tions were not compelled to resort to science and to the reclamation processes in order to earn large dividends. The trained chemist had not yet entered on the industrial stage. He did not hold the great industries in his hand as he does to-day. Furthermore, the state universities were scarcely able to train such men had there been a demand. They were struggling to keep up with the rapidly growing population of the state, and little more could be done than to teach general chemistry in crowded and poorly equipped laboratories. In fact, the state universities of the center and middle west twenty-five years ago were supported by the state as belonging in the same class as reform schools and institutions of similar nature. The state had not yet come to realize that the university is its best investment, not only from the mental and moral but also from the strictly commercial point of view.

The state universities, I think, occupy a position quite different from any of the other educational institutions. They are a part of the great commonwealth, they belong to the people of the state and hence must, if they fulfill their obligations to the state, not only train men and women for civic but also for purely scientific and industrial life. Neither must be neglected. During the past decade practically all of the state universities have come to realize this fact, and nowhere in the world has there been such rapid development along the lines of both pure and applied chemistry as in these institutions. The teaching of chemistry in these rapidly developing states has naturally and properly taken an industrial trend. There is not a single state university to-day which is not, besides doing research work, materially assisting in the industrial development of the state from which it receives its support. It is no longer difficult to obtain appropriations to well equip laboratories, as is evident from the splendidly equipped laboratories of the University of Illinois.

Of all these great unversities which have become not only great educational but also important industrial factors within the bounds of the states from which they receive their support, the University of Illinois stands among the first. Situated in the center of a great industrial population where trained men are always at a premium, its opportunities are boundless. It is bound to play an even more important part in the chemical development of the country in the future than it has in the past. With the man at the head, whom we have gathered here to-day to honor and bid a god-speed, I do not believe it is possible to predict too much for this university not only in purely didactic but also in industrial and applied chemistry. None of the branches of chemistry which must be taken up by this state university are new to him. He is the peer of Elliott or Remsen in didactics and of Silliman and Chandler in industrial chemistry. No man in the whole country is better fitted to take up the broad lines of chemistry now demanded by the state university. I congratulate the University of Illinois and the whole state in securing Dr. Noyes as standard bearer, and with such coworkers as Parr, Grindley, Bartow, Lincoln and Curtiss, this university will stand second to none of the state universities in preparing young men and women for the work demanded by this great state and by the whole nation.

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THE CONTRIBUTION OF CHEMISTRY TO MODERN LIFE

I think that few who have not paid especial attention to the subject realize how completely the world, as a place to live in, has been transformed during the past century. This transformation rests for its basis almost entirely on our fund of scientific knowledge, and especially upon the knowledge of physics and chemistry and biology which has been accumulated by scientific workers during the past seventy-five years. I wish to say something to you, this afternoon, of the part which chemistry has had in bringing about this wonderful change in our surroundings.

Our science goes back to the dark ages and before for its beginnings, but we, as chemists, haven't much reason to be proud of our intellectual pedigree. From the fifth to the fifteenth century, those who were known as chemists, or rather as alchemists, spent their time in searching for the philosopher's stone, which should change all things to gold, or for the elixir of life which should give eternal youth. The object which they sought was a sordid one, and while its attainment was quite generally believed to be possible, we have reason to think that many of the alchemists used the little knowledge which they possessed to deceive others more ignorant than themselves. We have been accustomed to say that our fuller knowledge has shown the folly of the alchemist's dream. Five years ago a distinguished chemist, in a public address, spoke of the doctrine of the transmutation of the elements as dead and every chemist who heard him agreed with his statement. But such revolutionary and startling discoveries have been made since then that a transmutation of the elements must now be considered as an accomplished fact.

This new discovery of transmutation did not come, however, along the paths the alchemists were following. Those paths were mostly blind alleys leading nowhere, though, now and again, some new fact about the way substances act on each other was discovered. And in spite of its obscure and mystical symbols and literature, and although the methods of experimentation were often more allied to magic and astrology than to science, alchemy left us a valuable inheritance of experimental knowledge. Many who took up the pursuit of alchemy from a desire for gold doubtless continued to work from a pure love of experiment.

In the sixteenth century some of those who had busied themselves with alchemy conceived the idea that chemistry might be of service to medicine. For one hundred years or more, the most notable of the chemists followed chiefly this new direction. They did not, however, discard the belief in the transmutation of metals. It was an age when authority still counted for very much and it seemed to them impossible to disbelieve the many circumstantial accounts of transmutation which had come down to them, often from sources that seemed thoroughly reliable. But, either because they despaired of success or because they found other things to do which seemed of more value, the chemists of this period turned their attention more and more away from alchemy and towards medicine and pharmacy. We may well doubt if their labors were much to the advantage of the suffering humanity of their time. Their crude empiricism and their wild and often mystical speculations as to the processes which go on in the body in health and disease were a poor basis for medical treatment. Doubtless many a poor patient fell a victim to their imperfect knowledge.

Thus far our science, such as it was, had followed utilitarian ends. The alchemist sought for gold—the medical chemist for new medicines. An embarrassing question often asked of a scientific man who has spent months or years of work over some problem is "What is the use?"—"Of what value will be the solution of the problem, if you succeed?" The contrast between the product of this thousand years of utilitarian science and the material results which have accrued during the two and a half centuries of better ideals is a sufficient answer, even from the material point of view—but I wish to protest against measuring the value of scientific work on the basis of dollars and cents.

About three hundred years ago there began to appear men who took an interest in the study of natural phenomena for the purpose of gaining a deeper insight into the nature of the world about them. There were, at first, very few men of this new type, and progress was slow in comparison with that of later times, but it was rapid when compared with the time of the alchemists. For these men were actuated by an entirely new and different spirit—the desire to *know* and the desire to gain knowledge that it might become freely the property of the whole world—and the knowledge they sought was not like that of the alchemist, whose aim was selfish and personal and whose greatest fear was that his secret discovery might become common property and so lose its value.

During the two centuries that followed there was a slow accumulation of chemical knowledge which passed freely among the few who had become imbued with this new spirit of investigation. During this period there was developed, too, the first really important generalization of the science—the theory of phlogiston which gave a qualitative explanation of the phenomena of combustion. This theory lived for more than a century and was useful in its time, but when the fundamental facts about combustion were discovered by Priestley and Cavendish and Lavoisier the theory was no longer needed. It was not displaced by a new theory, for the knowledge of the simple facts about oxygen and its relation to combustion was enough.

At the dawn of the nineteenth century Dalton gave to the world the next great generalization of our science—the atomic theory. This theory has been the central idea which has permeated the science and guided its development since that time. It has given to us a vivid picture which interprets and classifies for us the bewildering mass of experimental facts acquired by the work of thousands of chemists.

But while we find that this central guiding principle in the science was given to the world early in the century, there were as yet but few workers to cultivate the rich fields lying before them. There were no schools of chemistry, no great laboratories for instruction and research, such as we find to-day. But there were a few brilliant workers—Sir Humphry Davy in England, with his discovery of the alkali metals; Gay Lussac in France, with his laws of gases and discovery of iodine; Berzelius in Sweden, with his incredible achievements in the development of analytical methods and determination of equivalent weights. And for each of these there was another who gained from him an inspiration for scientific achievement—Faraday from Davy, Wöhler from Berzelius and Liebig from Gay Lussac. But Liebig did much more than go back to Germany to work in a laboratory of his own with perhaps an assistant or two. He founded in Giesen a laboratory for the training of investigators and it is scarcely possible to overestimate the importance of the influences which went out from that laboratory. To that laboratory came a company of enthusiastic young men gathered from all over the world. These men gained from their association with Liebig something of vastly greater importance than a knowledge of chemistry—they carried away an inspiration for research and an enthusiasm for the laboratory method of instruction. Largely from that laboratory as a center, chemical laboratories for the training of students spread throughout Germany and the world.

The fundamental principle of laboratory instruction is that the student comes into direct personal contact with the things about which he is to study and so gains first-hand knowledge. While chemists were the pioneers in this method of instruction, physicists and biologists soon saw its advantages and introduced it in those sciences. The principle has now permeated almost every line of teaching and we hear, to-day, of the laboratory method in history and psychology as well as in the physical sciences.

By the middle of the nineteenth century the methods to be used in training a band of chemists were being rapidly developed. And it came to be more and more clearly recognized that the training is not merely to give to the student a knowledge of chemical facts—it must give to him the power to think for himself and to strike out into new and untried paths. It is this power of individual initiative which is given to the students in the German laboratories that has placed Germany in the front rank in chemical manufacture as well as in research and instruction.

Some of the most important applications of chemistry in the industries were developed early, along experimental lines having little or no connection with scientific work. One hundred and fifty years ago, those who were smelting ores of iron and copper and lead and zinc knew very little of the work of the chemists of their day. And the same was true of those who were tanning leather, dyeing cottons, woolens and silks, burning bricks and pottery and china, making glass and working in many other chemical industries already well developed.

The soda industry was one of the first large chemical industries to be developed on a scientific basis. When we consider that the soda for our soap is now practically all made from salt, it seems hard to believe that one hundred years ago soap was made almost exclusively from the potash of wood ashes or from natural soda, the supply of which was very limited. I think we are forced to the conclusion that our great-grandmothers used very much less soap than we do. The first factory for making soda from salt was built by Le Blanc in France in 1791, but, partly because of the political conditions at the time of the Revolution, partly for other reasons, the factory was not a success. Le Blanc himself died a few years later, in extreme poverty, and it was not till 1823 that Muspratt established the industry successfully in England. From that time the Le Blanc process held undisputed sway till the early seventies. Since then it has fought a losing battle with the ammonia soda process, and to-day there is not a Le Blanc factory to be found in America. Now the ammonia soda is, in turn, being displaced rapidly by electrolytic soda. This sort of competition is typical of that which occurs in many chemical manufactures. In the case of Le Blanc soda it has been a most powerful incentive toward the improvement of the process. It has resulted in developing improved mechanical appliances for carrying out the operations, in the recovery of the hydrochloric acid and its use in the manufacture of chloride of lime and in the recovery of sulphur from the calcium sulphide. I visited a Le Blanc factory in England two years ago, where they told me that their sulphur for making the sulphuric acid used in the process came from Spain in the form of pyrites and that 85 per cent. of it left their factory as pure sulphur. In all this development the chemist has taken an ever-increasing part —in the development of new processes and the direction of old ones, and in that analytical control of raw material and finished product which has become indispensable in all kinds of manufacture.

The soda industry in its various branches was begun and has developed as the result of chemical work applied directly to the solution of technical problems. Since then it has often happened that work begun with the sole purpose of adding to our fund of scientific knowledge has led to important technical industries. The founding of one of our greatest industries began in this way, at the middle of the nineteenth century. In 1856 William Henry Perkin, then a young man of eighteen, was working in London as the private assistant of Professor A. W. Hoffmann. He was not satisfied, however, merely to spend the day on Hoffmann's researches and he fitted up a rough laboratory in his father's house where he could work in the evenings and in vacation time. Here, with a purely scientific interest, he tried some experiments which he hoped might lead to a synthesis of quinine. He got, instead, a dirty brown precipitate which must have seemed very unpromising. He became interested in it, however, and repeated the experiment with aniline. This gave him a black and still more unpromising product, but on examining it further he found in it a beautiful purple coloring matter which proved to be what we now know as the "Mauve dye." At that time, only fifty years ago, such a thing as an artificial dye was unknown, and we must marvel at the wonderful insight and energy of this boy who grasped the significance of his discovery and made it the beginning of the great industry of coal-tar dyes. After further study of the new compound and after practical tests in the dyeing of silk he gave up his position as Hoffmann's assistant and began the manufacture of the new dye. He was fortunate in having a father who had enough faith in the undertaking to risk almost his whole fortune on the venture, for it would have been hardly possible, then, to secure from outsiders enough capital for so hazardous an enterprise.

At that time benzene, the raw material for the manufacture, was not to be had in the market, of definite quality, and its distillation from tar had to be developed. Further, after the dye had been prepared it was quite different from the dyes then in use and methods for its application to silks and other goods had to be worked out. All these difficulties were finally overcome and within two years the mauve was supplied for the dyeing of silk. As soon as success was assured, others turned their attention in the new direction. Three years later magenta was discovered in France and soon after other dyes were prepared by Perkin, by Hoffmann and others. Hoffmann's discoveries of dyes are especially interesting because he thought that Perkin was making a mistake when he left him. And Perkin himself was much afraid that by entering a technical pursuit he would be prevented from following the research work in which he was so much interested. He determined, however, that he would not be drawn away from research, and in that determination and its imitation by others I think we may see the secret of much of the success of this industry. In no other industry are so many highly-trained chemists employed and in no other is the work so closely related to research in the pure science.

Twelve years after the discovery of mauve, Graebe and Liebermann succeeded in preparing alizarin, or turkey red, from the anthracene of coal tar. This discovery, again, was the result of pure scientific work undertaken without reference to its technical importance. The first method of preparation, too, was by a difficult process which was too expensive to be commercially feasible. As soon as the scientific problem had been solved, however, the question was taken up from the commercial standpoint and Perkin soon found an economical method for the manufacture of the dye. At that time large quantities of madder root were raised in Holland and elsewhere for the preparation of alizarin. It was soon found that the dye could be made much more cheaply from anthracene and within a few years the artificial alizarin drove the natural product from the market and the Dutch farmers were compelled to raise other agricultural products. So important is this dye that the value of the amount manufactured in 1880 is given as $8,000,000. It is estimated that it would have cost $28,000,000 to manufacture the same amount of the dye from madder root. This means that the world saves $20,000,000 a year in the manufacture of this single dye, an amount that would pay for the maintenance of a good number of chemical laboratories.

The development of this manufacture was so rapid that by 1873 Perkin and his brother found that it would be necessary to double or treble their factory to supply the demand. Perkin was then only thirty-five years of age and his love of research had survived his seventeen years of experience as a manufacturer. Partly for this reason, partly because he did not wish to assume the responsibility of the larger factory, he sold the works and after that time he devoted himself to scientific research, with distinguished success. The jubilee of the discovery of mauve and the founding of the coal-tar industry was justly celebrated last year as one of the great events of the century, but Perkin's scientific achievements and the way in which he stood for high ideals in research are, I think, of even greater value to the world.

The manufacture of mauve was quickly successful and after the scientific discovery of the structure of alizarin, commercial production soon followed. With indigo, the case has been somewhat different. The scientific problem was in itself more difficult and the course of events has illustrated with especial clearness the difference between the scientific and the technical solution of the same problem. Baeyer began his work on indigo in 1865. During the five years following he prepared a number of important derivatives, which contributed much toward the clearing up of the relation between indigo and other compounds. In 1870, he found that some of the work he was doing seemed to cover much the same ground as some work which Kekulè had undertaken and out of scientific courtesy he allowed the matter to lie dormant for eight years. In 1878, as Kekulè had published nothing further of importance, Baeyer returned to the problem and in 1880 he obtained a successful synthesis of indigo. With the brilliant success of alizarin in mind patents were taken out, and it was generally expected that the manufacture of the artificial dye would soon become of commercial importance. But these hopes of immediate success were not realized. Two principal difficulties were encountered. The original methods of synthesis involved a considerable number of difficult transformations between the raw material, toluene, and the finished dye, indigo. These transformations required a very large amount of careful scientific study before the conditions could be found under which they could be carried out in ways that would be economical of time and material. But when this side of the problem had received a partial solution as the result of fifteen years or more of work, a second difficulty presented itself in the magnitude of the interests involved. It is estimated that the world uses about 5,000 tons of indigo in a year. Now, even with the perfected methods it takes about four pounds of toluene to make one pound of indigo and the present production of toluene is only about 5,000 tons a year. The whole of the toluene produced would give only about one fourth of the amount required to supply the world's demand for indigo. Furthermore, the toluene now produced finds a ready market for use in the preparation of other dyes and other compounds. Any attempt to use a considerable amount of toluene for the manufacture of indigo would be met, therefore, by a rising price which would quickly make the production by this method commercially impossible.

Fortunately, another synthesis of indigo was discovered by Heumann in 1890 which made it possible to prepare indigo with the use of naphthalin as a raw material. As the supply of naphthalin is ample for the purpose, the second difficulty was overcome. But the new process required the solution of a whole set of new problems and it was not till seven years later that the Badische Anilin and Soda-Fabrik considered that the process was sufficiently well developed to justify preparation for the manufacture on a large scale. So carefully had they worked out every detail, however, that during the three years that followed they were willing to expend four and a half million dollars in building the factory and apparatus for this one enterprise. As the world uses in a year twelve to fifteen million dollars' worth of indigo, the manufacture on a large scale is justified, and there is every indication at present that the artificial indigo is slowly displacing the natural product. The farmers in India are already feeling this new competition and it is doubtless only a question of a few years before they will be compelled to devote their attention to other crops. The hope has been expressed that the land released in this way may be used for raising food products, which may give some relief from the famines so common in that country.

In 1856, in the same year in which Perkin discovered mauve, Henry Bessemer presented to the world at the Cheltenham meeting of the British Association the first account of his new process for the manufacture of steel. Previous to that time steel had been made by a roundabout, tedious process. The carbon was burned out of pig iron in puddling furnaces so constructed that only comparatively small amounts could be handled at once and the most arduous hand labor was required. From the wrought iron obtained in this way steel was prepared by packing the bars in charcoal and heating them for several days until they had reabsorbed the requisite amount of carbon. Bessemer conceived the idea that by blowing air through melted iron it would be possible to burn out the carbon and silicon in the iron, while the heat resulting from their combustion would keep the iron liquid. He thought, too, that if he could stop the blast at the right moment, before all the carbon was gone, he would have steel. He showed that in this way several tons of iron could be converted into steel in fifteen or twenty minutes, whereas the old process took half as many days. Such a revolutionary process attracted a great deal of attention, and he succeeded in selling the right to use the process to a number of manufacturers for a considerable sum of money. When they attempted to make steel by the new method, however, every one of them failed. It was found practically impossible to stop the blow at the right point to secure a uniform product. But Bessemer was not disheartened by the failure and for the two years and a half following he worked continuously, building new furnaces and tearing them down, until he finally solved the difficulty. It was found possible to determine when the burning out of the carbon in the iron was practically complete by watching the flame as it issued from the converter. Then, by adding the right amount of an iron containing manganese and carbon, the proper composition for steel could be secured. When Bessemer tried again to introduce his perfected process he met with a very cold reception from the manufacturers. They said they were not to be deceived a second time. He was finally compelled to build works and establish the manufacture for himself. He succeeded beyond the most sanguine expectations, and the revolution in the manufacture of steel which dates from that time is common knowledge.

Agriculture still remains the most important industry in the world. From the time that primitive man began to till the soil to the middle of the nineteenth century the farmer received but little aid from chemistry. The work of the last seventy years has changed all that. As late as 1840, it was generally supposed that plants grew chiefly from the vegetable humus in the soil. Many of the fundamental facts on which to base a more correct view had been known long before, but it was Liebig who first grouped these facts together and pointed out clearly that plants are nourished by the inorganic constituents of the air and soil and that it is the potash and lime and phosphorus and inorganic nitrogen of the soil which are vitally essential to their growth. On this simple foundation has grown up our great modern fertilizer industry, which brings to our farmers the phosphates from the south, the potash salts from Germany, and the nitrates from South America. The supply of the last is limited in consideration of the present demand, and there has been a good deal of speculation as to what our farmers will do when the beds of nitrates are exhausted. There is plenty of nitrogen all about us in the air, however, and several methods have already been developed for utilizing this inexhaustible supply.

I might speak further of the part that chemistry plays, to-day, in the making of paper, in the tanning of leather, in the boiling of soap, in the manufacture of glass, in making paints and varnishes and india rubber, in the making of cement and in the refining of petroleum, but I will not take your time with further details. In these and in many other industries the work of the chemist has become an indispensable factor. Fifty years ago there were very few chemists in America and those few were almost exclusively engaged in teaching. To-day it is estimated that there are 8,000 chemists in the United States and a very large proportion of these are employed in industrial work. But it is not in technical lines only that great advances in chemistry have been made. I believe the advance which has been made in chemical research is of much greater importance. I have spoken of the fact that Liebig gave to his students the love of research and that they acquired in his laboratory the power of individual initiative. In many of the chemical laboratories of our colleges and universities and technical schools are to be found to-day earnest workers who are seeking for new truths and who inspire their students with the power to think independently and to do original work. Whether the student's life work is to be in the field of pure science or in its technical applications, this power is the greatest gift that a teacher can impart.

While the material advantages which have come to us from chemistry are very great and may be justly emphasized, its greatest achievement is, after all, the part which it has had, together with other sciences, in transforming the way in which the world *thinks*. In its laboratory method it has replaced the old idea of authority by the idea of first-hand knowledge. It leads the individual to seek for himself the fundamental basis of his knowledge and it leads him not merely to pass that knowledge on to the next generation, but to transform it into a new and truer form. And as this scientific spirit permeates society it more and more destroys deceit and fraud, wherever found.

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SCIENTIFIC BOOKS

Foods and their Adulteration: Origin, Manufacture and Composition of Food Products, Description of Common Adulterations, Food Standards, and National Food Laws and Regulations. By Harvey W. Wiley, M.D., Ph.D. 8vo, pp. xi + 625. Eleven colored plates and 86 other illustrations. Philadelphia, P. Blakiston's Son and Co. 1907. Cloth, $4.00.

Seldom has a more timely book appeared than this, following so closely as it does the beginning of the enforcement of the new national pure-food law. For some time prior to the passage of this law public interest throughout the country had become vitally awakened to the importance of the pure-food issue. Amid a large mass of confusing and often exaggerated newspaper articles dealing with the subject, it is a comfort to find a book covering the field so completely, so sanely and withal in so interesting a way.

The book treats systematically and quite exhaustively of all the principal food products, dealing in turn with their manufacture, properties and composition, forms of adulteration and dietetic value, and including much information of a general nature concerning them. Beginning with the animal foods, it thus covers meats and the various meat preparations, fish, milk and its products and oleomargarine. Then follow the vegetable foods, cereals, vegetables proper, condiments, fruits, sugar, syrup, confectionery, honey, and finally infants' and invalids' foods.

Beverages are to be separately treated in another volume.

Though destined for a wide variety of readers, the book is apparently designed first of all for the benefit of the public, at a time when the public wants particularly to know about its food; and written as it is from a strictly scientific standpoint, yet in a popular way, by one who from long experience knows so thoroughly his subject, it will be widely read and to great advantage by the people as consumers.

Not only does the author cover the ground directly suggested by the title, but in a general and useful way gives throughout much information about food values and the use of food for bodily nourishment. The colored plates illustrating the appearance of cuts of healthy beef, for example, will be found especially helpful to the householder.

To the food manufacturer and dealer the book is almost indispensable, since it describes very plainly the methods of preparation and standards of purity, the effects of storage, and, in addition, gives much good and sound advice regarding what might be termed controversial forms of adulteration, such as chemical preservatives and artificial coloring, called controversial because their use with restricted labels has to some extent been legalized under some of the state laws, and because they have for years formed the subject of much difference of opinion among experts in food litigation.

In treating of these substances, the use of which unfortunately seems to be on the increase, and which form undoubtedly one of the most important phases of food adulteration, the author speaks in no uncertain way. He unequivocally condemns the use of chemical preservatives, such as boric, sulphurous and benzoic acids and their compounds, as in all cases deleterious to health, and would rigidly exclude them from all food products. Even saltpeter, so long used in the corning of beef, he regards as undesirable.

As to artificial colors, he would keep them