PRESENTATION OF THE MEDAL

TO-NIGHT the Institute of Chemists is performing through me a service, which is not only a personal one, but also by its action is establishing a new contact with workers in a neighboring field of science. Our performance to-night is clothed not only with an obvious desire to please, but also with a desire to reveal an interpretation and a spirit which pervades our organization. We believe in each other, in unanimity of understanding and effort and fair team play. It is our feeling that we record the favorable response of a large majority of the workers in our science by bestowing upon you this honor to-night. It personally gives me the greatest pleasure to be able to present you with this Medal of the Institute of Chemists in recognition of your meritorious work in your special branch of chemistry and for your broad influence as a teacher.

TREAT B. JOHNSON

PRESIDENT OF THE AMERICAN INSTITUTE OF CHEMISTS

SOME TENDENCIES IN THE PROMOTION OF CHEMICAL RESEARCH

IN recent years the civilized world has come to expect much of the sciences, and particularly of physics and chemistry. This attitude has been fostered at the outset by an awakened realization of what they have actually contributed in discoveries and inventions. The laws of nature are, in truth, the wealth of the world. Lord Moulton once remarked that without the teaching of science man blunders through life as a card player would blunder through a game of cards if he did not take the trouble to look at the cards in his hands and learn their value. The popular mind has lately become prone to believe that everything is possible to science; hence large responsibilities are likely to be thrust upon its masters.

Probably no influence or group of factors has contributed more largely to the recent exaltation of chemistry than the world war with its manifold involvements. The stress of the ominous years that witnessed a series of conflicts of hitherto unmatched enormity, the almost overwhelming necessities of readjustments in nearly every field of human activity, the depressing deprivations and the suddenly augmented demands confronting the antagonistic and even the non-combatant nations—such features served to impress in hitherto unrealized degree upon thoughtful peoples how indispensable chemistry has become to modern life in the complexity of present-day civilization. Problems of munitions and armament, of poisonous gases and optical glasses, of the supply of novel materials for use in the upper reaches of the air or in submarine depths, of food and clothing where agriculture seemed unable to meet new needs—these and innumerable other demands called for the chemist's resourcefulness in the fullest measure.

The story of many of the achievements of chemistry as revealed by war-time history has been rehearsed so often that it has become quite familiar in various details. Consequently it has been only natural for thoughtful persons to entertain the hope that this science would presently be diverted from the exigencies of strife and the distress of the state in order to be directed to the promotion of national prosperity and the betterment of the race. A distinguished chemist has remarked that "original research is in itself the most powerful weapon that has ever been or ever can be wielded by mankind in struggling with the great problems which nature offers on all sides for solution." (Meldola.) This thought has become the ardent belief of eager multitudes. The word research has become an expression to conjure with; a term used not infrequently without any adequate appreciation of its fundamental implications. Thus it has come about that science has been exposed upon an elevated pedestal to the fullest view of an over-awed public. "From time to time," a sympathetic writer has pointed out, "so many marvels have been suddenly sprung upon us in the past which have owed their birth to research carried on in silence in laboratories and the like that the general public is quite ready to treat such homes of research as mysterious workshops, the methods and aims of which are beyond them, but from which great discoveries may at any moment arise. It looks forward with hope to these future discoveries and it feels too much in awe of the secrets of science to desire to control or criticize the methods by which they are arrived at." (Moulton.)

The chemist himself, on the other hand, knows all too well that there is no royal road to untrammeled success in his domain. Across the fields that he traverses there are liable to be barriers of the most varied sorts that may impede or even completely stop his progress. He is not protected against the stumbling blocks encountered in other walks of life. Men of science realize that they can not answer the riddles of life or solve the problems of industry on command; yet the larger public is beginning to assume that in the scientific disciplines a little enthusiasm and well-directed energy will inevitably furnish the required solutions. The man-on-the-street sees the modern engineer constructing bridges of hitherto unattained proportions; he watches the skyscraper rising under the builder's guiding hand to surprising heights; and he observes the harnessing of mighty waters to do service unto man. Hence he expects the chemist also to work wonders on demand, all too often not appreciating that there is an utter lack of the fundamental information upon which the desired effort must be based. Incidentally there is too little realization of the fact that contributions of large practical importance have not infrequently been the by-product of research rather than the immediate goal of the investigator.

One can not always anticipate results in science. This significant truth is well illustrated in the history of the discovery of the X-rays by Röntgen. He was not searching for a method of penetrating the interior of the body with light; rather following the studies of Lenard and Herz he was engaged in consideration of radiation from the seat of electric discharge. Röntgen's contribution was the outcome of a chance observation. The fortuitous features of it have been depicted well by Bragg:

> The rays were discovered in 1896. Suppose that in 1894 the surgical profession had asked if science could furnish the powers just described. We are trying to reverse what actually happened, and to see if things could have taken place as they did "Through the Looking Glass." Now in the first place we can not imagine how the profession would come to think of making such a request. No one at that time had ever conceived the possibility of being able to do a thing which was uncommonly like seeing through a door. It would have been classed with vision of that penetrating kind if it had been proposed; and considered as incompatible with known facts. So indeed it was, if its accomplishment was to be some new act of ordinary vision; but the solution came in an entirely different fashion. The problem was solved indirectly, as so often happens; and for this very reason its solution could not have been expected or asked for. Not only may it be asked why this particular request should be chosen in preference to any other of a thousand requests which could be imagined; but it may be asked how it is to be expected that the request should be conceived at all. There was nothing to make any one think of asking for such a thing as x-rays. (Bragg, W. H.: "Physical Research and the Way of its Application." In "Science and the Nation." Cambridge, 1917, p. 30.)

"It is impossible," Bragg concludes, "to conceive of progress being made in this order, which is the reverse of the natural course."

The vaunting of the contributions of science to the welfare of nations, the story of how its progress has "revolutionized our civilization as to its methods and opportunities, as well as advancing our knowledge of the wonderful processes of nature," bring immense gratification to the devotees of science. The satisfaction in accomplishment is compelling. However well the scientist himself may realize his limitations, the same modesty of outlook does not characterize his latter day admirers. One may seriously inquire, therefore, whether some danger to scientific endeavor is not hidden in the current great expectations. In his essay on "Vain-Glory," Francis Bacon quoted the French proverb: "Beaucoup de bruit, peu de fruit": Much bruit, little fruit. Need we not fear lest failure of science to achieve in the ways now so confidently expected may prove to be a boomerang? The persistent worker in the laboratory is prepared to face temporary defeats with equanimity; they do not retard his efforts, but usually stimulate him to renewed endeavor. He realizes that research is essentially diligent, protracted effort. On the other hand, the public, the momentary admirer and supporter of the scientist, is not similarly inured to the inevitable shortcomings of experimentation. The public craves to-day, more than ever before in the history of science, a prompt and uncompromising answer to innumerable unsolved questions. It does not complacently brook the failures that may attend great expectations. Disappointment turns to disillusionment and then to distrust. When this occurs science is in danger of losing many an ardent admirer and perhaps not a few staunch supporters.

Scientists have repeatedly chafed under the indifference of nations to which they belong; they have clamored for respectful recognition if not actually for financial help. A sympathetic audience having at length been secured from those prominent in our national affairs, the advantage so laboriously gained must not be lost through vain boasting or the persistence of misconceptions as to what science can really do. If some nations were remiss before the war in cultivating chemistry, the pendulum of post-war enthusiasm for the neglected science may swing too far in the direction of expected immediate achievement before it acquires its normal rhythm.

Inasmuch as the expected perfection may fail of attainment in even the most ardently prosecuted scientific research, does not a duty devolve upon the workers to avert a debacle of interest in their undertakings? Joyous as it may be to acclaim the triumphs of science, is it not also desirable to educate the auditors with respect to the ways and means, the trials and errors, by which alone continued and permanent contributions are assured? The recognition that knowledge is finite, that progress involves change, that traditional beliefs are subject to revision, needs to be promoted. The public should be made to realize that the scientist is one of that large group of persons compelled at times to utter the truthful words: "I am wrong." In this connection a recent comment by Cattell is pertinent:

> If it is asked how the scientific man knows the truth, the answer is that he does not. He makes approxima-

tions and the bank of his knowledge is solvent so long as it honors his drafts. The Euclid-Newton bank honored until recently all the drafts that were drawn on it. It appears that it may fail to do so for some little ones; if this proves to be the case then our physical universe must be revised or discarded. It is equally true that no social system, no political theory, no religious creed, can be maintained when it is not in accord with science. The methods of science, slowly gaining in force and volume through the centuries, will in the end bring truth and reason into all our beliefs and actions. At least that is the hope of the world, for we can not rely on inherited instincts to meet situations always increasing in complexity. (Cattell: *The Scientific Monthly*, March, 1927, p. 200.)

Huxley once remarked that "what people call applied science is nothing but the application of pure science to particular classes of problems." It is indeed futile and undesirable to attempt to set distinctions between such categories of science. Nevertheless it may not be amiss to stress again and again the desirability of preserving an unfaltering interest in what are often referred to as fundamental problems. Whether it be in chemistry, physics or the biological sciences, the urge to "make good" is liable to lend an unwarranted emphasis upon achievements that are immediately practical. Their glitter and the enthusiasm that they create sometimes promote the abandonment of the arduous search for fundamentals. The secrets of the atom, the mysteries of the cell, the dynamics of living processes deserve to be revealed regardless of any immediate exploitation thereof in every-day life.

Among the far-reaching influences of the world war upon chemistry the consolidation of talent in the effort to solve pressing problems deserves special mention here. The supreme desire for victorious success brought about a collaboration of many chemists, drawn from diverse fields, in investigative work. The outstanding effectiveness in many instances of cooperative undertakings directed toward projects of large moment to the national welfare has challenged attention. The mobilization of the scientific workers appeared to be the realization of the adage that "two heads are better than one." The outcome of the war-time plan of combined investigative effort was so gratifying that the chemical fraternity presently began to debate whether so-called cooperative research could not profitably replace the more conventional mode of isolated individual undertaking. Numerous essays have extolled the virtues of communal effort, even ridiculing the stupidity of the scientific world in neglecting so long the obvious advantage of joint labors directed to a common end. The arguments have been supported by citations from the experiences of the research laboratories of a few large industrial enterprises.

Here again one may foresee a possible menace through preponderance of enthusiasm—this time on the part of chemists themselves—for war-time advantages. Patriotic performance is, after all, a somewhat exceptional expression of human nature. Personal ambition is the powerful directive force that accomplishes much good even when national distress is not involved. The urge to succeed is a worthy impelling motive for most persons of intelligence. In ultimate analysis the man, not the machine, invariably is responsible for progress.

It becomes a duty, therefore, to conserve the individual quite as much as to promote the group. The history of chemistry gives abundant illustrations of the importance of this thesis. Joint undertaking often brings brilliant results. But the human mind is not gregarious, nor is its possessor always readily adjusted to strictly cooperative enterprise. It is also a real service to save the exceptional man, enabling him to develop that individuality which is unbiased by preconceived notions and unhampered by the dominance of an insistent fellow-worker. May not the oft mentioned successful chemical research in some of the industries represent the advantage of community of interest rather than strict cooperation in undertaking? Competition in research is by no means always wasted effort, for it sometimes ends in verifying important deductions as well as serving to correct error and point out new viewpoints. Cooperative research needs no defender at the present time. It has become the cry of the hour. The preservation of individuality is the more likely to suffer neglect in a modern democracy of science. We are partisans as men, not as students of science.

Like other branches of science, chemistry has experienced marked changes in the favored technique of experimentation as well as a succession of altered attitudes with respect to what constitute the foremost topics of investigative moment. Latterly a hitherto unequalled interest has been centered in the importance of the quantitatively minute. This applies, for example, to the identification and study of substances that occur in very small quantities; likewise to measurements in which they are involved. The considerations of radioactive materials, of organic and inorganic catalysts, of hormones and vitamines bear witness to the prevailing enthusiasms. It has become quite customary to deal with reactions in which "parts per million" are involved. In a person of 70 kilograms of body weight a few milligrams of iodine may become responsible for the difference between nutritive well-being and profound metabolic upset. This means a health-promoting effect of the indispensable element in quantities of less than one part per million. An excess of a few hundredths of a per cent. of glucose in the blood leads to glycosuria. A variation of a few milligrams above or below the usual calcium content of the entire circulating fluid spells disaster. On such slender threads does the chemical balance of the human organism hang. These few illustrations are selected from my own department of study; they can readily be duplicated from all of the subdivisions of chemistry.

As might be expected, appropriate refinements of analysis have been introduced to meet the new situations. Micro-analysis has attained an unanticipated popularity. A few milligrams of an organic compound now suffice for the determination of an empirical formula; a few drops of blood or tissue fluid may furnish important indications of the chemical changes in metabolism. The micro methods have won their way rapidly into the chemical laboratory of to-day; and with them has come a greater readiness to attack unsolved problems of composition and behavior even where quantities of material available were once considered hopelessly inadequate.

The importance of "little things" in chemistry, the dominant significance of the minute in many chemical processes, greatly enhance the desirability of studying the potent rarer substances. In the effort to identify them the micro methods, frequently indirect in their implications, may leave the chemist in the lurch. The possession of a small sample of an impure derivative may permit only the crudest sort of examination that is quite as likely to tantalize as to reward. I venture to prophesy a growing employment of "large scale" operations in departments of chemical research that have scarcely outgrown the exclusive use of the test tube and the beaker for their major reactions. One can herald with a feeling of real assurance many future successes arising from the application of large scale chemical procedures. The inorganic chemist has long realized that the identification of the radioactive elements resulted only through the use of tons of ores in which they are hidden away. It remained for the biochemists, often engaged without success in studying the nature of the potent iodine-containing substance of the thyroid gland, to observe Kendall in this country and Harrington in England apply the processes of separation and purification to hundreds of pounds—not a few grams or kilograms—of animal tissue before the worthwhile discoveries regarding thyroxin were made. Willstätter's classic researches on chlorophyll called for the use of enormous amounts of green leaves. The quest of the antirachitic vitamine—vitamine D—has already involved the saponification of a few tons of cod liver oil without as yet yielding in a state of requisite purity sufficient of the potent factor to establish its actual chemical nature beyond question. The epinephrin of the adrenal medulla remained elusive until it was prepared in adequate amounts for critical study. Unless a wealth of pancreative gland is made available for the separations, the complete story of the chemistry of insulin is not likely to be written. How greatly our knowledge of glutathione and the ergothionine of the blood would have been enhanced if large scale operations had been initiated to secure them in that abundance which the industrial chemist often enjoys in his studies of new compounds. The chemistry of both animal and plant cells—materials rich in unknown numbers of unidentified substances some of which are presumably of large biological significance—awaits the employment of factory-like operations affording better opportunities to attempt the difficult separations of unrecognized compounds. Such undertakings require large support as well as real talent; they also hold out large promises of achievement in fields where the less pretentious operations have thus far yielded scanty returns. Cell chemistry is destined to emerge from the microscopic stage of investigation.

The scientific consideration of the laws of nature as they are exemplified in the properties and combinations of the elements has gradually become departmentalized, so to speak, in somewhat peculiar ways in chemistry. It has never been easy to draw a hard and fast line of division between physics and chemistry. Their dominions overlap here and there; at least there is a border region where the primary interest involved is difficult of classification. Chemistry, in turn, has become organized into a group of subdivisions representing convenience of administration far more than any logical distinctions that would justify independent treatment of them. Inorganic chemistry, organic chemistry and physical chemistry, not to mention the more pragmatic subdivisions, are being promoted in a degree of isolation that has undeniable drawbacks. For the moment physical chemistry formulated with new viewpoints, employing novel methods, and armed with all the enthusiasm that belongs to a vigorously growing venture seems to be leading in the attack upon the current problems. Its contributions are undeniable. Physical chemistry has gained a dominant position in the chemical endeavors of the present generation; yet a critical observer may well wonder whether part of the advance has not consisted in the application of a revised nomenclature, in new formulation of old experiences, in more courageous entrance into poorly cultivated domains. The progress under the banner of physical chemistry has been more largely that of the natural evolution of a science than of any revolutionary approach to its besetting puzzles. The world will welcome the gains that any branch of chemistry promises to bestow; but it would indeed be unfortunate if the momentary enthusiasm for one department were to obscure the deserts of the other subdivision.

This thought may properly merit emphasis at the present moment when the prestige and popularity of organic chemistry seem to be eclipsed by the younger physical chemistry, perhaps even to the extent of being in danger of real neglect by the oncoming students. Shall they forget such "marvelous achievements of theoretical reasoning and of practical skill" as the commercially successful synthesis of indigo from coal tar products at a time when, as Pope remarked, the manufacture of natural indigo was carried out by methods which the Pharaohs might have criticized as conservative? Can we afford to overlook the fact that the organic chemist deals with manifold substrates which involve the surface relations, intermolecular forces, hydrogen ions and chemical equilibria of physical chemistry? Surely the day of the organic chemist has not yet passed. Physiological chemistry, about which I may perhaps speak with greater assurance, is feeling the effects of the prevailing prejudice created by the new domination. A survey of some of the biochemical literature gives the impression that the broad field of the detailed composition and function of living structures is being envisaged from a somewhat narrow angle—one in which colloidal phenomena, ionic equilibria, permeability factors, osmotic and surface forces furnish the chief basis for the outlook. Yet we remain grossly ignorant as to the actual chemical composition of most of the tissues and fluids of both plants and animals. A constructive inroad into these unexplored recesses, an endeavor to discover the unrecognized organic compounds out of which the living cell, the morphologic background of protoplasm, the basis of life, is built up can not fail to be worthwhile. It calls for superior chemical talent; for something more than the ability to analyze products in the conventional terms of protein, fat, carbohydrate and ash. Cytoplasm and nucleus, chromosomes and vacuoles are little more than words to the biochemist. Here is hidden much temporarily neglected wealth remaining to be uncovered.

This appeal for a rejuvenation of interest in what may be regarded as one phase of organic chemistry should not be interpreted in any way as even the slightest disparagement of the rival branches. It is made, rather, with the purpose of showing the limitations of exclusive "fashions" in chemical research; it is uttered with the hope of encouraging a greater integration of the varied aspects of chemistry that now receive isolated independent consideration. Perhaps nothing could be more conducive to this end than a reform of the current methods of teaching chemistry. The approaching centenary of the first artificial synthesis of a "product of life," Wöhler's production of urea, might not only be a reminder that so-called vital forces are dispensable, but also mark the broader recognition of the essential unity of chemistry.

In the discussion of my major theme a few comments on the preparation of the investigator and the training for chemical research may not be out of place. Among the criticisms to which the academic world is now-a-days being subjected one hears frequently the charge that memory training plays a rôle too exclusively. The late Sir James Mackenzie, an eminent physician familiar with the experimental method, supported the complaint in words that his biographer has described as "the only 'revenge' which Mackenzie ever permitted himself against the educational system by and through which he had suffered." With his own experiences in mind he wrote:

> There are two very distinct qualities of the human mind: memory, and the power of reasoning. The earliest to be developed is that of memorizing, and this can be cultivated with great ease. The power of reasoning is quite different, although, no doubt, memory takes a part. When we look at a great number of students, we discover that this power of memory is greatly developed in a few, and all our educational methods are devoted to its cultivation. Examinations are specially contrived for the purpose of discriminating those with the best memories, and to them all the honors and prizes are given.
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> The individuals who, on the contrary, possess more of the power of reasoning than their fellows, receive no consideration. There are minds which have a difficulty in remembering isolated facts, but if these facts are related in some consecutive manner, they can not only remember them, but also appreciate their bearing on one another. But this type of mind is slow in acquiring knowledge, and in our present-day methods of education less and less encouragement is given to this type of student. His peculiar powers are never developed, and their presence is never suspected.
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> "The outcome of the teaching of to-day is to hail the student with superior powers of memorizing as the brilliant student, and the one with the great future. The consequence is that his path from the outset is made easy for him. Bursaries and scholarships fall to his share, and before he has acquired any experience, he is appointed to a teaching post. In the absence of any knowledge acquired from the results of his own observations, he is forced to teach that which he was himself taught, and, as he can not discriminate between truth and superstition, he hands both on to his students. As years pass he comes to believe what he has taught is true and may even grow impervious to new ideas which are contrary to the beliefs he has been expounding."

(Wilson, R. M.: "The Beloved Physician, Sir James Mackenzie." New York, 1926, p. 24.)

A reaction against the type of education that Mackenzie thus assailed has asserted itself through the wide-spread introduction of the so-called "laboratory method" of teaching in which the student is being left more and more to his own devices. This is the essence of the inductive method. It promotes keenness of observation and critical judgment; it presupposes the open mind. As so often happens with our enthusiasm for the new, the inductive method has been driven in some places beyond its greatest effectiveness. Freedom to start on a voyage of discovery in the student laboratory does not invariably lead to the desired shores. The ways of the pioneer discoverers have usually been long, and their progress slow. After all, there are facts, multitudes of facts, long since described, which could be rediscovered by each generation of students if this laborious process seemed worth while. Why require it?

Without a background of facts thinking becomes a difficult, if not a futile task. A rich store of fundamental facts is the indispensable equipment of what Pasteur so expressively termed the "prepared mind." Many persons are privileged to make chance observations; only the prepared mind profits by them. "Curiosity alone," Bigger has written, "will not make more than a laboratory dabbler, a dilettante of science. Many other qualities must be added to make a worthy researcher. Knowledge, both wide and deep, of his subject and of related sciences is needed to fit him for his work and to help him to surmount the difficulties with which the paths of science are so liberally sprinkled." (Bigger, J. W.: Irish J. M. Sc., Jan. 1927, *6,* 19.) Didactic instruction, so largely discredited at the present time, may yet regain some measure of favor as an economical procedure for ascertaining essential facts. The test tube and the reagent bottle are not the alpha and omega of a chemist's training.

Waste of time is no more tolerable in student days than in after life. The candidate for a career in research should be spared from wasting time in useless laboratory work. Peabody recently remarked that "the popular conception of a scientist as a man who works in a laboratory and who uses instruments of precision is as inaccurate as it is superficial, for a scientist is known, not by his technical processes, but by his intellectual processes; and the essence of the scientific method of thought is that it proceeds in an orderly manner toward the establishment of a truth." (Peabody, F. W.: J. A. M. A., March 19, 1927, *88,* 877.) The student may often be started on an effective course far earlier than our standardized school systems now permit. A recent writer on school education has remarked:

> The teaching of science in our schools, which has been improving so slowly during the last twenty years must be stimulated and some scientific method of selecting and coordinating the science subjects to be taught must be introduced. It would seem rational that mathematics should be the earliest science dealt with, followed by physics, chemistry and mechanics, and that wholly subordinate importance should be attached to the biological sciences, because the elementary stages of these latter subjects are necessarily largely descriptive and insusceptible to broad treatment as illustrative of scientific reasoning and method. That our schools do not keep in view the fundamental scheme which correlates all the natural sciences is obvious; it becomes especially evident when the large amount of time often devoted to botany is contrasted with that allotted to physics and chemistry. (Pope, W. J.: "The National Importance of Chemistry." In "Science and the Nation," Cambridge, 1917, p. 20.)

Appropriate coordination of preparatory studies is an important desideratum in the early training of the successful investigator; for it will help him to know things and forces not in isolated instances, but in their truer natural relations.

Chemical research has become a dignified profession that has abundantly justified itself. Those who are devoted thereto have the duty of encouraging its efforts, of safeguarding its future, and of promoting its personnel. Critical comments, such as some of the foregoing remarks involve, should not be construed as an outburst of pessimism. Change is the essence of progress which even the optimist may endeavor to safeguard.

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WILLIAM MARC CHAUVENET

WILLIAM MARC CHAUVENET was born in the U. S. Naval Academy at Annapolis, Maryland, March 4, 1855. His father, the distinguished astronomer and mathematician, was at that time superintendent of the U. S. Naval Academy at Annapolis. William Chauvenet died in St. Louis on December 11, 1926, in his seventy-second year. When his father was appointed first chancellor of Washington University, the family moved to St. Louis. William was educated at the Smith Academy and the Wabash University in St. Louis. After leaving college he was appointed as an assistant on the U. S. Geological Survey in 1880 and was under Raphael Pumpelly at Newport, R. I. After remaining there a year or two he was ordered to report to the professor of geology