no better means than that which the history of general science affords of making the accumulated wisdom of the race tell on the active American life of to-day.

The problem of presenting this subject adequately would be greatly simplified if there were in English a good book of four or five hundred pages on the Evolution of Scientific Thought. Let us add, since we are merely expressing a pious wish, that it should be a model of concise and logical exposition written with the charm and lucidity of a Huxley. It should rest on a background of general ideas, and be a philosophy of the sciences; at the same time it should not neglect the applications of science, and should incite an interest in industry and invention.

Some such work is needed by the scientific world as a sort of confession of faith, or canon of the truth it holds and teaches. Without some summary of what investigation has demonstrated the professor has less authority than the clergyman in the minds of young men and women. He is held in general to be an unbeliever, because he is negative rather than positive, destructive rather than constructive, a cold critic of what others teach rather than an enthusiastic exponent of the faith he holds. The professors fail to express what they really think and feel. The mind of the learned world has traveled far from the agnosticism of the middle of the nineteenth century. It is not merely that in reference to traditional faiths scholars do not believe, or believe not; they believe something else. It is too general to say that they believe in education and enlightenment and simple goodwill. It is merely intellectual to proclaim: I believe in the law of gravitation, the nebular hypothesis, the circulation of the blood, the cellular structure of the tissues, organic evolution, the continuity of germ-plasm, the dependence of human thought on nerve tissue, the evolution of mind, and the cure of disease through the development of antitoxins. But when hundreds of such truths are presented historically as the fixed points in a cosmos established by the combined efforts of men, the cumulative effect is to take us beyond a cold intellectual formulation of an ordered universe to an enthusiastic affirmation of the reign of law to be widened by the energies of the generations. Moreover, within its scope come social and ethical as well as physical and other mental phenomena, and through the historical study of ethics and sociology the student is led to see the gradual triumph of beneficent customs and legislation, supported on principles of justice, equity, freedom and good will.

Such a philosophical summary of the history of science introducing the best minds of the continent, perhaps the foremost million of the population, to the vital ideas of the time, seems an almost imperative need of American culture. For in the realm of ideas there is no such thing as spontaneous generation. Those who seem the originators of great movements are those who have been brought under great influences. Apparent exceptions to this rule, like Shakespeare or Darwin or Lincoln, prove, on examination, excellent examples. There is little difficulty in tracing historically the continuity of human thought. It follows that we can not hope for a generation of original thinkers unless we immerse our students in the stream of the world's thought. The most inventive mind must have material on which to react, and can not strike out in a vacuum.

The more or less friendly foreign critics who discuss American culture complain of our exclusive devotion to practical aims, our lack of conversation, and a certain narrowness in our outlook. From one point of view these so-called faults seem as fair as others' virtues. But it is wisdom to recognize the just element in these strictures. Practical considerations alone warn us against narrowness of training. It can be shown from a history of the industries that frequently progress has been opposed by men whose experience has confined them to one department, or to one section of one department. Advances have come here as in the sciences from outsiders. Rightly understood this is a further argument, not for lack of culture, but for breadth of culture. Such freedom of outlook, without any impairment of our robust and practical ideals, can be gained by the study of the work of Faraday, Newton, Kepler, Franklin, Darwin and Pasteur, and the general conceptions on which their work was based.

In conclusion one must recognize that science is international, English, German, French, Italian, Russian, all nations cooperating in the interests of racial progress. Accordingly, a survey of the sciences tends to increase mutual respect, and to heighten the humanitarian sentiment. The history of the sciences can be taught to people of all creeds and colors, and can not fail to enhance in the breast of every young man or woman, faith in human progress and good will to all mankind.

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SOME INCONSISTENCIES IN PHYSICS TEXT-BOOKS

THE following is a quotation from Kohlrausch's "Physical Measurements":

> The coefficient of capillarity may be *defined* as the weight of fluid which is supported by the unit of length of the line of contact of its surface with a thoroughly wetted plate.

Now a coefficient is a proportionality factor, a pure number expressing the measure of some specified force or property. For example, the volume coefficient of expansion of a gas is the ratio between the increase in volume per degree rise in temperature, and the volume at zero degrees centigrade, the pressure remaining constant. If we keep the expression coefficient of capillarity or capillary constant it must be as the *ratio* between the weight of liquid raised above the undisturbed level and the length of the line of contact of its surface with a thoroughly wetted plate.

In my opinion there is a difficulty with ratios involving quantities measured in different units. It is much simpler, for instance, to grasp the significance of the ratio of the extension of a wire per given or unit tension, to the initial length (see Duff's "Text-book of Physics," p. 122) than of Young's modulus expressed as the ratio of the longitudinal stress to the longitudinal strain; the stress measured as tension per unit cross section and the strain as extension per unit length.

The quotation from Kohlrausch is not in any case a *definition:* it explains how the *surface tension* of a liquid may be *measured.* Capillarity is the phenomenon of rise or fall of liquids in tubes due to the surface tension of the liquids. In most recent text-books and laboratory manuals the term coefficient of capillarity, capillary constant or coefficient of surface tension is not used. Duff, for instance, and Ames in his "College Physics," state this:

> If a line be imagined drawn along the surface of a liquid, the part of the surface on one side of the line pulls on the part on the other side, and if the length of the line be supposed one centimeter the pull in dynes is taken as the magnitude of the surface tension of the liquid.

Another term used inconsistently is *specific.* A specific quantity is concrete and so should be expressed in a unit. But we find specific gavity defined as a *ratio.*

> The specific gravity of a body is the ratio of the mass of any volume of it to the mass of the same volume of pure water at 4° C. (Carhart's "College Physics"). Specific gravity may be defined consistently as the weight of unit volume of the substance (Watson's "Text-book of Physics"). But it is useful to keep in the definition, because of our methods of determining specific gravity, the idea of comparison. Kimball ("College Physics") calls it relative density, defining it as "the ratio between the density of the substance considered and the density of a standard."

The definition of the specific heat of a substance is consistently given, in most recent text-books, as the quantity of heat in calories which will raise the temperature of one gram of a substance through one degree centigrade. The specific inductive capacity of a medium is, however, defined as the ratio between the capacities of two condensers equal in size, one of them being an air condenser, the other filled with the specific dielectric. But this ratio is as often called dielectric constant, sometimes the coefficient of induction.

These points are small ones, but they are puzzling to beginners and always annoying.

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