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# CHEMISTRY AND EDUCATION[1]

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NEARLY a century and a half has passed since chemistry was first recognized as a subject worthy of study in our colleges. Maclean in his "History of the College of New Jersey" states that this college as early as 1795 included chemistry among the subjects for the study of which provisions were made. Other reputable universities of that day soon followed, and early in the last century chemistry was a required study in the course in liberal arts at Columbia, Harvard and Princeton. This new-born infant, however, was not received with any great cordiality into the family of studies that had long constituted the essentials for the baccalaureate degree. Its growth was impeded in many ways, and there were times when there was some fear as to whether it would survive the rigors of doubt and suspicion to which it was exposed. Years were to pass before laboratory work was offered as an essential part of the course, and even then in some of the colleges, at least, the students electing laboratory work were regarded with suspicion as to their sanity. They were thought by some of the classicists to be allied with the alchemists of old, who sought in secret places to transform the baser metals into gold, or to discover that mystic something that would bring perpetual youth to its fortunate possessor. Gradually the science won its way, even though there were few students and the library and laboratory facilities were very meager. The following quotations taken from the reports of the professor of chemistry, fifty years ago, in a university that to-day has a laboratory costing more than $1,000,000, adequately equipped, and with an enrolment of 3,000 students in the department of chemistry, will serve to give us some insight into the conditions for studying chemistry at that time:

> Five students took the course in general chemistry; in analytical chemistry we have two students, one of

[1] Address of the president of the American Chemical Society, Cincinnati, September 10, 1930.

whom is ready to begin his course in quantitative analysis. . . . At present the chemical library of the University consists of Watt's Dictionary—a valuable work, but not fully supplying our needs . . . we have begun to take a chemical journal. . . . A Chemical Hall is needed with which also the mining and metallurgy could be associated. This need not be an expensive structure; for $20,000 a building could be erected that would provide ample room and the very best facilities for carrying on these important departments.

Evidently in those days as in the present not all the students were adequately trained, for we read:

I regret to add that the class is hampered by a few students who are not well prepared for the work. It is probable that some, if not all of these ill-disciplined pupils will fail to pass their first examination.

Janitorial troubles there were in those days, even as at the present time, for we read again:

Each laboratory, in addition to its hood has four flues that must remain open whatever may be the theories or the practices of the janitor. It has, also, subject to the will of the janitor, an opening extending the whole length of the ceiling and open to the sky.

But a great change has taken place. Opposition to the study of science gradually gave way, and interest grew apace, so that the present century and especially the last decade has witnessed a growth in the appreciation of chemistry and in the provisions for its study in our schools and colleges far beyond any expectations. Laboratories, a number of them costing in excess of $1,000,000, have been built and furnished with all the equipment necessary for instruction and research. The enrolment has increased correspondingly. In the twenty-nine universities belonging to the Association of American Universities, there were registered in one or more courses of chemistry during the last year more than 25,000 students. According to the statistics compiled by Mr. C. J. West, of the National Research Council, the number of graduate students engaged in research in the various fields of chemistry increased from 1,700 in 1924 to 2,498 in 1929. Of this latter number, 1,200 were candidates for the master's degree and 1,298 for the doctor's degree. A recent bulletin published by the Federal Office of Education lists statistics of more than 1,000 colleges and professional schools. Counting but an average of 50 students in chemistry in each of these (a very conservative estimate) the number of students of chemistry in these institutions exceeds 50,000, to say nothing of the large number of such students in our secondary schools.

Many causes have operated to bring about this growth in the appreciation of our science. The great industrial development of recent years has created an unprecedented demand for trained chemists, a demand reflected in the number of students electing chemistry as their major course. The war made vivid the possibilities of our science and led to an increased willingness to provide adequate facilities for its study.

But along with these factors is another, which, I fear, teachers of chemistry absorbed in their work have been slow to recognize. I refer to the new views regarding education and the educative process. We are living in a rapidly changing world. Those of us at all mature in years have witnessed the unearthing of fundamental knowledge such as no other generation has ever witnessed and, some would say, more than have all other generations together. It was only about thirty-five years ago that Thomson first found conclusive evidence of the existence of the electron; indeed, most of us recall the time when the atom was regarded as a single indivisible particle, true to its name. Following closely on the discovery of the electron came the X-rays. The invention of the radio and of wireless communication is well within the memory of the youngest of us. The Wright brothers flew their first airplane on the sand hills near Kitty Hawk, North Carolina, in 1903. Automobile statistics list in 1896 only four gasoline auto cars in this country; one of these was in a museum, and another wouldn't run. To-day there are 25,000,000, and in place of going miles to see one, as I recall doing, we must watch our step to avoid one.

Along with this rapid growth in knowledge of our science and in its application to useful ends has come also a growth in appreciation of the value of education and a desire to share in its advantages. The number of students in our high schools increased from 500,000 in 1900 to 4,500,000 in 1930. In the same period the registration in our higher institutions of learning (colleges, universities and professional schools) has increased from 250,000 to 1,000,000, while more than 50,000 students are registered in our graduate schools alone. We have often heard the statement that the great teacher is born, and not made, yet to-day we find colleges of education on every hand, and we hear much of "teacher training." Adult education is coming to the fore, and even the air is filled with college courses. One has only to press the right button to bring to one, offhand, a course in almost any desired subject. Our whole nation is, indeed, going to school.

This increasing appreciation of the value of education has been accompanied, and naturally so, with much discussion as to the aims of education and the most efficient methods for obtaining the desired ends. Educational organizations of all kinds have been formed, new journals dealing with educational problems have sprung into existence, new ideas are being tested and the curricula of our schools and colleges are being modified to accord with our modern ideas. Bureaus devoted entirely to research in the field of education are finding a place in our universities, and to-day one hears almost as much about educational research as about chemical research.

Many of us, at least, have been suspicious of the modern emphasis upon methods of teaching as likely to overpower attention to content, fearful that popularization might stifle the spirit of mastery and investigation. Naturally, among the many presentations of ideas, some will appear beside the mark—even nonsensical. But it will not do for us to dismiss all this discussion with a mere wave of the hand as the lightly spun and passing theories of those who might well be engaged in something more worth while, something, we might say, more scientific and less philosophical. To ignore the writings in the field of education to-day of such thinkers as Dewey, Whitehead, Eddington, Bode, Barry and others is a reflection not upon these great scholars, but upon ourselves.

For we must keep in mind that the members of the instructional staff of the departments of chemistry in our colleges and universities are not only chemists, but teachers as well. The teacher of chemistry should be just as much concerned with what is new and of value in the theory and aim of education as the teacher of psychology or of English. Interest in research should not diminish interest in teaching. It sometimes seems to me that our appreciation of the teacher is declining. One of the most difficult positions to fill in our departments of chemistry to-day, and to my mind one of the most important, is that which has to do with guiding the instruction of the students in the basic introductory course. Men adequately trained in chemistry more and more seem to think it beneath their dignity to have anything to do with the beginner, apparently forgetful of the fact that the great chemists of all times regarded the introductory course as being of so much importance that they were unwilling to trust it to any one other than themselves.

As to methods of instruction, I confess that if by method one means order of presentation, proportion of lecture to quiz, etc., etc., I have never been able to become enthusiastic over their importance. But if by method is meant such an ordering of classroom and laboratory as will develop in the student alertness, mastery, self-guidance and the reseach spirit, then method is important; there must be certain fundamental principles underlying all successful methods of teaching, important and worthy of study, and teachers apparently brilliant may fail of results because of lack of them.

But whatever may be the facts concerning the value of the study of methods, there certainly can be no doubt as to the value of the study of the aims of education; for if we are to do effectively we must have a very definite and clear-cut idea as to what we are attempting to do. It is especially essential that teachers of chemistry be familiar with the best thought of the day concerning the aims of education. For, to a constantly increasing extent, chemistry is taking its place as one of the fundamental subjects included in the liberal arts curricula of our colleges. All evidence points to a constantly increasing appreciation of the value of our science as a constituent of these curricula. "More and more," says a writer, "science will find its way into our college courses, for what we need and what we must have is significant knowledge." The one thing that may interfere with this increasing appreciation will be the failure on the part of the teachers of chemistry to understand that they are not being asked to make technical chemists of the students in the basic introductory course but to provide a piece of genuine scientific training, however limited, that shall lead students to understand, to trust and to appreciate the scientific habit of mind as one of the great determining factors of our civilization, and that shall put them in possession of those fundamental principles of science, serviceable whatever be their walk in life.

There has been much discussion as to whether chemistry viewed in this way as a constituent of the course in liberal arts should not have a different treatment from the course arranged for our future chemists. We have, at least, a name for such a course; but in the main, the discussions have had little influence on the character of the course.

Two methods of procedure are open to us. (1) We may separate our students into two classes, according to whether or not they expect to make chemistry their life work, and give to each class courses differing fundamentally in character; or (2) we may so shape our introductory course that it will serve the aims of education and be of value to all students alike. The first of these methods is open to the very serious objection that the course offered to the general student is likely to resolve itself into a collection of facts pertaining to chemistry, interesting undoubtedly, but serving neither the aims of education nor those of science—enjoyable bedtime reading but out of place in serious college work. Equally true, the technical course might miss many of the suggested and cultural values. It would seem entirely possible to frame a course that would be of value to all alike, providing a foundation knowledge of the science of chemistry but stressing acquaintance with fundamental laws and principles; also habits of clear thinking and independent judgment such as contribute to constructive ability and ultimately to good living as well. Many a liberal arts student not supposing himself interested in science through such a course has had awakened the profound intellectual passion of his life.

With the belief that the basic introductory course in chemistry should be of such a character as to make it serve all students alike, the future chemist as well as the non-chemist, I propose to select one or two of the fundamental ideas concerning education that seem to me especially applicable to such a course. In doing this I shall quote directly or indirectly from such authorities as Dewey, Whitehead and Barry, for, as expressed by a recent writer in the *Atlantic Monthly,* one can not write intelligently concerning education to-day without finding oneself sooner or later cribbing from one or another of these leaders of educational thought. Moreover, I am only too well aware how inadequate the necessary condensation will seem to scholars in this field.

In brief, we are passing from the static, receptive idea of education to the dynamic idea; from the view that education consists in the mere accumulation of knowledge as an end in itself to the view that knowledge is to be sought in order that it may be used to invent, to create, to control; from an idealization of the past to an immediate concern with the present, based upon the power of scientific control. The past is our storehouse of experience and the foundation under our feet, and is of value just in so far as it is of service in guiding us into larger knowledge and into those uses and applications that contribute to right living. "Education is the art of utilization of knowledge," says Whitehead. "The only use of knowledge of the past is to equip us for the present. . . . We must beware of inert ideas, that is to say, ideas that are received into the mind without being utilized, or tested, or thrown into fresh combination." Education, then, is intimately connected with right living, with the ability to understand and relate ourselves to the civilization in which we live.

In a process of education as so conceived, we are using, and developing by using, the scientific method or habit of thought. Indeed, it is this development of the scientific method or habit of thought which is the scientist's fundamental contribution to the educative process. "From the humanistic as well as from the purely intellectual point of view, the general acquisition of scientific knowledge is of far less consequence than the inculcation of the scientific habit of thought" (Barry).

What then should be the character of our introductory course in chemistry, to the end that it will be in harmony with these modern views concerning education, and with the function of the contribution to be made by scientific training?

(1) In the first place, the subject must be chemistry, sound chemistry, fundamental chemistry; not a mere collection of interesting facts illustrated by striking experiments in which the fireworks entirely blind the students to the principles involved. Not facts in chemistry, although these are important, but ability to think in the domain of chemistry must be the chief end. Chemistry lends itself so admirably to a display of that which partakes of the miraculous that it is difficult at times for the teacher to keep from lapsing into the rôle of the prestidigitator. There is much to be said for the insistence of the late Johannes Thiele that all apparatus used in illustrating his lectures should be of the simplest possible type, most of it home-made, so that the principle to be illustrated rather than the apparatus used should engage the attention of the student.

I may be wrong, but I can not help believing that at the present time we are overstressing the popular side of chemistry to the detraction of the science itself. Popular chemistry has its place, a very important place, and we owe a great debt of gratitude to men like Harrison Howe and to our late lamented Edwin Slosson, who wrote accurately and interestingly concerning the affairs of chemistry in a way that the average person, wayfarer though he might be, could understand. We are greatly indebted also to the Chemical Foundation, and especially to Mr. and Mrs. Francis P. Garvan, for their generous aid in arousing a wide-spread interest in chemistry. But when popular chemistry finds its way into our high schools, and it is doing so, and even I fear into some of our colleges, not as an addition to but as a substitute for the side of chemistry that must prevail if our science is to serve either the aims of education or the development of the science itself, there is cause for serious thought. There is a great demand to-day, especially in our high schools, for the so-called practical chemistry, a demand that is reflected in the advertisements of our text-books in chemistry; and some seem to forget that all so-called practical chemistry to be of any value must be based upon fundamental theoretical principles. We must remember that the mere storing of one's mind with facts, however interesting they may be, is not education; neither is it science. All modern philosophies of education cry out against it. Henry Adams says somewhere, "I have never loved or taught facts, if I could help it, having that antipathy to fact which only idiots and philosophers attain," and one of his students has stated that "mere facts bored him. Adams-like he was unhappy unless he could get at laws, principles." "A merely well-informed man," says Whitehead, "is the most useless bore on God's earth." I suspect that it was the same idea that led the late Samuel Crothers to write that delightful essay on the "Honorable Points of Ignorance." We may well ask ourselves whether in our introductory course we are not overstressing the merely interesting and the entertaining, giving too much time to petty details rather than to fundamental principles and laws. I sometimes fear we are, and I have often wondered whether this tendency carried on through succeeding courses may not have something to do with the fact that, notwithstanding the almost lavish expenditure of money for training in chemistry in our country—far beyond that of any other nation—only one Nobel prize in chemistry has found its way to our shore.

(2) If it be true that one of the chief aims of education is the "inculcation of the scientific habit of thought," then it goes without saying that the central aim of our course in chemistry, whether in the high school or in the college, must be the development of the scientific habit of thought in the minds of the students. We talk much about the importance of this training, but I wonder how many of us keep our teaching polarized by this idea. Bertrand Russell has said in effect that while the scientist has good ideas he is slow to practice what he preaches.

(3) The end of trained thinking is scientific control. The teacher will lose a great opportunity if he fails to lead his students to see that this method of study is applicable not alone to the solution of problems that lie within the domain of chemistry, or science in general, but also to many of those problems that affect our well-being as a nation; to the problems of Muscle Shoals and to the framing of an equitable tariff law as well as to the unraveling of the vagaries of vitamin D; to the problems connected with efficient management of our cities as well as to the determination of isotopes; to the problems confronting the agricultural interests of our country as well as to the action of chlorophyl in photosynthesis. The scientific method must be the dependence in the solution of all such problems, and when this method is cast aside, either through the urgency of immediate action or because of special interests, sooner or later the penalty will be exacted. It is a pitiable spectacle to-day that the judgment of more than 1,000 of our leading economists in regard to a subject upon which they should be preeminently qualified to speak could be disregarded by that honorable body, the Senate of the United States. It shows either a woeful ignorance on the part of our economists or an entire absence of sound judgment on the part of the Senate—you may take your choice. Our Congress would hardly pass laws affecting the well-being of the human body against the protest of 1,000 of our leading physicians; but when it comes to the consideration of ailments affecting not the human body but the body politic, even the wayfarer regards himself as capable of writing the prescription.

What we need to do is to develop in our people the *scientific mind* as opposed to the *popular mind,* and the right beginning of this must be made in all the science courses of our colleges and even in our high schools. Wolfe in his book "Conservatism, Radicalism and Scientific Method" discusses the characteristics of these two kinds of minds, and I quote briefly, although not always literally, from him:

> The scientific mind is objective, impersonal, and desire is subordinated to reason; the popular mind is subjective, personal, with reason subordinated to desire. The scientific mind is observant, significantly informed, and curiosity is impersonal and disciplined; the popular mind is unobservant, ignorant, and curiosity is personal or lacking. The scientific mind is objectively skeptical, critical, tolerant, and can suspend judgment; the popular mind is credulous, uncritical, intolerant, and jumps at conclusions. The scientific mind is constructively imaginative, fearless in facing facts and courageous in defending its scientific convictions; the popular mind is fanciful, fearful of disagreeable facts and lacking in the courage of its convictions, unless motivated by special interest or backed by authority. The scientific mind has faith in law; the popular mind has faith in whim.

This development of the scientific mind in our people is a fundamental factor in promoting the welfare of our country for, as stated by Luckiesh:

> The benefit of scientific knowledge should not and will not end with its utilization in material things. Only genius can extend the border of scientific knowledge, but the humblest man can be taught its spirit. Doubtless, human beings will always have their frailties, but as the scientific spirit infiltrates more and more throughout business and industry, and thence throughout civilization, it should develop honesty and tolerance, and make better human beings.

How else than through the discipline of some one of the sciences shall our young men and women acquire this scientific habit of mind? Is it not an obligation resting upon the teacher that he keep the development of the scientific mind just as clearly in view as the content of the science he teaches? In all this the chemist must do his part.

(4) In the next place, we should not lose the opportunity afforded by our course in chemistry to teach regard for natural law.

Dr. W. W. Campbell, the distinguished astronomer, makes the following statement in reference to natural law:

> If I were asked to name and describe the most wonderful fact known to man, my reply would be: So far

as our observations and experiences go, every particle of matter in the physical universe is endowed with the property and necessity of obeying the fundamental laws of nature. Our universe of stars, our own star and our earth in all its parts have been developed throughout long ages, to their present state, under the guidance and compulsion of perfectly definite and apparently simple laws. We have no reason to suppose that these laws are ever set aside or varied in the slightest degree.

Many of these laws so govern the every-day experiences of our lives that even the most ignorant regard them. If one jumps off the housetop, one knows the penalty that will be exacted for ignoring the law of gravity. There are many other laws, however, not so obvious, which if ignored will exact a penalty affecting not only the individual but groups of individuals, and even the nation as a whole. I recall that in the chemical lecture room in which I sat as a student there was printed in large letters on the wall above the blackboard the sentence, "Nature makes no leaps." There it was day after day impressing a great fundamental truth upon the minds of the students. Perhaps this statement has not the dignity of a natural law, but it does express in a general way one of the habits of nature. The earth as it exists today did not leap into its present state. According to Sir James Jeans, 2,000,000,000 years of gradual development were required. Neither has man reached his present state overnight; it has, according to the same authority, taken some 300,000 years of slow development.

And natural law does not obtain only within the material side of the universe. The great principle of evolution is in the popular mind confined to man's derivation from a lower type; there is little understanding of the fact that the principle of evolution is of so wide an application that we have come to think of the growth of institutions and moral ideas and capacities for action as an evolutionary process. To ignore this law of slow development will as surely bring its penalty as to ignore the law of gravity. If "nature makes no leaps," then time is always a factor in development. Many of our troubles, individual, local and national, have been due to the fact that we are in too great a hurry to achieve results. We desire to improve present conditions by making a great leap. This tendency to become impatient and to get in a hurry has been the cause of more than one of our great wars, as well as of untold lesser troubles. The scientist has great respect for time, knowing that no matter how beneficial the final result may be or how strenuously we may exert ourselves to bring about the desired end, time is an essential factor in effecting the final solution.

We have only to look about us for illustrations of the trouble that results from refusing to regard this method of nature. For many years there was a slow but gradual progress made in overcoming the evils of intemperance. Through education and local option this progress continued slowly but surely. Then we got in a hurry, and almost overnight, under stress of emotion and by vote of the people we made a leap from a position in which a large percentage of our people could legally obtain liquors as a beverage to one in which no one could legally do so. By vote we substituted compulsion for education and continued development of ideas and good habits. And many seemed to be surprised at the results. Now, having ignored this fundamental habit of nature, we find ourselves in a pretty fix. Whether to go on in the hope that, somehow, in due time natural processes will catch up with our attempt and come to our rescue, or whether to return to a former position and to reach the desired end gradually but surely, is one of the most perplexing problems before the nation. The scientist does not expect the miraculous. His interest is centered not so much in bringing about a temporary improvement as in accomplishing a permanent result; and he is willing to wait the necessary time.

Recently we have been witnessing an effort on the part of our federal government to assist the agricultural interests of our country. It is very doubtful, to say the least, whether the temporary withdrawal of large supplies of grain in an effort to maintain the price is in accord with well-known principles of economics. Indeed, it would seem that such a procedure, even if temporarily successful, would continue to call forth increased production—a situation which every one should realize must be avoided if the goal of price maintenance is to be permanently attained. Some of our legislative bodies have a committee whose duty it is to see that every proposed bill is in accord with the constitutional law. It might be equally well to have a committee of competent persons to determine if the proposed bill is in accord with natural laws.

If our nation is to prosper and civilization to advance, we must take into account these fundamental laws and work patiently and intelligently in the light of them. Some of us are evidently too old to learn this or too egotistical to believe it; the young men and women in our colleges are neither. The importance of regard for natural laws should be impressed upon them in no uncertain way in the hope that future generations may be wiser than we. Again, who are better qualified to do this than our teachers of sciences, and upon whom does the obligation rest more heavily?

(5) Another fundamental fact that our course in chemistry should stress is the oneness of all science. How often the teacher of chemistry is informed by the student that he does not care for physics so he is

going to study chemistry, or that chemistry does not interest him and so he is going to study physiology, or even that he does not care for organic chemistry and so he is going to confine his studies to inorganic chemistry. We are partly to blame for this state of affairs since in the development of science we enclosed each branch of science with barriers that were well-nigh insurmountable by either student or teacher. Happily these barriers have been torn down, although not all of them in their entirety.

Furthermore, the existence of departments in our colleges and universities often misleads the student, and the present tendency to unite certain existing departments into a single one rather than to multiply them is a hopeful sign and will lead to greater efficiency. To-day no one can draw a definite line between the domain of chemistry and that of physics. Courses that are given in one university in the department of chemistry are sometimes, with perfect propriety, given in the department of physics in other universities. We are beginning to wonder if these two departments could not be united into a single department, greatly to the advantage of both student and teacher and the advancement of research.

While the barriers that formerly separated the different divisions of science have largely disappeared, disclosing a most fruitful field of study and investigation, at least traces of them still exist within each division. In our department of chemistry we rarely give courses in chemistry, but in organic chemistry or analytical chemistry or some other branch of the subject. Moreover, each division is apt to have its own special guardian, who sometimes posts his territory with "keep off" signs. Instances are by no means unknown in which the teacher whose investigations led him from his own special branch into another, as is certain to be the case, was made to feel that he was trespassing in forbidden fields. Dr. Langmuir stated last year before the division of chemical education that the course in mathematics from which he derived the greatest good was not a course in trigonometry or analytical geometry or calculus, but simply a course in mathematics in which the teacher made his selections at will from whatever branch of the subject lent itself to an understanding of the fundamental principles of mathematics as a unit. I have often thought that an admirable course in chemistry would be one in which the science was considered as a unit, and not broken up into divisions. Such a course would impress upon the minds of the students the unity of the different divisions into which, for the sake of study, we divide the domain of chemistry. Even the graduate student to-day finds it difficult to conceive chemistry as a whole. When called upon to take an examination in the field of chemistry he is likely to insist upon knowing not only the branch of the subject but also the particular course in which the examination will be given.

(6) Many of the topics that lie within the domain of chemistry are not only of fundamental importance to an understanding of the science itself but illustrate in an admirable way the development of the scientific method of study or some other important principle. Such a topic as the constitution of matter illustrates what I have in mind. Not only is this topic of primary importance in itself, a foundation stone upon which the superstructure of science is built, but the wise teacher will not fail in the discussion of the subject to use it also as an illustration of the scientific method of attacking a problem. He will point out that here we have theory in the process of making. Within a short space of time our ideas concerning the make-up of the atom have undergone radical changes, and we fully realize that the end is not yet. There is a tendency on the part of some persons to lose faith in scientists because of their changing views. But to cling to ideas not in accord with our present tested knowledge is as deplorable as the willingness to change our minds with every new whim or idea, to be blown about with every new suggestion made. Even our greatest scientists are sometimes guilty of this inertia of mind toward accepting new knowledge. The spectacle of the great Priestley, clinging to and defending the phlogiston theory, in the light of the experiments of Lavoisier and others, always seemed to me pitiable in the extreme.

May I give another illustration? Not long ago I chanced to meet an old student of mine, now grown to manhood and distinguished in many ways, especially in the domain of literature. I had an irresistible impulse to ask him whether he had derived anything of value from his course in chemistry, fully realizing that the question might prove an embarrassing one to both teacher and pupil. But it did not prove so to either, for to my great surprise he stated that if he had to select the one idea that he had gained from his college course that had been of greatest service to him in framing his philosophy of life it would be the one derived from a discussion of the periodic law. He had been much confused by what seemed to him an entire absence of order in the universe; he had read that "all this scene of man" is "a mighty maze but not without a plan"; yet he could find no convincing evidence of this plan; and he recognized for the first time in his study of the periodic law unmistakable evidence of order in the universe, for in no other kind of universe could one predict not only the existence of unknown elements, but the properties of these unknown elements as well.

This same question is still in the minds of many students. Modern discussions concerning the universe seem to them to add uncertainties, notwithstanding the judgment of such an authority as J. A. Thomson, when he writes, "Gone is the old sense of bewildering confusion. Every day discloses some new orderliness in the Universe." But the thoughtful student will realize that a helter-skelter world is not a world in which one can predict with a great degree of certainty the existence of either unknown elements or unknown stars. And if all is not yet clear he will realize, in regard to our knowledge:

'Tis a half-time, yet Time will make it whole.

(7) If history is of value in bringing to us the experience of the past in order that it may be a guide to us in the present, then it would seem that the history of our science may well play an important part in our general course. Our students must understand that chemistry did not reach its present state of development in some miraculous way but as the result of centuries of research carried on by alchemists, by "natural philosophers" and experimenters, often at heroic cost; that chemistry is a tremendously growing, developing science right now to which the student may be the one to make a future contribution as far reaching in value as those made by the great chemists of the past and of the present.

The history of chemistry can also be made to illustrate in an admirable way the development of the scientific method of study. In the old days many facts and phenomena were attributed to the forces of nature, to the gods or the devils, rewarding or punishing men, as the case might be. But the scientific method was born. Men began to experiment, to reason, to frame hypotheses, to test them to see if they would not serve to explain the facts. If they did not, the hypotheses were modified or new ones framed, until at last a working theory was evolved. As time went on new facts brought to light may have necessitated further change in theory or caused the substitution of an entirely new one in its place. The phlogiston theory served its day but gave way to the onward march.

Moreover, the study of the history of chemistry can hardly fail to have an influence upon the student's attitude towards life, call it his philosophy of life if you choose. He is no longer in fear of the displeasure of evil forces or imaginary spirits whose anger must be constantly appeased. If he is ever to be struck by lightning, as some one has said, in effect, he knows that it will be due not to the anger of the god of thunder but because under the existing conditions his body offers the least resistance to the passage of the electric discharge. Moreover, he knows how to avoid these conditions and the lightning loses its terror. He realizes that he is living in a world governed not by chance or whim but by natural laws; that he can count absolutely upon the action of these laws; he knows that they will never be set aside either to his advantage or to his disadvantage. He feels secure, then, in ordering his life in accord with reason and not subject to the wild chance of unknown forces.

Perhaps, from the statements I have made, some may think that I would rob the fundamental course largely of its chemical content; that I would present the play without the actor who really makes the play. To all such let me recall the statement already made that the course must deal with chemistry, fundamental chemistry. What I am pleading for is that the course should be in accord with our modern ideas of education; that it should stress fundamental laws and principles rather than mere isolated facts, and that whenever any of these laws have an application beyond the domain of chemistry there should be no hesitation in suggesting this application. It may be that a course so constituted would leave less time for the discussion of purely chemical facts; but this does not concern me. An examination of the various courses in chemistry in at least some of our colleges leads one to believe that we are expecting the student to learn all there is to know about chemistry while in college, rather than to build a foundation for future development. My principal theme is that our teachers of chemistry have a great opportunity not only to train the future chemists of our country but also to train our young men and women in the ways of right living and sound scientific thinking.

And finally the teacher of chemistry, in his enthusiasm for the value of science, must not forget that after all science is not everything. For the teacher who has awakened great enthusiasm in his students, who has developed in them the scientific habit of thought and a knowledge of the place of chemistry in the whole field of science, has not done quite his best for them unless he has reminded them by frequent suggestions and by his own attitude that science is but one way of thinking—not the only way; indeed, in the last analysis, it is "a method plus its body of significant knowledge." The other great departments of university work should be a constant reminder of this; the science student too often feels separated from them, and sometimes he even feels he has outgrown them. He must be made to realize that science does not give us the values of life, it does not harness its knowledge to ideal interests. Professor Dewey tells us that "the standing problem of modern philosophy is the relation of science to the things we prize and love, which have authority in the direction of conduct." Indeed, it may be that a great change is going on in our sense of values and in the basis of their authority, so that our aims may be confused, and we may have a long way to go in our enlargement from individual to social ideals. But in furnishing knowledge, sought out for the very testing of values, in a creative attitude and a method of building toward the "good life," the scientific worker has a great contribution to make. His may be the optimism, when faith is failing in some other domain of the spirit; a humble attitude toward his own part, a generous understanding of the larger whole in which his work finds its significance.

# THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

## THE FOURTH CLEVELAND MEETING

PREPARATIONS for the fourth Cleveland meeting of the American Association and associated societies are well advanced. The meeting is to open on the evening of Monday, December 29, and it will continue throughout the week. This promises to be one of our larger and more comprehensive meetings. More than thirty independent scientific organizations are planning to hold meetings in connection with the association this year and all sections of the association will be represented. The American Statistical Association, the American Sociological Society, the American Economic Association, the American Political Science Association, the Stable Money Association, the American Association for Labor Legislation, the American Association of Teachers of Marketing and Advertising, the American Association of University Instructors in Accounting and the Farm Economics Association are also making arrangements to meet in Cleveland in convocation week. Their sessions are to be held in the downtown hotels, while the association sections and the other societies will hold most of their sessions in rooms of the Case School of Applied Science and Western Reserve University, which are adjacent.

According to the rules, the council of the association will meet Monday afternoon for its first Cleveland session and other council sessions will be held at 9 o'clock on the following days. Council members are asked to attend. The executive committee will hold a session on Monday morning. Business to come before the council at Cleveland is to be referred to the executive committee first, and memoranda concerning such business should be in the Washington office by December 20. Communications that arrive late, especially those coming to the permanent secretary after the opening of the meeting, may fail to receive consideration, for the week of the meeting is a very busy one for all officers of the association.

Reduced railway rates for this meeting have been granted by the railway associations, on the certificate plan, as in recent years. Any one wishing to go to Cleveland for the meeting should purchase a one-way ticket and secure a certificate for the meeting of the American Association for the Advancement of Science. Names of societies do not need to be mentioned. Upon arrival at the meeting the certificate is to be handed in at the registration office. After being endorsed and validated it will be returned to its owner, who may then purchase a return ticket at one half the regular fare. This arrangement applies for practically all places in the United States and Canada.

The Hotel Statler is to be general headquarters for the American Association. Hotel headquarters for the sections and societies have been designated as follows:

*Hotel Statler:* Section A (Mathematics), American Mathematical Society, Mathematical Association of America, Section B (Physics), American Physical Society, American Meteorological Society, Section D (Astronomy), Metric Association, American Association of University Professors.

*Hotel Hollenden:* Section F (Zoological Sciences), American Society of Zoologists, Entomological Society of America, American Association of Economic Entomologists, American Society of Parasitologists, Wilson Ornithological Club, Section G (Botanical Sciences), Botanical Society of America, American Phytopathological Society, American Society of Plant Physiologists, American Society of Naturalists, Ecological Society of America, American Microscopical Society, Phi Sigma Biological Research Society, Section N (Medical Sciences), American Society of Tropical Medicine, Section O (Agriculture), American Society of Agronomy, American Society for Horticultural Science, Potato Association of America, Association of Official Seed Analysts, American Nature Study Society.

*Hotel Winton:* Section H (Anthropology), American Anthropological Association, American Folk-Lore Society, Section I (Psychology), Section L (Historical and Philological Sciences), History of Science Society, Section Q (Education), Section C (Chemistry), Section E (Geology), Section M (Engineering).

*Hotel Cleveland:* Section K (Social and Economic Sciences).

The hotel headquarters for the social-science groups are as follows:

*Hotel Statler:* American Statistical Association, American Political Science Association.

*Hotel Hollenden:* American Sociological Society.