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*THE CONDITION, PROSPECTS AND FUTURE EDUCATIONAL DEMANDS OF THE CHEMICAL INDUSTRIES.**

IT has been well said that chemistry is an offspring of the nineteenth century. The closing years of the eighteenth century had some glimpses of the wonders the new science had in store, but it remained for the workers of the first decade of the nineteenth to collaborate the results obtained by their immediate predecessors and develop the new truths which finally established the foundation of the glorious structure, which has now grown so great. During this period human necessities were in every way augmented, and particularly in France, claimed to be the fatherland of our science, human ingenuity was sorely taxed to meet these needs.

The struggle to find ways and means stimulated the energies and increased the zeal of the searchers after truth, and the utilitarian quest, as is always inevitable, brought forth results of interest and value above and beyond the actual needs, furnished data upon which are based the most important and fundamental laws of the science and firmly established many of the most important of our industries. The labors of the chemists of the last decade of the closing century had cleared away the

* Address of the President before the American Chemical Society, Chicago, 1900.

haze which surrounded and covered the truths already developed and opened the way for further promotion of the newly-born science. Lavoisier had led, by the introduction of systematic and accurate observation and record, to the crystallization of what had so far concentrated, and his associates, imbued with his spirit and inspired by his genius, were ready and willing to carry forward what he had so nobly begun.

And so the science was launched. How it has progressed during the century now closing has been told in many ways by many men, and the history seems ever new. New laws and new truths found applications in the industries and increased the material wealth, and the industries in turn furnished the material, the data, the incentive, for much of the additional investigation necessary to the development of the further laws.

The activity of the last decade of the last century has its counterpart in that of the century just closing. If the former century established the foundations, the closing century has furnished a superstructure worthy of the great minds who began the work. And whether we consider the later achievements from the side of abstract science, or from that of the applications of the great laws to the material needs, the glory is equally manifest and the wonder no less profound. Whether we consider argon, and helium, neon, krypton and xenon, and the beautiful researches which led to their discovery, polonium and radium, and their remarkable properties, the Röntgen reactions or the liquefied gases, and the attainment of the almost lowest limit of low temperatures; or the wonderful advances in illumination, the production of high temperatures in the electric furnace, the development of new compounds and forms of matter through the aid of these temperatures, the applications of high electric tensions to the production of new reactions, even those most familiar with them must feel the influence of the mighty strides and look into the future with enthusiastic hope.

The interest manifested in the new science in the old world was quickly extended to the new, and it found most active lodgment here. Students and associates of Black in Scotland, Fothergill in England and of the French chemists of the last quarter of the century in Paris started the work, and the names of Rush, Hutchinson, Woodhouse, McLean, Franklin, Rumford, Priestley, Silliman, Hare, Seybert, Norton, Dana and others, will ever find affectionate memories in the minds of the chemists of America. What these men started has been actively developed by those who followed them, until to-day the science and its applications find more actual workers in our country than are to be found in any other country within the bounds of civilization.

The first half of the century had comparatively few men in the United States who could be classed as working chemists. Chemistry had, it is true, been taught in a way in many of the colleges. But systematic work, as we know it to-day in many of the institutions of learning, was practically unknown. Those who felt the special need of, and had a desire for, such instruction were constrained to seek the facilities in other lands, until generous and at the same time practical men, such as Lawrence, Sheffield, Packer, Pardee and Harrison, with enterprising eyes and prophetic vision, saw the advantages to be derived from the further development of the sciences and provided the means whereby well-furnished laboratories could be opened up, and facilities for the profound study of the science could be made possible. But the industrial needs of the country for more exact knowledge of the natural laws extended beyond private munificence, and the national legislatures early recognized the importance of the better education of those who must manage the rapidly growing industries. The successful efforts of the late Senator Justin S. Morrill and his associates, in securing the enactment of the law which provided for the establishment in each State of an institution for study of agriculture and the mechanic arts, is well known and will always be gratefully remembered. No less important were the efforts of the late Mr. Hatch of Missouri, who labored so earnestly and eventually so successfully for the establishment of the State agricultural experiment stations. There can be no question that nothing has done more for the promotion of the science of chemistry and its applications than the acts of these great captains of industry and legislation. We shall not forget further the wonderful benefactions of Johns Hopkins, Clark, Case, Rose, Rockefeller, Stanford, Schermerhorn, Havemeyer, Fayerweather, Carnegie and others, who have furnished through splendid munificence the magnificent facilities not only for instruction in the science but for abstract research as well.

The science received splendid impulse and inspiration in the meeting at the grave of Priestley in 1874. It brought the chemists of the country, then comparatively few in number, together and established the bond of good fellowship and scientific sympathy, always so necessary to true progress. The most important outcome of this most important gathering was the organization of our own society. In his address delivered at that meeting Professor Benjamin Silliman named eighty-five chemists who had contributed to the advancement of the science in the United States at that time.

In 1876, the American Chemical Society was organized and during the year enrolled 230 members, of which 190 were professional chemists. The impulse given in Northumberland was effective, the example of a few devoted and public spirited men was followed, and though a period of almost fifteen years was requisite to the ultimate firm establishment of the work of the organization and the integrity of the Society itself, the great aims of its founders to secure the harmonious and thorough organization of all the chemists of the country finally prevailed. The Society has continued to increase in membership and influence, until at the present time thirteen local sections have been established in the various parts of the country, all actively working, and at least six of them holding monthly meetings, during all but the summer months, for such scientific intercourse and discussion as cannot fail to be fruitful in the promotion of the science. The roll of membership now contains about 1,750 names, and while this represents but a small proportion of the working chemists of the country, its growth henceforward must be rapid and the hope of the founders fairly realized.

The *Journal* covers annually nearly one thousand pages of matter fairly representative of the work of American chemists, and it has become necessary, because of increased demands for it, to publish an edition of three thousand copies. Its pages are open to communications on all subjects relating to chemistry and its applications, and it is the hope and expectation that the valuable *Review of American Chemical Research* may be accompanied in the near future by abstracts of papers published in the foreign journals, thus furnishing to all our members information regarding the world's works in chemical science and practise.

The progress made in the applications of chemistry in our country can properly and fully be told only in the results of the census now in progress and in hands which promise results of higher value than have ever before been obtained in such work in this country. We may congratulate ourselves that it has been entrusted to our past president, Dr. C. E. Munroe, whose tastes and training have so admirably fitted him for the delicate and difficult task submitted to him. But we have in the figures prepared by the Bureau of Statistics of the United States Treasury most significant data regarding the progress made during this closing decade of the closing century. From this source we learn that of products classified as chemicals, drugs and medicines, we imported during the year ending June 30, 1890, to the value of $41,601,978, while for the year ending June 30, 1900, this value had become $52,931.055. Most of the materials represented in these figures entered into consumption in industries, based wholly or in part upon the applications of chemistry. We cannot enter into the details of these statistics, but we may consider with interest and profit a few figures relating to some well known industries, and which are instructive in this connection as showing the variations which have occurred during the decade.

Chemicals imported in 1890 and 1900 respectively:

	1890.	1900.
Caustic soda	$1,470,335	$158,793
Soda ash	3,493,288	665,104
Potash, Chlorate of	238,840	102,337
Soda, " "		93,076
Lime, Chloride of	1,385,080	1,461,858
Glycerine	928,935	2,138,670
Alizarine colors	358,882	771,336
Coal tar colors and dyes	1,787,553	4,792,103
Other coal tar prod		397,780
Milk, Sugar of	46,510	399
Glass	7,411,343	4,038,753

The figures indicate enormous growth of the alkali industry in the United States during the decade and show that in this branch of industry we are entirely independent, as regards supplies, of foreign producers. The figures for glycerine show the possibilities of expansion of another industry, while the almost astounding growth of the importations of alizarine and coal tar products and dyes indicates the necessity for the further development and utilization of our own sources of crude materials of like character and the extension of that already begun. The rapid growth of the establishment of the by-product coke ovens reveals great possibilities in this direction, and it must be disappointing if the characteristic enterprise fails to take advantage of these possibilities.

If the importations of chemical products are interesting and indicate great activity and growth in the industry, the figures for the exportation of similar products are even more significant. We submit figures for the years ending June 30, 1890, and June 30, 1900, respectively, including in the table some data for 1876, the year of the organization of our Society. To have predicted these results in the beginning of the quarter-century would have invited incredulity, but so also would predictions regarding the advances to be made in other lines of human industry. The figures are worthy of careful study.

Values of exports of domestic products of the chemical industries for the years ending June 30, 1876, June 30, 1890, and June 30, 1900, respectively:

	1876.	1890.	1900.
Bark and extracts for tanning	$223,276	$263,754	$376,742
Beeswax		17,927	91,913
Blacking	81,401	238,391	880,049
Candles	229,311	143,073	191,687
Celluloid		39,004	174,264
Acids	50,300	98,084	146,722
Ashes, pot and pearl	75,597	26,211	49,566
Copper, Sulphate of			2,120,745

	1876.	1890.	1900.
Dyes and dyestuffs		717,128	498,056
Lime, Acetate of			776,413
Other chemicals not separately enumerated	2,471,195	2,840,931	5,536,716
Cider		193,283	64,283
Coke		53,586	1,233,921
Coffee and cocoa, ground and prepared, and chocolate		93,735	228,241
Earthen, stone and china ware		175,477	575,823
Fertilizers	922,221	1,618,681	7,218,224
Glass and glass ware	646,954	882,677	1,933,201
Glucose or grape sugar		855,176	3,600,139
Glue	5,798	88,484	225,844
Grease, grease scraps and soap stock		1,506,819	2,944,322
Gunpowder and other explosives	67,887	868,728	1,888,741
India rubber, gutta percha and manufactures of	88,816	1,090,367	2,364,157
Ink, printers' and others		147,057	259,776
Leather		11,175,141	15,363,584
Lime	77,568 (Lime and Cement)	134,994	85,854
Cement			163,162
Malt		60,412	215,198
Malt liquors	42,664	654,408	2,137,527
Matches	153,680	62,284	95,316
Naval stores	9,799,923	7,444,446	12,474,194
Oil cake and oil cake meal		7,999,926	16,757,519
Oils, animal	1,975,972	1,686,643	718,997
Oils, mineral, crude	2,220,268	6,744,235	7,364,162
Oils, mineral, refined or manufactured	30,502,312	51,403,089	68,246,949
Oils, vegetable, Corn			1,351,867
" Cotton seed	146,135	5,291,178	14,127,538
" Linseed	23,770	55,036	54,148
" volatile or essential	248,270	223,435	256,597
" all other		102,792	554,295
Paints, pigments and colors	179,882	578,103	1,902,058
Paper and manufactures of	795,176	1,226,686	6,215,559
Paraffin and paraffin wax		2,408,709	8,602,723
Perfumery and cosmetics	375,011	430,151	358,589
Photographic materials		3,891	1,164,465(1899)
Plaster		5,153	35,017(1889)
Lard	22,429,485	33,455,520	41,939,157
Lard compound and substitutes			1,474,464
Oleo and oleomargarine		6,773,522	10,920,400
Butter	1,109,496	4,187,489	3,142,378
Cheese	12,270,083	8,591,042	4,939,255
Milk		303,325	1,133,296
Salt	18,378	29,073	55,833
Soap	684,739	1,109,017	1,773,921
Spermaceti	35,915	116,757	67,125
Spirits, wood			320,306
Spirits, grain (neutral and cologne)		178,257	59,277
" brandy			83,698
" rum		663,039	903,808
" whiskey, bourbon		498,250	764,860
" " rye		137,029	121,241
" all other		165,535	24,921
Starch	524,596	378,115	2,604,362
Sugar and molasses	6,745,771	3,029,413	3,697,366
Tallow	6,734,378	5,242,158	4,398,204
Varnish	54,906	206,483	620,059
Vinegar	6,133	10,520	12,583
Wine	33,483	270,930	62,592
Wood pulp		2,245	458,463
Yeast			36,061
	$102,054,750	$174,803,105	$264,501,771

The figures show grand totals as follows:

For the year	1876	102,054,750
" " "	1890	174,803,105
" " "	1900	264,501,771

In the decennial period just closing the increase in the value of the exports of products of domestic manufacture was therefore about the same as during the preceding fourteen years, and during the quarter-century the growth has been 260 per cent. The growth has been persistent and steady, and indicates what may be expected in the immediate future as well as what is now the condition of development of our chemical industries. This latter condition becomes more manifest when we consider that the products exported constitute but a small proportion of the production, and we may in some degree at least anticipate the results which must be obtained in the pending census investigation.

As a further illustration of the growth of the chemical industries, we may call attention to the condition of the coke industry in the United States in 1880 and 1898 respectively, as illustrated in the following table:

	1880.	1898.
Establishments	186	342
Ovens { built	12,372	48,447
Ovens { building	1,159	1,048
Coal used, net tons	5,237,471	25,249,570
Coke produced, net tons	3,338,300	16,047,299
Total value of coke at ovens	$6,631,267	$25,586,699
Value of coke at ovens, per net ton	$1.99	$1.594
Yield of coal in coke, per cent	63.0	63.6

If we consider that in the recovery ovens, which are fast taking the place of the older and less rational types, this coal should yield 3.38 per cent. of tar, .34 per cent. its weight of ammonia and 8.17 per cent. of gas liquor, all of them bases of most important chemical industries, the figures are significant.

Equally interesting must be the information to be furnished regarding the capital represented in the chemical industries in this country. At the present time, we are able to judge of this to a minor extent from the reported capitalizations of the recently organized companies constituting combinations of preexisting companies. It is true that in these cases the capital represents in a very considerable measure what is known as good will, franchises, etc., but it nevertheless represents earning power and the the average market value corresponds very closely with par value. Taking only those organizations devoted to the chemical manufactures exclusive of the gas and metallurgical and explosive industries, we find that the capitalization as reported in the stock lists amounts to the enormous value of about $1,500,000,000, and this takes no account of many of the incorporated industries not specially reported, nor the industries not incorporated and yet active. It does not include the recently developed electrolytic industries, in which the cash capital actually invested, as we learn from competent authority, amounts to more than $1,500,000. The newly-established by-product coke industry is so rapidly developing and is absorbing capital with wonderful rapidity, while the comparatively new beet root sugar industry has already developed to such an extent as to involve capitalization of nearly $100,000,000 and to develop the establishment of manufacturing plants of magnitude beyond the imagination of foreign manufacturers in the same line a few years ago. Yet this is a general characteristic of the modern chemical industries of the United States, and it is interesting to note that much of the development has been effected empirically and by men comparatively little versed in the principles and laws of the science upon which they are based. The industries have had the aid of but few educated chemists. Happily this condition is rapidly changing. Rational work is coming to be recognized and the demand for well-trained chemists is increasing. We cannot yet boast with the Germans that single works employ more than one hundred thoroughly educated chemists, yet inquiry shows that many of the important works have corps of chemists numbering from ten to fifty, while very many more have smaller numbers. The same inquiry affords some clue to the number of chemists actually at work in this country. If we compare the list of members of the American Chemical Society, we find that more than two-thirds are engaged in technical work. Furthermore, of the few chemists reported in the inquiry just referred to, scarcely one-third are members of the Society. A fair estimate based upon such data leads to the conclusion that more than five thousand chemists are actually at work in the United States and that eighty per cent. of these are connected with the industries. A study of the lists of the graduates of the educational institutions leads to similar conclusions. Fischer reported as the result of special inquiry made three years ago that in Germany four thousand graduate chemists were employed in the industries and about two hundred in teaching and special investigations.

So then we find that the chemical industries of the United States are growing with enormous rapidity; that they are being concentrated into fewer but larger works; that operations and reactions are being carried out with a magnitude which the earlier chemists would never have predicted; that new methods are being followed; new principles applied, greater accuracy of results demanded both as to quality and yield of the products; that the products now issue from the works in lots of tons at a time of a higher degree of purity and with a greater economy than were possible but a few years ago with lots of a few hundred pounds. For instance, the great sugar refineries each yield from one to two million pounds daily of a product, the purity of which may be considered absolute. The modern beet sugar works have in some cases capacity for treatment of from 1,000 to 3,000 tons of roots daily, and consequently the purification of almost an equal quantity of juice.

And if so great advance has been made during the closing quarter-century and even decade, what shall we say of the possibilities of the future? What is to be the magnitude of the chemical industries of the United States? What shall be the character of the products issuing from them? What will they require of the men who must direct and control them? That is to say, what will be the educational requirements of the American chemical industries of the almost immediate future? These questions are not new to our own country, and their importance has forced itself with powerful intensity upon those engaged in the chemical industries in the old world: it has been the subject of most earnest discussion, particularly in Germany and England, during the past five years at least. Nor has it been in all respects satisfactorily answered. Even within this closing month of the closing century the cable has flashed news of the complaint on the part of the leading statesmen of England that the training of technologists in that country is inadequate to the development necessary to meet foreign competition, and at almost the same time brings news of the inauguration of new institutions for technical education. And in Germany also, the home and starting point of many of the great industries, the demands upon the educational institutions for the better training of technologists are being pressed from every side. It is natural to believe that the time is not far distant when we too shall be called upon to make and meet similar demands. It may be pardonable therefore to discuss briefly what these requirements are likely to be.

First of all, experience shows that those who financially control the great industries fully appreciate the need of improvement in both processes and products are particularly apt in propounding hard questions in connection therewith, and always expect that these questions shall be answered quickly and with the utmost accuracy. Young men who early come to a realization of this fact and prepare themselves by broad and thorough education to meet it are those who will succeed in the industries and ultimately have a controlling influence in their management. And what is to be said here on this subject is directed as much to the students as to those who instruct, for it is not difficult to understand the restrictions placed upon teachers by the students themselves in the struggle to arrange work leading to the training, which many realize to be absolutely essential to meet the requirements of the near future.

For it is beyond question that the most thoroughly educated man is sure to best meet these requirements and become the leader in the industrial struggle of the near future. Dr. Duisberg, the director of the great color works at Elberfield, Germany, rightly fixed the standard when he said that 'above all a general comprehensive education is required. We must have in the industries persevering, energetic men with broad views.' And Dr. Chittenden was right when he said "give a young man a broad knowledge and a thorough conception of the principal laws of physics, mechanics, hydraulics, etc., and he will soon adjust himself to the environment of professional work and eventually rise to a plane far beyond that of the man whose training has been purely technical," and concluding his paper he says, "the rapid development of the sciences and their manifold industrial applications have opened up avenues for new ventures of great magnitude, and there is an increasing demand for young men of broad scientific knowledge and training. He who wishes for the fullest possible measure of success must prepare himself thoroughly for his life work and he can do this in no better way than by acquiring a broad and liberal education."

This important requisite to success could not be better described. Careful general training is conducive to the best thought and the best expression of the results of inquiry. And it is too frequently true that technical men are especially lacking in this particular. Too early specialization must tend to narrowness of view and therefore to limited influence. The general culture work of the preparatory schools, or of the colleges, will always be profitable, whether as preparatory to a specialty or an auxiliary to its prosecution. These principles will apply to all technologists, whether they are chemists or not.

But what shall be the character of the special training of the technical chemist? First of all, we must admit, that this must cover thoroughly and profoundly a study of the science of *chemistry*. Dr. Fittig declares: "Our problem is to study the science as such; to lead the student into the methods of strictly scientific investigation, to put him into position to solve pure scientific problems entirely independent of the question, whether he shall devote his powers to the services of the science itself or apply it to practical questions." He claims that many students take up the study without the scientific instinct. And Erlenmeyer says "a true scientific training should produce ability and susceptibility for all and every use. With a knowledge of the principles and laws of the science, their use becomes easy, they proceed independently." Foerster, discussing the needs of the electrochemists, says "but above all be particular to secure fundamental training in the entire field of chemistry, thus utilizing the principle insisted upon by Liebig, that the best training for any specialty rests upon the broadest foundation in the whole of scientific chemistry." Dr. Duisberg says further: "in technical chemistry the sharp eye of the scientifically trained man is wanted in order to recognize the individual developments of the reactions in progress, which can be seen only through the accompanying indications." And Richard Meyer truthfully declared: "if our technologists did not properly appreciate the service rendered by men trained in the spirit of Liebig, chemical investigation would miss the stately crowd of auxiliary powers, without which the heights, from which we may now look proudly backward and hopefully forward, could never have been attained." And W. H. Perkin says that "technical education will be of small value unless it is carried out on a very broad and scientific basis."

These views of the leaders in the science of chemistry must find an echo in the mind of every man who has had experience in the industries. In no department of human activity is a thorough knowledge of the fundamental laws so needful, nor can the knowledge of any law be safely neglected if successful work is to prevail. For all the laws apply all the time and few cases will arise in which the more important can be avoided. To suppose that the industries can be carried on in the face of severe competition without such knowledge is to invite failure in every case. Empiricism may succeed in times of plenty, but adversity breeds rationalism and fosters the support it can bring. So then we may make no distinction between inorganic and organic chemistry, analytic and physical chemistry, for each one has its place in the world's work and no one can predict when any one of these branches will be called upon to render material aid.

But whatever may be the department of chemical study, the relation of the science to physics will be keenly felt and the dependence of each upon mathematics as the true foundation will become manifest. For this latter science is just as powerful an aid in the determination of the motions of the atom and molecule in matter as of those of the worlds and constellations in space. And if it cannot be neglected in astronomy, no more can it in chemistry and physics. Indeed, it illustrates the unity of all the sciences, even as it does the correlation of all the forces. Dr. Lorenz set forth the need of all chemists in this particular when he said: "Modern electro chemistry is an exact science and its principles and a knowledge of it rests upon a foundation of mathematics. It is in every way desirable that every electrochemist shall be trained in the higher mathematics and be thoroughly able to utilize both differential and integral calculus." He particularly recommends as a preparation therefor the 'Introduction to the Mathematical Treatment of the Sciences of Nernst and Schonflies' and says: "if the student have an intensive rather than extensive training in mathematics, he may be thrown into the sea of natural science and left to swim." So also Foerster discussing the character of the instruction in electrochemistry in the technical high school, while insisting upon 'thorough fundamental work in organic and inorganic chemistry, physics and physical chemistry' does not fail to include in his plan of work 'the principles of higher mathematics.' Dr. Koerner, discussing the 'Importance of Physical Chemistry to the Industries,' says: "It is most characteristic of it (physical chemistry) that it utilizes the most powerful of all natural aids to scientific investigation, the higher mathematics." And in the curricula of the technical high-schools in Germany we find almost without exception that in the course of chemistry, as well as in engineering, the higher mathematics is taken up and completed before the end of the first part of the year, if not before the end of the first semester. It thus becomes the ground work of, and preparatory to, all the important work which in those great institutions must follow it.

And finally, the technical chemist of the near future must be trained in the principles and practises of engineering, trained to make and operate the mechanical means for carrying out effectively the chemical reactions of the industries in a large way. For, after all, these reactions differ only in degree from those of the research and preparation laboratories, and if in the latter the students must be trained in making and assembling the forms of apparatus for use in the various operations of pulverizing, separating, roasting and incineration, solution, precipitation, separation of solids and liquids, washing, drying, and care of precipitates and crystals, the production and control of heat, the transfer of solids and liquids, the production and application of vacuum, evaporation and distillation, the conditions of crystallization, etc., in the small way in the laboratories, he must be taught to apply all these and more, in the large way in the works. Indeed, the only difference between the two may be comprised in the terms micro-chemistry and macro-chemistry; chemistry and the operations belonging to chemistry, carried on in a small way with limited or small quantities or volumes; handling solids and liquids in quantities of a few grams or a few cubic centimeters, or liters, on the one hand, or of tons of solids and thousands of gallons of liquid on the other. How, for instance, would the chemist untrained in the principles of engineering proceed in handling materials in quantities involving several tons of solid matters and 30,000 to 50,000 gallons of liquid in a single charge?—a requirement not uncommon in the modern industries and sure to be more common in the future industry. In his day, perhaps, the great Liebig was right and Wöhler was right, and Fittig not far wrong, when they maintained that with a thorough knowledge of the principles and laws of chemistry, all else in the industry involving their application would be easy. It is possible that the genius of the young operator would come to his aid and enable him ultimately to devise means to meet his ends, but time and labor must be saved by training in the methods, whereby such means may be established and a knowledge of means already at hand acquired. The authoress of a late popular work of fiction was right when she said, 'untrained genius is a terrible waste of power,' and though it may not be as applicable here as in an earlier paragraph, she was also right when she said in the same connection, "So many persons think that if they have a spark of genius, they can do without culture; while really it is because they have a spark of genius that they ought to be and are worthy to be cultivated to the highest point." And this applies to the chemists who must operate in a large way and with large masses of matter, either solid or liquid.

In a discussion of this subject in England, where perhaps more than elsewhere in the world the need of engineering capacity on the part of chemists has been most keenly felt, and where, on the other hand, engineering capacity, embodied in such men as Mond, Bell, Muspratt, Weldon, Perkin and Chance, has brought forth such splendid results. Ivan Levinstein, himself a leader in the industry, said: "It must also be palpable that a chemist intended for industrial work, who, along with sound training in chemistry, has also acquired a fair knowledge of chemical engineering, must be better fitted for his work than the man who is only practically acquainted with the handling of china basins, phials or a Liebig's condenser." And in the same discussion Watson Smith endorsed "what had been said as to the importance of teaching the scientific principles involved in the special construction of apparatus and plant for chemical processes on a large scale."

Dr. Ost, whose connection with both the industries and teaching has been so intimate, says: "Liebig, who had for long years taught technical chemistry in Giessen and, as none other, had promoted the applications of chemistry, could say in 1840 'I know many (those trained in pure science only) who now stand at the head of soda, sulphuric acid, sugar and cyanide works, dyeing and other industries, and without ever having had previously to do with them, were completely entrusted with works processes within the first half-hour, and in the next brought forth a number of most important improvements.' Sixty years ago, this judgment characteristic of the time, this enthusiastic declaration of Liebig, would constitute a dogma, but it is no longer tenable. The chemist graduated from the technical high school is no longer in position to begin his factory experience with introduction of improvements." This, Ost says, is because of the better and more perfect organization of modern works. And Dr. Lorenz of the Zurich Polytechnicum says: "The electrochemist should not be graduated until he has been taught how to use modern methods in very large apparatus. We find in electrochemistry wide difference between the theory and the facts. In the laboratory current yield and greatest economy of electrical energy are often the principal consideration, but in technology corrosion of electrodes or diaphragms is much more expensive than any variation of energy." What an important illustration of a special study of materials of engineering in the preparation for the chemical industry. And what a sensation of sympathy this must arouse in all those who have had to do with the handling of corrosive materials in the very large quantities and volumes, which modern methods involve. How often it happens that success of an important operation is delayed and even made impracticable because of want of knowledge of suitable resistant material for construction of containing vessels or apparatus.

Probably the most important contribution to this subject is that of Mr. Beilby. In his address he says: "I have rarely seen the chemistry of a process lagging behind the engineering; most frequently it is the other way. The chemical reactions involved in the ammonia soda process are simple and easily understood, but it required the genius and practical skill of men like Solvay and Mond to devise apparatus which could establish the manufacture on its present secure basis. What are the elements of which the skill is made up? The scientific basis must be a thorough knowledge of the principles of chemistry, physics, dynamics and mechanics, and added to this there must be a practical acquaintance with the materials of construction and the methods by which they are worked into structures. The designing and construction of apparatus for chemical works is a distinct branch of applied science. It is in this that special skill is required, for works operations are not simply laboratory operations.

"The ideal chemical engineer should be in thorough sympathy with the modes of thought and with the methods of working of both the chemist and the engineer. Just as the professor of engineering teaches how to apply the law of statics, dynamics and kinematics to the design of structures or machines, so should the professor of chemical engineering trace the applications of the laws of chemistry and physics and dynamics in the problems which occur in designing chemical apparatus for works. I am quite satisfied that in the present state of popular opinion the position and work of the technical chemist will not be properly recognized, unless he can associate himself, by his training and practice, with the engineering side of his calling." Professor Meldola says: "The sooner a chemist is made to realize the enormous practical difference between a laboratory and a factory process, the better it will be for him."

Professor J. A. Reynolds, Director of the Municipal Technical Schools of Manchester, England, says: "English chemists are not engineers and English engineers are not chemists, and hence the enormous difficulty which arises in the endeavor to bring to successful commercial results the fruits of laboratory research." While Mr. David Howard considers that the "influence of mass action, the question of so many pounds of coal per horse power hour and other like things, cannot be dealt with on a small scale, but are all important on a larger scale. We want chemical engineers who can make new roads in chemistry as mechanical engineers do in railways."

It is also important to consider the course of study proposed by Mr. Beilby in his paper for prospective industrial chemists. His large experience in the chemical industry gives him power to speak with authority, and young men who look forward to a successful career in the industry will do well to give it most careful consideration. And even more important, perhaps, are the courses of instruction carried out in the West of Scotland Technical College and in the Municipal Technical School in Manchester, England, and published in the *Journal of the Society of Chemical Industry* during 1899. Students who have had the advantage of these courses must be better fitted than those who have not been similarly favored. Yet we must believe that the courses laid out in the technical high-schools of Germany, and, we are proud to say, in some of the schools of technology in our own country, are in some respects better. A combination of the two classes of course might be made with profit to both the classes of institutions. It is important that the works chemist should be trained in the construction of the special forms of apparatus he needs to use, but they should be accompanied or preceded by the principles and practise of mechanical engineering. The most practical courses, perhaps, are those laid down in many of our own educational institutions for instruction in mining engineering and metallurgy, in which chemistry of the operations is considered in connection with the mechanical details of its applications, and we have advised students desiring to prepare for the chemical industries to pursue these courses in the best institutions first, and to follow them with a year or more of exclusive study of chemistry both pure and applied. If it were possible to add to the courses of chemistry as much of engineering, civil, mechanical and architectural, as is found in some of the metallurgical courses, the ideal would be nearly met. But we can fully sympathize with those teachers who find the time available too limited for such a combination, and appreciate the fact that either the student must come to the professional school with better preliminary training in the preparatory subjects, or the course must be extended beyond the usually provided four years' work. In any case, if the course of engineering could be carried side by side and simultaneously with the course of chemistry, the needs of the prospective technical chemist would be most fully met and the requirements of the future chemical industry most nearly fulfilled. In some of our institutions in which all studies are practically optional, such a course might be arranged and profitably followed, and notwithstanding the longer time which might be involved in its completion, the graduate from it would issue with brighter and better prospects of success in his profession than one less broadly trained. And in the selection of the subjects for such a course, the plans of study laid down in the technical high-schools of Germany, in the technical schools of England and of our own country, may be profitably followed.

In 1897, we expressed the view which seems thoroughly applicable now and which will perhaps bear repetition here. We said: "It seems, therefore, that the demand of the present time and of the immediate future can be met only by broadly educated men: by men who have been trained, not only in chemistry itself, but in the great principles of physics as well. A good technical chemist must be first of all a thoroughly educated chemist. After that, to attain the highest success in this country, he must be educated in the principles of engineering; the production and applications of heat; the production and applications of electricity; the transmission of power, the movement of liquids; in general, the means whereby the reactions of chemistry may be carried out in a large way We need, therefore, chemical engineers, and these in the nature of the requirements must be broadly and thoroughly educated men. While they must be trained in the work of the research laboratories, which are being organized in connection with many of the great industries, they must likewise be prepared to put into practical operation in a large way the results of the researches they have been called upon to make."

These truths have not changed and if these conditions of education and training are fully met, the progress of our chemical industries must be greatly augmented, the science must, by reaction, be actively advanced and following the experience of our German confrères in the words of Meyer, we may look hopefully forward, and in the near future proudly backward, to accomplishments greater than the world has ever known.

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*MAN'S PLACE IN NATURE.**

IN the opening paragraphs of his most memorable contribution to knowledge ('Man's Place in Nature,' 1863), Huxley made mention of certain similarities between the activities of anthropoids and those of men; and, while the burden of the work was devoted to structural homologies, the initial keynote was retouched here and there throughout the discussion. Huxley's classic contribution to anthropology needs no encomium; it was a pioneer's mile-mark of progress, erected under difficulties; and it suffices that all later travelers have found it in the direct way of experiential truth. Yet it is worth while, now and then, to take stock of advances subsequent to, and largely consequent on, the Huxleian declaration.

Since Huxley's pioneer work, a host of investigators have carried forward the study of structural homologies connecting the genus *Homo* with lower genera and orders; and to-day the physical similarities are among the commonplaces of knowledge, whatsoever the background of philosophical opinion concerning cause and sequence. During the last decade or two the investigators themselves, with scarce an exception, have gone one step further, and now include sequence of development from lower to higher forms as among the commonplaces of opinion, whatsoever the background of metaphysical notion as to cause. There the strictly biologic aspect of the question as to man's place in nature may safely be considered to rest; there has been little advance in opinion beyond that of the pioneer in 1863; but the data have been multiplied, and the knowledge and opinion have been diffused widely.

Since Huxley's epoch-marking memoir

*Address of the retiring President of the Anthropological Society of Washington, delivered before the Washington Academy of Sciences and Affiliated Societies, February 26, 1901.