trymen; then proscribed and hunted by associates; a fugitive in a foreign land, obliged to seek an asylum amongst his enemies, after combatting for the cause of liberty under the banners of Washington, and lastly, seized as a traitor and delivered up to the Emperor of Germany, who threw him into prison, from which one of our craft, Eric Bollman, risked his all and suffered unspeakable torments, that he might set free the idol of his young manhood!

Even chemistry has had its romances.

Other pictures might easily be sketched before you. Their novelty and their display of technical skill would promptly arouse earnest thought and profound mental absorption. But they would lead us far afield. The line of demarcation between past and present would fade into nothingness, and those interested would be surprised and yet happy to hear that the War of 1812, with the commercial restrictions preceding it, caused such a scarcity and dearness of the more prominent and valuable substances, so that one may safely declare the reestablishment of chemical manufactures dates from this time (1812). Foreigners conversant with chemical procedures in German, French or English factories were among the very first to undertake these ventures. Capitalists among our own druggists engaged this foreign skill that their own works might again be brought into operation, so that ere long factories for the making of Prussian blue, Scheele's green and other pigments, and heavy chemicals were quite rapidly inaugurated; hence 93 years ago thirty chemical establishments were in operation in the United States, with an aggregate capital of $1,158,000 and an annual output valued at not less than $1,000,000. Those fostering these undertakings had heeded the injunction of the chemically wise:

> Thrust in thy sickle, and reap; for the time is come for thee to reap! The harvest of the earth and factory is ripe.

And thus runs the story of our science with its many divergent lines. We cherish it, for experience has told us "to hold each strange tale devoutly true."

And how are we to adequately express our joy at the achievements of our friend whose fiftieth milestone in the cultivation of his favorite science is now reached? We have followed him through all his years as student, teacher and industrialist. We've rejoiced in his success, known to the world, and observing his still youthful step—his keen interest and intelligence in the multitudinous activities on every side, we're sure he contemplates even greater things in the coming years. So we'll content ourself by saying—

> Press on, true soul!
> Thou wilt win the prize.
> Thou wilt reach the goal!

UNIVERSITY OF PENNSYLVANIA EDGAR F. SMITH

FIFTY YEARS OF CHEMISTRY IN AMERICA[1]

WE are accustomed to thinking of our country as young, and so it is when compared in point of years with China. Its beginnings were extremely modest and its future to those who founded it must have been very doubtful, in spite of their courageous optimism. It took years to establish even an approximately firm foothold and a great many more years to solidly establish the position. When we look back upon the work of the early comers we can not but admire their dauntless courage, their industry, their thrift, their prudence. Our whole nation was built upon these and similar virtues, and I hope it will never come to pass that the uneasy quest for what is glibly termed progress will tempt us to look elsewhere than to eternal verities for the real progress of the nation.

Our forebears with everything to do and very little to do it with recognized the supreme importance of educating their children, and very early in their history institutions of higher learning were established. As they progressed with the building of a nation, the need of education became more and more clear, and institution after institution was founded, usually with very slight means, in order that higher education should advance and be more generally obtainable. One hundred years ago, Lafayette College was thus established, and you are to-day celebrating this fact with commendable pride and exultation. The history of the college has been a splendid one and its future is assured. Its long list of honored teachers and distinguished alumni is a visible sign of the success of its work. Its influences, however, which are not visible and are not even known, can not be measured. I congratulate the college on its history and on its work.

During the last half of its life, a man has been associated with the faculty who has made his mark not only within these walls, but outside of them. It is not my purpose to go beyond my text and deliver a eulogy of Edward Hart, but I desire to add my testimony to that of many others who have known him well during that time and appreciate his faithfulness, efficiency and singleness of purpose, happily joined with a saving sense of humor. The college does well in celebrating at its centennial time the semi-centennial of this worthy man's connection with the institution.

It is appropriate in honoring this man who, during the fifty years, has been constantly teaching chemistry and adding to its theoretical and prac-

[1] Address in connection with the celebration of Professor Edward Hart's fifty years of continuous service in the department of chemistry, Lafayette College, October 16, 1924.

tical knowledge, to consider what fifty years have done in this country for the science of chemistry and its application and what chemistry in turn has done for the country. Some of us can look back to the beginning of the period, as we so often do, not only with a feeling of amusement at what existed then but with astonishment at what has happened since. It is true that all branches of engineering and scientific knowledge have progressed tremendously hand in hand, but I think it must be admitted that chemistry has not only done its share but has greatly helped the other sciences to achieve what they have done. The whole progress has been colossal, but I wonder when Professor Hart's centennial is being celebrated whether the chemists of that day will not look back upon us of to-day with the same feeling of amusement at our lack of knowledge and the expensive mistakes which we have unwittingly and ignorantly committed.

In discussing fifty years of chemistry in America, there are so many points of view that the subject can not be covered within the limits of a short address, or even within the limits of a five-foot bookshelf. The historical side, the teaching side, the scientific side, any one is so full of interest that all deserve especial consideration. It is my purpose to speak briefly on the technical side without attempting anything in the way of dates and figures which in themselves would take up all the time allotted to me, besides being very dry hearing. I will lightly touch on a few of the high spots, realizing that there are very many which I will not even mention and realizing also that those I do mention are not complete or likely to be within my lifetime. I have seen a great many chemical problems solved, but I have never seen one that was solved so completely that there was no room left for improvement. Having this in mind, it would therefore be useless to attempt chronological order, and of course it would be foolish to endeavor to align them in the order of merit or importance, as no one can tell how the unimportant things of to-day may become the great and vital things of to-morrow.

I have always called sulfuric acid the pigiron of technical chemistry. Its uses are innumerable and its importance is vital. Fifty years ago this industry was practically in its infancy. Nothing was known beyond the simple chamber process, and no two manufacturers agreed as to the standard content of H_2SO_4. 66° acid ran all the way from 66° to 65°, or even less. The discovery of petroleum and its refining soon showed the importance of a standard high strength. For a number of years, the improvements in the chamber process, including concentration to 66° Be, and a trifle higher, were continuous and more or less secret. The revolution came when an acid of much higher strength—fuming acid—was needed in the arts and therefore had to be produced. A London firm, as far as I can ascertain, was the original producer in a large way of fuming sulfuric acid, by what is known as the contact process. When the requirements of the coal tar dye industry in Germany indicated need of something as strong as what was known as Nordhausen acid, but necessarily much cheaper, this firm exported it to that country. This condition could not last long, as the requirements were too large and too important. Many of you will remember the remarkable paper of Kneitsch which demonstrated the fact that investigators in Germany were alive to the situation and met it splendidly. It remained, however, for this country to develop the best process for the manufacture of this highly important material which lays at the foundation of our own needs for the treatment of certain petroleum distillates, for the great dye industry which has developed here, for high explosives, and unhappily for the manufacture of poison gases which "man's inhumanity to man" brought so prominently and unexpectedly before us during the World War. Fortunately for all these purposes, and others to which I will not allude, the production of fuming sulfuric acid in this country had become larger in 1914 than in any other country in the world and, I think I may add, more efficient.

In considering sulfuric acid, we should not lose sight of the brilliant work done by Herman Frasch in unlocking the tremendous sulfur deposits in Louisiana and Texas. Enormous quantities were known to exist, but until Frasch discovered the way, no one was able to economically withdraw them from their resting place. Thanks to Frasch, to-day the output is enormous, the process well understood and our country is placed far in the lead of the rest of the world in the production of this absolutely necessary chemical.

Another accomplishment must be mentioned, namely, the production of soda ash by what is known as the Solvay (or ammonia-soda) process.

While it is true that this process was conceived sixty odd years ago, its great improvements and refinements have taken place during the last forty years. To-day soda ash is made almost exclusively by that process and has been brought to an astonishingly cheap cost of production if we may judge by its selling price. When we consider the importance of the industries which have been fostered on the strength of this cheap and pure chemical, we must give the process a high place in the accomplishments of the last fifty years.

Petroleum and its distillates come strictly under the head of chemicals. This whole industry has been developed practically during the last fifty years. Fortunately, the first petroleum discovered was of a comparatively simple composition and methods for its refining were soon devised. The growth of the demand for these products and the discovery of oil in many different localities, all with different compositions, made the problem more complex and more interesting. The difficulties of the industry were greatly increased by the lack of balance of the demand. As an example, I will mention an interview I had with one of the high officials of the largest refining company, during which he told me of the extreme difficulty of disposing of the lighter fractions. What the people wanted was kerosene and lubricating oils; what they didn't want was gasolene. He told me he was at his wits' end to know what to do with gasolene. A few years later I had another interview with the same official and he told me the trouble now was to get gasolene enough. As you know, the invention of the internal combustion engine revolutionized not only the oil industry but a good many others, but what made the internal combustion engine possible? Various devices, including cracking, were resorted to, in order to increase the production of that fraction which a few years before had been a drug. Fortunately, this key industry is much better understood to-day than even twenty years ago, and I have no doubt that those engaged in it will be equal to the problems which the future has in store, and these are both numerous and difficult.

Fifty years ago, by-product coke ovens were in their infancy. Coke was made in beehive ovens, and everything in the coal, except the coke, was lost. The by-product ovens, as the name indicates, made available a good deal of the wealth which had been so carelessly wasted and to-day give us large volumes of illuminating gas, ammonia for the farmer, benzene, toluene, naphthalene, etc., for the dye-maker, tar for the roofer and road-maker, and of course the coke which was the primary objective.

During these fifty years another astonishing thing was done which had a most dominating influence upon the electrical industry in all its branches. I allude to the refining of copper by electrolysis—an industry which has assumed majestic proportions and furnishes nearly all the "red metal" used in the world. Long after Professor Hart came to Lafayette, little was known of the metallurgy of copper, and no one knew how to analyze it without an error sufficiently large to make the industry in its present state impossible. The producers of copper and its ores, realizing this fundamental difficulty, wrote to a number of chemists to see if it were possible to suggest a method of analysis which would be absolutely correct and therefore enable one chemist to check another. The accepted method was worked out in a Long Island laboratory and was based upon the idea that all the copper in an ore or other substance could be electrically deposited upon a platinum cathode, and its increased weight after the copper had been deposited would show the actual weight of the copper in the given quantity of material under consideration. This method with certain refinements to increase its accuracy has been in use ever since. The question was naturally raised, if you can thus deposit a gram, you can deposit a pound or a ton, or a thousand tons, and this was the foundation of the electrolytic copper industry. Being put into practice, another fact was developed which was not noted in the laboratory when dealing with small quantities. The mud which settled at the bottom of the electrolyte was found to contain all the silver and gold, platinum, palladium and other valuable impurities contained in the ore, in more or less minute quantities. The recovery of these residues has saved to the world many hundreds of millions of dollars of gold and silver which otherwise would have gone forth as impurities in the copper. Electrolytic copper itself, on account of its extreme purity, has rendered valiant aid to the working out of the complex problems of the electrical engineer and research worker. Of this period, therefore, we have to record that the electrolytic copper industry of the world and all that that implies was born in a chemist's laboratory and brought up to its present state of efficiency with little delay.

We all remember Sir William Perkin's discovery of mauve, the importance of which does not seem to have been appreciated by the inventor himself or by any of his countrymen. The study of what led to the great industry of coal-tar dyes and organic remedial agents was left largely to the Germans, who seem to have appreciated the importance of the work and made good use of the start they acquired. The by-product coke ovens had made the raw material available for large operations, cheap sulfuric acid and soda ash were also obtainable, but the German chemists are entitled to great credit for what they did with these factors. The war brought to our attention with stunning force the fact that an industry of vital importance for both peace and war had been allowed to get into the hands practically of one nation. Fortunately, necessity being the mother of invention, we in this country met that problem man fashion and have worked it out in a manner deserving the highest praise. This is not the time or place for a disquisition on the importance of synthetic organic chemistry, but it is a very appropriate place to say that in the future we need have little fear that our country will fall behind in the great procession. Given a pressing need, and the American chemist has never been found wanting in the past, and this to my mind is abundant augury for the future.

One of the most recent triumphs of chemistry is the practical solution of that essential problem—the fixation of atmospheric nitrogen in a form that enables us to use this lazy gas in some of its very active and energetic combinations. Nature has supplied unlimited quantities of it in the air we breathe, and during eons of time has fixed some of it in such familiar substances as coal and nitrate of soda. But to man it was impossible to utilize this vast storehouse of wealth, although it was realized that in time it would be imperative that he should do so. The first partially successful attempt was by Bradley and Lovejoy in their little experimental plant at Niagara Falls. They proved that under certain conditions the nitrogen of the air could be chemically united with its oxygen. Like many another pioneer, they pointed to a fact, but could not make the knowledge lead to a financial success. Their work, however, made others think along oxidation lines made possible by electrical discoveries, and to-day Norway's remarkable hydro-electric conditions yield the world large quantities of nitrates. The oxidation of atmospheric nitrogen became therefore practicable where electric power is cheaply installed and where other uses for it are lacking. In a country like our own, with factories on all sides demanding power and willing to pay much more for it than the nitrogen industry can possibly afford, I do not see any likelihood of the successful establishment of the electric arc process here in spite of all we read about Muscle Shoals. But it is a pleasant task to state that the fixation problem was solved, even if what seemed to be a better way came later.

And what is this better way? Professor Haber and his associates found that nitrogen would unite with hydrogen, in the form of ammonia, under high pressure in the presence of that "still small voice" of chemistry, a catalyst. Ostwald found that with another catalyst, the hydrogen could be easily displaced by oxygen, making nitric acid, and there you are! These two facts made the great war certain, and extended it three years longer than it otherwise would have lasted. Professor Haber told me recently that his attention was attracted to this matter and the possibility of its solution when visiting the little plant at Niagara Falls to which I have alluded. "Behold, what a great matter a little fire kindleth."

We are not behind in this vital question in our own country. One plant has been in successful operation for more than three years, and others are starting. If, unhappily, war conditions should arise, we have the patriotic satisfaction of knowing that the materials for carrying on war are all within our own borders. This knowledge should go a long way towards preventing the necessity of thus using our resources, but it is nevertheless a pleasant thing to know that they exist.

Naturally, the peace uses of nitrogen are far more important and pressing. Peace is our usual condition, thank God! and war is a hideous excrescence which should be and will be made impossible, if not by the improvement of human nature, which is the best way, then by the advance in scientific knowledge which may mean the suicide of the race—a silly alternative.

I have briefly touched on a few of the revolutionary accomplishments of applied chemistry, during the last half century. There are many more. While the chemist can point to them all with pardonable pride, he will not, I am sure, forget the important assistance rendered by the engineer. The problems have been large enough to require all sorts of talent for their solution—another instance of the value of cooperation.

In view of what fifty years have accomplished with, at the beginning, very little knowledge shared by comparatively a few men, what may not be expected of the next fifty years with present knowledge possessed by a vast army? There is abundant room for the imagination. I will venture only one prediction. The most elaborate and delicate chemical works ever devised is the human body. Much has already been done by the chemist in delving into its secrets. Positive results have been obtained which have almost annihilated certain diseases and modified others. I predict that during the next half century, the chemist, working hand in hand with the physician, will discover the origin and nature of most of the enemies of the human body, notably that arch-enemy, cancer, and not only alleviate their effects but absolutely prevent their sinister operations. Then indeed will the human race be relieved of some of its heaviest handicaps, and be freer to progress towards the light of truth which is its principal business, for we have it on the highest authority that "the truth will make you free."

WM. H. NICHOLS

NEW YORK, N. Y.

MEMBERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE PER MILLION OF POPULATION IN THE UNITED STATES

SOME results of a study of the geographical distribution of the membership of the American Association for the Advancement of Science, with special