SCIENCE

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*CHEMISTRY IN THE UNITED STATES.**

IN the history of science, from whatever point of view we may consider it, the several branches develop according to a natural order. The more obvious things attract attention first; the less obvious are recognized later. Plants, animals, stones and stars are studied even by savages; but the hidden forces of nature, governed by laws which can be utilized for man's benefit, escape discovery until civilization is far advanced, and even then are revealed but slowly. At first each department of knowledge is purely empirical, a mass of facts without philosophical connection; but sooner or later speculation begins, the scattered evidence is generalized, and an organized science is born. The study of concrete facts, the recognition of our surroundings, precedes the study of relations.

Among the sciences, chemistry is one of the youngest. As an organized branch of systematic knowledge it has little more than completed its first century. Before the time of Robert Boyle it was hardly better than empiricism. At first a few scattered facts were recognized, involving transformations of matter. Some of these were applied in the arts, as in metallurgy and in medicine; and their generalization led simply and naturally into alchemy, with its search for the philosopher's stone, the uni-

* Presidential address, Philosophical Society, Washington, December 12, 1896.

versal solvent and the elixir of life. There was no chemistry in the modern sense of the term, but only a group of visionary speculations which foredoomed their devotees to failure. In these failures, however, truth revealed herself, discoveries were made other than those which were expected, and the foundations of a new science were laid. It was more than forty years after the landing of the Pilgrims at Plymouth when Boyle announced the true definition of a chemical element, and the discovery of oxygen was not made until over a century later. The history of modern chemistry and the history of the United States begin at nearly the same time.

In America, as in the world at large, the development of science followed along the natural lines. A new country had no time for abstractions, such as chemical studies were in the early days, and only the more obvious branches of investigation received much notice. Botany and zoology flourished to some extent, and even mineralogy had able students ; for the resources of an unexplored continent could not be ignored. Astronomy, too, was somewhat cultivated, but because of its usefulness in the measurement of time and navigation, rather than for its interest as an intellectual pursuit. The practical side of science was necessarily and properly foremost ; and this fact is nowhere more apparent than in the physical researches of men like Franklin and Rumford. The obvious and useful came first; philosophy, theory, might wait until men had more leisure. So, while chemical discoveries were rapidly multiplied in Europe, little advancement could be recognized here. Even that little was utilitarian, and chemistry in this country was first brought into general notice through its relations to medicine and pharmacy, and through the agency of medical schools.

Prior to the year 1769 chemistry had no independent existence in the work of American colleges. It was taught, if indeed it was taught at all, only as a subordinate branch of natural philosophy. But in the year just named, Dr. Benjamin Rush was appointed to a chair of chemistry in the medical department of the University of Pennsylvania—an event which marks the first recognition of the science in the United States by any institution of learning. Other medical schools soon followed the example thus set, and chemistry took its place as a regular subject for study. Rush, however, was not specifically a chemist ; he had, indeed, been a pupil of Black, in Edinburgh ; but he carried out no chemical investigations and added nothing to the sum of chemical knowledge. His high reputation was won in other fields; but as the first professor of chemistry in America he occupies a historical position.

In 1795 the trustees of Nassau Hall, now Princeton University, elected Dr. John Maclean professor of chemistry. Other colleges soon followed the lead of Princeton, and within a very few years chemical science was well established as a distinct branch of study in many American institutions. The teaching, however, was wholly by text-books and lectures, the laboratory method was unknown, and the teacher commonly divided his attention between chemistry and other themes. There were professors of chemistry and natural philosophy, of chemistry and natural history, but rarely, if ever, professors of chemistry alone. Moreover, little time was given to the subject; the classics and mathematics overshadowed all other studies, and the pupil learned hardly more than a few scattered facts and the barest outline of chemical theory. When we note that to-day Harvard University employs twenty-two persons, professors, assistant professors, instructors and assistants in chemistry alone, we begin to realize the great advance which has been made in the teaching of science since the days of Maclean, Hare and the elder Silliman.

In 1794 Joseph Priestley, the famous discoverer of oxygen, driven from his English home by religious persecution, sought refuge in America. He took up his abode at Northumberland, in Pennsylvania, where he died in 1804, and where his remains lie buried. His coming greatly stimulated the growing interest in chemistry upon this side of the Atlantic, for Priestley entered at once upon close relations with many American scholars, and took an active part in the work of the American Philosophical Society at Philadelphia. At Northumberland he completed his discovery of carbon monoxide, and made some of the earliest experiments upon gaseous diffusion; but unfortunately much of his time was devoted to theory, and to defending against the attacks of Lavoisier's followers, the moribund doctrine of phlogiston. Priestley's discovery of oxygen was the corner stone of chemical science; but the discoverer, great as an experimentalist, was not successful as a philosopher, and he never realized the logical consequences of his achievement. To the day of his death he opposed the new chemical philosophy and clung to the obsolete ideas of an earlier generation.

During the first quarter of the present century the progress of chemistry in the United States was slow. It is not my purpose to discuss in this address the details of its advancement, for that work has already been exhaustively done by another;* still several events happened which deserve notice here. First, Robert Hare, in 1802, invented the oxyhydrogen blowpipe. With that instrument, in following years, he succeeded in fusing platinum, silica and about thirty other refractory substances which had hitherto resisted all attempts at liquefaction. But few men have given a greater extension to our experimental resources. The calcium light and the metallurgy of platinum are among the direct consequences of Dr. Hare's invention. Secondly, in 1808 Professors Silliman and Kingsley, of Yale College, published their account of the meteorite which fell at Weston, Connecticut, the year previous. This paper attracted widespread attention, and drew from Thomas Jefferson the oft-quoted remark "that it was easier to believe that two Yankee professors could lie than to admit that stones could fall from heaven." The analysis of the meteorite was the work of Silliman, and was among the earliest of its kind. It was done with appliances such as a modern high school would despise, and without the aid of any manual of analytical chemistry; and its merit is due partly to the fact that it was well done, and partly to the way in which great difficulties were overcome. In weighing the work of the early investigators we must remember that they lacked the resources which are so easily commanded nowadays, and that the methods of research had not been reduced to system. Their success was in spite of disadvantages which would baffle most men; there was less encouragement than now in the way of popular applause, and their efforts are therefore all the more praiseworthy. Today scientific investigation is an established art, its ways are well worn and well trodden; and, although the highest achievements are as difficult of attainment as ever, even a beginner may hope to accomplish something.

During these early years much attention was paid by American chemists to the study of minerals, for rich new fields were open; and in 1810 Archibald Bruce began the publication of *The American Minerological Journal*, of which four numbers were issued.

*Benjamin Silliman, Jr. 'American contributions to Chemistry.' American Chemist, August, September and December, 1874. An address at the 'Centennial of Chemistry.'

This was probably the first attempt to publish in this country a magazine devoted entirely to science and supported wholly by native contributions. As early as 1811 there was a Columbian Chemical Society in Philadelphia, and in 1813 a volume of its 'Memoirs' appeared. In 1817 the *Journal of the Academy of Natural Sciences of Philadelphia* was started; and the next year saw the birth of Silliman's *American Journal of Science.* The last named periodical, a classic among scientific serials, was for sixty years the chief organ of American chemistry; and even yet, despite the rivalry of more specialized journals, it contains a fair proportion of chemical contributions. The first American to publish a systematic treatise on chemistry was Prof. John Gorham, of Harvard College, whose 'Elements of Chemical Science,' in two octavo volumes, appeared in 1819. The work was well received and was an excellent one for its day.

The period from 1820 to the outbreak of the Civil War was one of steady progress in America, both as regards scientific research and in the development of institutions. Colleges were founded, societies were organized, there were better facilities for work, and the general appreciation of science became greater. But, for the reasons which were stated at the beginning of this address, the so-called natural sciences rather took the lead, and there was more activity among geologists and zoologists than in the field of chemistry. Many States organized surveys; the general government sent out exploring expeditions; and so geology and natural history received a patronage in which chemistry had little or no share. The chemists were mainly dependent upon their own resources, and got along as best they could. Still, their number increased, their published investigations became more numerous, and their services were in greater demand, both commercially and in the work of instruction.

At first the would-be chemist had to make his own pathway. Chemistry was taught in the colleges, not as a profession to be followed, but as a minor item in that ill-defined agglomeration of knowledge which in those days was called 'a liberal education.' In 1824, however, the Rensselaer Polytechnic Institute, at Troy, was founded, and a new era in scientific education began. In 1836 Dr. James C. Booth opened a laboratory in Philadelphia for instruction in practical and analytical chemistry, and in 1838 Prof. Charles T. Jackson did the same thing in Boston. Chemistry could now be studied in something like a systematic manner, but the students who were able to do so went abroad, at first to London, Edinburgh and Paris, and later to the famous laboratory of Liebig in Germany. The impulse toward foreign study continues to our own day; even though American facilities have increased enormously, and a good chemical training can now be obtained at home.

The decade from 1840 to 1850 was a period of great advancement in American Science, and several events of the utmost importance occurred. In 1829 James Smithson, an Englishmen, bequeathed his property to the United States, to found in Washington 'an institution for the increase and diffusion of knowledge among men;' and in 1846 his project was realized. The Smithsonian Institution was established, and under the direction of Joseph Henry it became at once a center of scientific influence and activity. Smithson, it will be remembered, was a chemist and mineralogist, and it was, therefore, eminently proper that the Institution which bore his name should, from the very beginning, maintain a chemical laboratory. Furthermore, in the earlier years of its history, the Institution provided courses of popular lectures upon chemistry; it has subsidized some chemical investigations, has published original researches, and it has issued a number of useful works in the way of special reports, volumes of physical constants and bibliographies. Although its energies have been more conspicuously exerted in the fields of zoology, anthropology and meteorology, it has done much for chemical science; the subjects which interested its founder have never been neglected. In the history of American chemistry the Smithsonian Institution plays an honorable part.

In 1847 and 1848 the Sheffield and Lawrence Scientific Schools were founded, the one at New Haven, the other under the protecting shelter of Harvard College. In the one, chemistry was taught by J. P. Norton and the younger Silliman; while Horsford conducted the laboratory at Cambridge. The much older Polytechnic Institute at Troy had developed mainly as a school of engineering, so that the two new institutions practically stood by themselves, as the only higher schools of chemistry—schools in which professional chemists could receive a thorough training—within the limits of the United States. Their influence soon began to be felt, their graduates went forth to take important positions, the stimulus to scientific studies spread to the colleges, and the chemist became recognized as the representative of a new learned profession. Law, medicine and divinity no longer formed a class by themselves; other branches of scholarship were to take rank with them.

In 1846 Agassiz came to America, bringing with him the research method as a method of education. Himself a zoologist, his influence as a teacher was evident in all directions, and chemistry shared in the new impulse. There were many pupils of Liebig and Wöhler in the United States, men well imbued with the spirit of the new education; and to them the coming of Agassiz was a reinforcement and an inspiration. The old college curriculum was compelled to expand, and the true conception of a university began to be recognized on this side of the Atlantic. In 1848 the American Association for the Advancement of Science was organized, and science received a national standing which the local academies and societies could never have given it. The influence of the Association upon chemistry will be considered later.

In 1850 Josiah P. Cooke was elected professor of chemistry in Harvard College. He had received his bachelor's degree only two years earlier, but during his student days no chemistry had been taught to the Harvard undergraduates. Practically self-taught, and largely through the medium of experiments, he realized the value of the laboratory method of instruction and, in spite of conservative opposition, he set to work to bring about its adoption. He was allowed at first the use of one basement room for his purposes, but was compelled to pay all or nearly all of the laboratory expenses out of his own pocket, for the college funds could not be wasted on strange innovations, and the recitation method still reigned supreme. Prof. Cooke, however, understood how to be patient and persistent at the same time; year by year his courses of study were extended, by slow degrees his resources increased, and in 1858 Boyleton Hall, the present laboratory building, was completed. At first, part of the building only was assigned to chemistry; now all of it is devoted to the teaching of that science. It is truly a monument to Prof. Cooke, whose energy and persistence caused it to be erected, and to whom, more than to any other one man, the full recognition of the laboratory method in American colleges is due. The initiative was taken by the scientific schools, but the colleges were compelled to follow; and to-day even the high schools, the feeders of the colleges, have their chemical laboratories in which elementary practice and qualitative analysis are taught. Chemistry is now seen to be one of the best disciplinary studies, and it fails in educational value only when the teaching of it is entrusted to improperly trained pedagogues of the obsolete text-book school. The teacher who is a slave of text-books is as bad as no teacher at all. To teach chemistry one must think chemistry; a mere memory for facts is not a sufficient qualification.

Leaving out of consideration the names of many American chemists who published important researches during this period of our history, for personal details would not be in place here, we come down to the date of the Civil War, which marks an epoch in more senses than one. In science, as well as in politics, the war divides American history into two periods—the one a period of preparation and slow growth, the other a period of swift advances and fruition. Through the war the Nation had received a sharp stimulus, and the re-establishment of peace was followed by wonderful progress in many directions. Population and wealth increased with great rapidity, and in due time that wealth began to flow into educational channels. The Nation itself embarked in many new enterprises; these demanded the aid of science, and so the latter received encouragement which its students had hardly dreamed of before. Even during the war the land-grant college bill was passed by Congress, and soon every State was provided with new facilities for scientific instruction, and the demand for trained teachers was greatly increased. The foundation of Cornell University, which opened its doors to students in 1868, was one of the consequences of this bill. In 1864 the School of Mines of Columbia College began its work; in 1865 the Massachusetts Institute of Technology was started; and these were followed by the Polytechnic School at Worcester in 1868, and the Stevens Institute at Hoboken in 1870. Even the older schools of science developed more rapidly, and in the Lawrence Scientific School particularly the research method of instruction was pushed into great prominence by Wolcott Gibbs. Hitherto our professors of chemistry had been commonly content with teaching what was already known, but under Gibbs the student was taught to think and to discover. Training in the art of solving unsolved problems became a part of the school curriculum. This phase of chemical education was brought into still greater prominence some years later, in the laboratory of the Johns Hopkins University, and now it is well nigh universal. Original research, once an occasional feature of American college work, is now emphasized in all of our better universities, and the student's thesis outweighs his examinations in importance. At first, as was but natural, our educational system was modeled after that of England, with Oxford and Cambridge as the shining examples to follow. Here, as there, the passing of examinations was the one supreme test of scholarship; but the growth of science in Germany attracted our better students thither, and they returned full of the modern doctrines. The German graft upon our English stock has made our universities what they are to-day, and now the man who can increase knowledge is more highly esteemed than him who merely knows. The knowledge which is fruitful outranks the sterile culture whose end is in itself. In all departments of learning, education has become more vital, more of a living force; and in this great movement forward the chemist has been a leader and a pioneer.

For many, many years the chemists of America were unorganized, a thousand scattered units, each doing what he could as an individual, but with no bond of union other than that of common interest. Here and there chemical societies were founded, to last for a year or two and then perish for lack of proper support. They were local experiments, nothing more; and no list of them could be made. In the more general societies, like the American Academy in Boston and the Academy of Natural Sciences in Philadelphia, the chemists had a part, but it was one of minor importance—an item among many.

In the American Association for the Advancement of Science there were some chemists who attended the meetings from time to time, and occasionally presented papers. They were overshadowed, however, by the more active representatives of other sciences, and their share in the proceedings was rarely conspicuous. The Association was divided, at the time of which I speak, into two sections—A and B, and in the first of these chemistry, physics, mathematics and astronomy were crowded together, with chemistry the least prominent of all.

In 1873 the Association met at Portland; and a handful of chemists, most of them young and unknown, but enthusiastic, were present. The time was ripe for a step forward, and that step, a very short one, was taken. The Association was requested to allow the formation of a sub-section of chemistry; a year later, at Hartford, the request was granted, and the sub-section began its career.

Some two weeks before the meeting at Hartford, on August 1, 1874, about seventy-five chemists met at Northumberland, in Pennsylvania, to celebrate, at the grave of Priestley, the centennial of the discovery of oxygen. It was now proposed to organize an American Chemical Society, modelled after the already flourishing societies of London, Paris and Berlin; but action was deferred, in order that the new experiment in the American Association might have a fair trial, and that the danger of undue competition, with its attendant division of forces, might be avoided. The new sub-section received general support, it grew and flourished; and when, in 1881, the American Association was reorganized, it became the full Section C of the present body. To-day the chemical section is one of the strongest and most vigorous in the Association, with a large and faithful membership which has been built up in great measure by the efforts of the men who started it twenty-three years ago.

In 1876 the project for an American Chemical Society was revived, and an organization bearing that name was established in New York. It obtained a fair membership and published a journal; but as all the meetings were held in one city it did not command the support of the country at large, and it became essentially a local body in spite of its claims to national scope. It was national in theory, and also in purpose, but it failed to receive general recognition; and it exerted no wide-spread influence until, after sixteen years of existence, it became a potent factor in the development of a larger enterprise.

In 1884 the Chemical Society of Washinton was formed. This was professedly local in its character, and so too were several other bodies of chemists which were organized within a year or two of this time. There was no concentration of effort among the chemists of America, except in the American Association, and that, unfortunately, met but once a year. There were nuclei enough, however, for crystallization to begin, and in 1888 another step was taken. The chemical section of the American Association appointed a committee to confer with like committees from other societies, and to report upon the question of a national organization. Conference after conference was held; report after report was presented; there was opposition, of course, from various quarters, and indifference to be overcome; there were conflicts of interest and the inevitable rivalries. But the movement was started; it was finally endorsed in due form by the old chemical section, and in time success was won. In 1891 and 1892 a plan was agreed upon, and the present American Chemical Society was established.

The two principal factors in the problem, apart from the American Association, were the American Chemical Society in New York and the Chemical Society of Washington. The former had the name and a charter, and, with some reason, claimed to occupy the field. The other made no claims, but would not concede primacy to the first. Professional interests and good feeling, however, carried the day; there were concessions from all sides, and the following plan was adopted: The existing name and charter were accepted. The New York body became a local section of the reorganized Society, and the Washington organization did the same. The old journal of the Society was consolidated with the flourishing *Journal of Analytical and Applied Chemistry*, with the editor of the latter, Prof. Hart, in charge. Other local sections were provided for, and it was agreed that the Society should hold two general meetings a year—one in winter, the other in coöperation with the American Association. Thus all interests were reconciled, and the scattered forces of the chemists began to converge toward a single point. A strong Society was created, with a good monthly journal; and to-day it numbers over a thousand members, with nine local sections in various parts of the country, carrying on continuous work. Hereafter the summer meeting will be held jointly with that of Section C in the American Association, making both bodies stronger and more efficient; all opposition has been overcome, the membership of the Society is rapidly growing, and the future seems bright. The example which has been set by the chemists may be a good one for others to follow. "In union there is strength." In New York there is also a section of the British 'Society for Chemical Industry;' and, in addition to the journal already mentioned, there is the well-established *American Chemical Journal*, managed by Prof. Remsen, at Baltimore, and a new periodical devoted to physical chemistry, which has just been started by Professors Trevor and Bancroft, at Cornell University. Our chemists are now well provided with means for publication, and there seems to be no dearth of material with which to fill the pages of the three separate journals. The *American Journal of Science*, the 'proceedings' of some local academies, and the foreign chemical periodicals also receive a share of our output. The facilities for publication seem to increase no faster than the activity of the American chemists.

On the purely scientific side the government of the United States has as yet done little for the advancement of chemical research. But indirectly, for economic reasons, it has done much, especially since 1876. So, too, have the governments of various States and cities, especially with regard to the analysis of fertilizers, and in the direction of sanitary chemistry. Some investigations concerning the water supply of cities have been carried out by local Boards of Health, and among these the researches instituted by the Massachusetts Board have been of the highest scientific quality. No better work of its kind has been done anywhere; and its results, intended for local benefit, are of far more than local value. On the part of the general government the patronage of chemistry has covered a wider range, and many bureaux have been provided with laboratories. In the Department of Agriculture a considerable force of chemists has long been employed, dealing with questions of the most varied character. The United States Geological Survey maintains another important laboratory, and still others are connected with the Bureau of Internal Revenue, the Mint, the Army and the Navy. In the Torpedo Station at Newport investigations are carried out relative to explosives, and at the custom house in New York a number of chemists are engaged in the valuation of imported articles with reference to the assessment of duties. In short, the government calls upon the chemist for aid in many directions, and the appreciation of his usefulness increases year by year. In all this work, however, chemistry is rated as a convenience only, and valued for what it can give; its advancement as a science is not considered, and such growth as it gains through governmental encouragement is purely incidental. Good researches of a strictly scientific character, real enlargements of scientific knowledge, have come from laboratories maintained by the government; but they represent the rare leisure of the investigator and not the essential object of his work. He is sometimes permitted to investigate for the sake of chemistry alone; but such labor is extra-official, and forms no part of his regular duties. The chemist is compelled to serve other interests, other sciences it may be; and only the time which they fail to demand is his own. Considering the enormous importance of chemical research to all the greater industries of the world, it should receive fuller recognition by the National government, and be encouraged most liberally.

I have already referred to the Land-grant College Act of 1862, under which so many agricultural and technical schools came into existence. In 1887 Congress passed another act, intimately related to the former, by which the States and Territories were each granted the annual sum of fifteen thousand dollars for the maintenance of agricultural experiment stations. These stations, some of which have other resources also, are actively at work, and they receive some coordination under a bureau of the Federal Department of Agriculture. Chemistry receives a part of their attention, and in 1894 one hundred and twenty-four chemists were employed in them. These chemists, and those connected with the Washington laboratory, are bound together in the Association of Official Agricultural Chemists, which meets annually. A prime object of that association is the improvement, definition and standardizing of analytical methods; and along this line it has done admirable work. The data obtained in the different experiment stations are thus rendered strictly comparable, and a higher degree of accuracy is reached than would have been attained under conditions of absolute individualism. The Association fills a distinct place of its own and is in no sense a rival of the American Chemical Society. Indeed, the members of the official body are nearly all members of the other.

In the industrial field, as well as in the domain of pure science, the chemists of the United States have made rapid advances during the past thirty years. In manufacturing chemistry the growth has been only moderate, at least in comparison with the growth of other industries, but still it is evident. We still import heavily, and depend upon Europe for many chemical products which ought to be manufactured here. In some special lines our goods are among the best; in others we are wofully backward. To some extent our tariff and revenue legislation has had a bad effect upon our chemical manufacturers; as, for example, in increasing the cost of alcohol; and certain defects in our methods of scientific teaching have also been to blame. To this subject I shall recur presently. In metallurgical processes the United States can hold its own, however, and especially in those which involve the applications of electricity. The electrical furnace, for instance, as it is used in the manufacture of aluminum, is distinctly an American invention, and the electrolytic refining of copper is carried out in this country on a scale unknown elsewhere.

If we consider the subject of applied chemistry at all broadly, we shall at once see that it has several distinct aims; such as the discovery of new products, the improvement of processes and the utilization of waste materials. It seeks also to increase the accuracy of methods; to make industrial enterprises more precise, and therefore more certainly fruitful; in short, to replace empiricism by science. It is, perhaps, in this direction that chemistry has made its most notable advances in America, and that within comparatively recent years. Three decades ago, even our greatest manufacturing establishments employed chemists only in a sporadic fashion, sending occasional jobs to private laboratories, and then only after counting the cost most parsimoniously. Except in a few dyehouses and calico printeries, the chemist was not fully appreciated; great losses were often sustained for lack of the services which he could have rendered, and the cost of goods was therefore higher than was necessary. By degrees, however, a change was brought about; one effect of industrial competition was to narrow margins and to render greater accuracy of manipulation imperative; and so the chemist was brought upon the scene. To-day it is almost the universal custom among manufacturers to maintain chemical laboratories in connection with their works; and this is especially true with regard to metallurgical establishments, oil refineries, soap, candle and glass works, in the making of paints, varnishes and chemicals, and so on in many directions. Even the great firms whose industries are connected with the Chicago stockyards, with their artificial refrigeration and their manufacture of lard, lard and butter substitutes, meat extracts, pepsin and fertilizers, all employ skilled chemists and provide well-equipped laboratories. In the making of steel and iron the processes are followed by analyses from start to finish, from ore, fuel and flux to the completed billets; and the chemists who are thus occupied have gained marvellous dexterity. The analytical methods have been reduced to great precision, and are extraordinary as regards speed; work which once required a day to perform being now executed in less than twenty minutes. Exact measurement has replaced rule of thumb; certainty has supplanted probability; industry has become less wasteful and surer of a fair return; and to all this the chemist has been a chief contributor. Without his aid the manufactures of the world could never have been developed to their present magnitude and efficiency. His influence reaches even beyond the furnace or the factory and touches the greatest economic questions. Take, for example, the financial agitation through which our country has so recently passed, with its discussion of monetary ratios. Chemical processes have profoundly modified the metallurgy of gold and silver, cheapening the production of both metals, and changing the commercial ratio of their values. Can the bi-metallic question be intelligently investigated with the chemical factor left out? Furthermore, chemistry has created new industries in which both gold and silver are employed; and so, affecting both supply and demand, touches their ratios still more deeply. When politics becomes true to its definition, when it is really 'the science and art of government,' then we may expect politicians to consider questions like these and to study the evidence which chemistry has to offer.

One other phase of applied chemistry, chiefly developed in this country, remains to be mentioned. In 1875 the Pennsylvania Railroad opened a laboratory at Altoona, in charge of Dr. C. B. Dudley; and eight or nine other great railroads have since followed its lead. In these railroad laboratories, which employ many men, all sorts of supplies are tested, and large contracts for purchases depend upon the results of analysis. Among the articles regularly examined, preliminary to buying, are iron, steel, various alloys, paints, varnishes, soaps, wood preservatives, disinfectants, *et cetera*. On the Pennsylvania system alone the purchases controlled by these tests amount to from two to three millions of dollars annually, and the saving to the company is undoubtedly very great. In many cases other purchasers adopt the specifications of the railroad and base their contracts upon the same standards, the analyses to be made in the same way. Adulteration is thus discouraged and prevented, and the moral effect upon the seller, who must be honest, is most salutary. When detection is certain the temptation to commit fraud vanishes. To the improvement of analytical methods the railroad laboratories have contributed materially, so that their work has true scientific significance as well as practical value.

Now, although we may properly take pleasure in the advances which American chemists have made, we have no right as yet to be fully satisfied. We have done much, but others have done more; and until we stand in the front rank we should not slacken our efforts. The competition of research is fully as keen as the competition of trade, and even if we may win the lead we must work hard to keep it. In spite of all that I have said of its growth, industrial chemistry in the United States is still in its infancy, and comparison with other countries is in some respects wholesomely humiliating. England and France have built up chemical industries vastly greater than ours, and in certain directions Germany leads them both. Moreover, the German industries and the trade depending upon them are increasing at a marvelous rate, and in England the chemists at least have taken serious alarm at the growing competition. Branches of manufacturing which were once almost wholly English are now mainly German; discoveries which were made in England have been developed in Germany, and now the British economists are seeking for the reason.

To the chemist the reason is plain, and is to be found by a study of two systems of education. The English universities and schools have clung to obsolete methods, and have attached great importance to examinations and the winning of honors. To the honor men positions and preferment are open, but the honors are awarded in the wrong way. In Germany, on the other hand, the pathway to success lies through research; honors are given to the men who have increased knowledge; and the effect of this policy is felt by every manufacturer upon German soil. Take, for example, the great chemical works at Elberfeld, in which about one hundred scientific chemists are employed in addition to a great force of laborers. Every one of these chemists received a training in research; every one is expected to make discoveries; and the results of their investigations are immediately applied in the manufacture of new preparations and the improvement of processes. The German employer does not ask the chemist to do for him what he can do already, but rather to supply the greater forces by which he can rise above his competitors and command the custom of the world. To that policy we have not yet fully risen in America; our technical schools have thought too much of routine drill and discipline; and until we profit by the example of Germany more thoroughly than we have done we cannot hope to rival her in chemical industries. Our practical men value science for what it can do directly in their interest, and rarely look deeper into the possibilities of abstract investigation. In reality, pure science and applied science are one at the root; the first renders the second possible, and the latter furnishes incentives for the first. Where science is most encouraged for its own sake there its applications are most speedily realized. This is a lesson which America has yet to learn, at least to the point of full and complete appreciation.

What, now, have we done, and what should we do? We have made a great beginning; we have built up good laboratories, backed by richly endowed institutions of learning; millions of dollars have gone into the teaching of chemistry, and the stream of research flows on with ever-increasing volume. American investigations and investigators are known throughout the civilized world; their creditable standing is fully recognized; our analysts are among the best; and yet—and yet—something is wanting. A great mass of good work has been done, beyond question; but no epoch-making generalization, fundamental to chemistry, has originated in the United States, nor has any brilliant discovery of the first magnitude been made here. The researches of American chemists have been of high quality, but not yet of the highest; there is solidity, thoroughness, originality; but with all that we cannot be satisfied. The field is not exhausted; there are great laws and principles still to be discovered; the statical conceptions of to-day are to be merged in wider dynamical theories; for every student there are opportunities now waiting. Shall we do our share of the great work of the future, or shall it be left to others? Shall we follow as gleaners or lead as pioneers? He who has faith in his own country can answer these questions only in one way.

At present, American chemists labor under some disadvantages which have not been fully out-grown. Research, with most of them, is at best encouraged, but not expected as an important professional duty. The teacher must first teach, and in too many cases the routine of instruction takes all his strength and time. The resources available for education have been scattered by sectarian rivalry; several schools are planted where only one is necessary; and the teachers, duplicating one another's work, and furnished with slender means, cannot specialize. Two chemists dividing the work of one institution can do more than four who labor separately. The field is too large for one man to cover alone, and yet most of our men are expected to do it. This evil, however, is growing less and less, and in time it may cease to operate. With the increase of true post-graduate institutions the work of American chemists will improve, for in that part of the educational domain research is an essential feature. Give our men the best opportunities, the best environment, and they will do their share of the best work.

In one direction, perhaps, the possibility of advancement is greatest, and that is in the institution of laboratories for research. At present the labor of investigation is unorganized, unsystematic, a little here, a little there, but no coördination; and consequently our knowledge is after all a thing of shreds and patches. In making this statement I do not exaggerate. Take any class of scientific data, examine any series of chemical compounds, and note the gaps which exist in it. A chemist in Berlin has studied one of the compounds, another in Paris has prepared a second, many bits of information have been gathered by many individuals, and so knowledge slowly accumulates. The organization of research is to be one of the great works of the future, when discovery shall become a profession, and groups of students shall cooperate toward the attainment of clearly specified ends. To some extent this work has already been done for astronomy, and more than one observatory could exemplify what I mean. In a fully manned and equipped observatory great investigations, too large for one astronomer to handle alone, can be carried out systematically; and this is actually done. In mapping the heavens, even, several observatories can combine their forces, each one covering a definite part of the field; but in chemistry no policy of this kind has yet been possible. The extension of the observatory method to other departments of science is the advance for which I plead.

Suppose now we had a great laboratory, fitted up for chemical and physical work together, well endowed and well manned. What might we not expect from it? Great problems could be taken up in the most thorough and orderly fashion, methods of work might be standardized and groups of physical constants determined; the results would aid and stimulate individual students everywhere, and applied science, too, would receive its share of the benefit. There is to-day a growing commercial demand for accurately determined constants, and no institution in which the demand may be adequately supplied. At Charlottenburg, in Germany, there is a beginning; in London the munificence of Ludwig Mond has made possible a similar start; but nowhere is such a plan as I propose in full and perfect operation. The United States has great observatories, fine museums of natural history and flourishing universities; why should it not have institutions for physics and chemistry also? These sciences touch many industries at many points; their applications have created wealth beyond all possibility of computation; now let that wealth do something for them in return. Half the sum that the Nation spends in building one battleship would erect, equip and endow a laboratory more complete than any now existing, whose influence would be felt throughout all civilized lands and endure as long as humanity. In this the United States might take the lead and set a great example to all other nations. The United States has long been a follower in science; may she soon take a higher place as teacher.

F. W. CLARKE.

U. S. GEOLOGICAL SURVEY.

THE AMERICAN PHYSIOLOGICAL SOCIETY.

THE ninth annual meeting of the American Physiological Society was held in Boston and Cambridge on December 29 and 30, 1896. The sessions of the first day were held at the Harvard Medical School, those of the second day at the University Museum, Cambridge. The following communications were presented and discussed:

Studies in the physiology of the mammalian heart. W. T. PORTER.

Cannulas were placed in the aorta and the innominate and pulmonary arteries of the cat. A thermometer was inserted in the right auricle through the superior vena cava. All other heart vessels were ligated, except the coronary arteries. Warm defibrinated cat's blood flowed into the aorta under pressure, passed through the coronary vessels and escaped, in drops as a rule, from the pulmonary cannula. A mercury manometer connecting with the innominate artery recorded the pressure at the mouths of the the coronary arteries. A Hürthle membrane manometer, coupled with a tube that was passed into the left ventricle through the left auricular appendix, registered the force and frequency of ventricular contraction. Variations in the temperature of the blood and the volume of the escaping drops were too slight to affect the correctness of the conclusions.

Intraventricular pressure curves were presented to demonstrate the following