Development of Chemical Science in Indiana.

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Indiana is this year celebrating the one hundreth anniversary of her entrance into the sisterhood of States. Almost weekly in the various counties, pageants are being held in which local and state history is being enacted depicting the earlier life of the state and the gradually changing conditions that have led up to the modern social, religious and educational environment.

It seems not unfitting at this time, and in this presence, to call attention to some of the more scientific phases of the development of this commonwealth to the end that we may see more clearly the struggles through which, and, may I add, by which, some measure of success has been attained; and know better the meanderings of the stream upon which our barques are being urged to the haven of still larger accomplishment.

It is my purpose, therefore, in the few moments at my disposal, to bring before you in review, not the development of the whole scientific thought of the State, interesting as that might be if I were capable of doing it, but some of those things which are more closely related to the science of chemistry. However, in the early history of Indiana science the different branches were not as clearly differentiated as now, and chemistry and its practical applications were closely associated and entwined with both physics and geology, so the influence of the chemist is not always clear.

The soil and climate of Indiana are peculiarly well adapted to agricultural pursuits. Therefore it is not wonderful that, when the two great streams of immigration, from the northeast and southeast, met upon the soil of the state it should be found that a very large proportion were young men and women of humble parentage with little or no eduation and without financial standing. They came here to force from the great forests and from the rich virgin soil hidden under them that which would supply them with better homes than they had known in the east, and with better educational outlook for their children than they possessed. Consequently it is to be expected that the early history of the state would be free from any hint of scientific thought, or of the applications of science to the affairs of life. The New Harmony settlement may seem to contradict this statement; for in the settlement were men of scientific standing. Later these men and their successors exerted great scientific influence. But in the earlier years their influence was along socialistic and religious lines. Not until after the adoption of the constitution of 1850, and the provision therein for an adequate support of the public school system, does there seem to have been any attempt by the state to apply scientific knowledge in assisting the people.

Soon after the adoption of this constitution the legislature established the department of Geology and appointed David Dale Owen to the office of state geologist. Mr. Owen was the son of Robert Owen one time owner of New Harmony. He had done work for Kentucky and other states; was a brilliant man and had a thorough knowledge of the geology of the Mississippi valley. A younger brother was appointed his assistant and the two undertook a preliminary geologic survey of the state. Among other things they investigated the soils in different parts of the state, comparing the chemical analyses of the virgin soils, as well as the subsoils, with those which had become poor from croppings. Thus they laid the foundation for the great fertilizer industry of the state, and began to educate the farmers to the idea that plant food, once removed with the crop, must be returned to the soil if the latter is to retain its original strength. In transmitting his report of the analyses of these soils Robert Peter, a chemist from Lexington, Ky., wrote as follows: "Chemical study of the soil and of plants and animals, has demonstrated that certain elements, necessary to vegetable and animal development, are gradually consumed from the soil in the crop. * * * The mineral constituents * * * are found in relatively small proportion and must be carefully husbanded and restored to the soil in order to maintain constant fertility. Such a process * * * would be the perfection of agriculture. And such a system is perfectly practicable in an agricultural community where the chemical nature of the soils, of manures and of vegetable and animal products have been studied and understood. The path of improvement, therefore lies in this direction, and it is the duty of our enterprising farmers to prepare themselves to improve it, by the scientific study of their profession; and of states and communities liberally to aid progress in this pathway." He then concludes as follows: "The fundamental study in this relation is that of the chemical nature of the soil; a study which is yet in its infancy, but which may be matured by judicious patronage into a branch of science of extensive utility." Such a message, from such a source, must have carried conviction to many a farmer whose soil gave poorer returns with each succeeding year. And its influence, consciously or unconsciously, must have persisted even to the present.

The Owens also began a study of the coal regions of the state, marking their boundaries in the counties where coal was to be found. To some extent they classified the coals on the basis of their best use and compared them with coals from other sources. They pointed out beds of paying iron ore and the quarries of limestone with which to flux it, and thus started the iron industry of the state. This, as now known, is not large in comparison with the present sources of supply, but at that time it was a most important addition to the resources of the commonwealth. From their knowledge of the geology of this and adjoining states these men were able to tell the people what other valuable minerals might lie beneath the surface in paying quantities and what ones, if found at all, would be only in small pockets brought in by glacial action.

The state geologist died while in office and the brother, after writing and publishing a comprehensive annual report, was appointed to succeed to the office. The chemical and geologic work done before 1860 laid the foundation for future work in the development of the varied industries of the state. But small appropriations and poor equipment made possible only a beginning in spite of the earnest endeavors of these most conscientious, gifted and scientific men. The civil war period produced an hiatus in the work which was first resumed in 1869 under the efficient management of state geologist, E. T. Cox, and his assistants. Under the leadership of Governor Conrad Baker the powers and purposes of the office of the state geologist had been enlarged, and provision made for building and equipping a chemical laboratory. The first year was largely occupied in building this laboratory as an addition to the east side of the state house; but when completed it was said to be one of the best equipped laboratories in the west. In his first report Mr. Cox says, "I trust soon to be able to commence a series of elaborate investigations of the iron-smelting ores, iron ores and fluxes used in the blast furnaces of Indiana, that will, it is confidently believed, prove of great utility to the iron masters, and materially advance the manufacturing interests of the state." And he goes on to say that a large portion of his time had been spent in receiving visitors and imparting geological information to capitalists from many parts of the country, who were desirous of investing money in the various branches of manufacture within the state.

Mr. Cox, who, was not only a great geologist, but a great advertiser of the state resources, extended the scope of analytical chemical work to include hydraulic cement clays, pottery clays and glass sands; and he so greatly advertised the work accomplished that in the ten years of the occupancy of the office probably millions of dollars were invested in Indiana industries. In the first annual report there is a full page illustration of a blast furnace in operation. In the 1872 report there is long descriptive letter, written by Hugh Hartman, of the then new Bessemer process of steel manufacture. The next year the same gentleman has a description of the industries represented at the Vienna exposition. In 1871 he writes "chemistry as a science was almost unknown in its practical applications fifteen or twenty years ago; now it is the only foundation upon which even practice can grow. Chemistry is at the bottom of modern iron production." Infinitely truer is it today. Not only in the iron industry, but in a thousand others it is the foundation for financial success.

The study of glass sands led to the erection of a number of glass factories which, later, were stimulated by the discovery of natural gas in the state. These became, and for years remained one of the larger industries of the state. In this and following administrations analyses of the clays of the state opened the field for the cement industry which, in both the southern and northern sections has become so important an addition to our economic wealth. It is probably true that the analytical work done under the direction

of Mr. Cox was the beginning of the earlier, if not the more recent, prosperity for which the state has long been noted. From the standpoint of the industries and wealth the twenty years following the civil war were crucial in this state.

In this connection I cannot refrain from mentioning still more recent work which is of great moment to the people of the state. I refer to the notable work of Harvey W. Wiley, a pioneer chemist of the state, who, by his interest in the welfare of the people, awoke the nation, as well as the state, to the importance of the pure food question, and who is the author and defender of many of the pure food laws of the country. Through his interest in agriculture and his work and writings on the chemical side of this field of work he has stimulated practical research and added much to the health and prosperity of the nation. No less splendid and important has been the work of another man who, in his earlier years, was a chemist in the employ of the state in the department of Geology. I am thinking of our neighbor, Dr. J. N. Hurty, and his work on sanitation and preventive medicine. His work is also nation wide, and he has brought honor and, what is more important to us, an increased measure of health to those who are living now and who will live here in the ages to come. Both of these men rank equally with the Owen brothers, Cox and others in the work they have done for our commonwealth.

There is another phase of the subject about which I wish to speak briefly. It has reference to the development of chemistry in the higher educational institutions of the state. Like the more material industries education started rather tardily. The common school system was begun in 1824; but for lack of financial support was not well organized until 1852; and only in 1865 was its normal development certain. In the meantime small colleges were springing up like mushrooms, but, being under the care of some church or denomination without much financial support, their development was slow and precarious. It must be said, however, that in comparison with their size and educational advantages, their influence was very great. Many of them have survived and are today among the strongest agencies for development in the state. In their curricula they patterned after Harvard, Yale and Princeton, but, unlike these institutions they had no well defined functions and no permanent standing. As late as December, 1878, President Tuttle, of Wabash College, in comparing the eastern colleges with the western said, "There the college is a well defined thing, and a greatly prized thing. Here the college is so indefinite a thing that it means many things which are not very similar. Not a dog wags his tail against Yale or Princeton, but who is there here but feels at liberty to cast a stone at the college, whatever its pretensions? Our rights are questioned and our methods denounced."

Dr. Tuttle, whom some of us remember with great reverence as "The grand old man" was, at that time, in the zenith of his power and influence in the state. By education he was a pure classicist, and for sixteen years

he had been president and educational director of one of the classical colleges of the state. One of the things which caused him to speak despairingly, as quoted above, was the fact that in the educational air there were floating the germs of a new education; an education which he thought would, if allowed to propagate, poison if not kill the real education so dear to his heart. He lived to see the new education well established and to value it at its true value. But in the address from which I have quoted he proceeds, among other things, to frame an argument in favor of the continuance of classical education in the colleges and to denounce the newer ideas of a practical or scientific education. This was less than forty years ago and during the period that the Owen brothers and Cox were doing such important work for the state. I speak of this only to point out that in such an atmosphere and against such leadership chemistry, with the other sciences, waged its battle —often a losing one—for equal rights.

In the development of the sciences many of the arguments advanced by the classicists proved to be well founded, many of the weaknesses predicted by them came true. The standard of education was lowered; the quality of scholarship was poorer; men of little mental ability and less character passed through the college courses; mechanical work took the place of mental effort; the experimenter replaced the thinker. In 1880 John M. Coulter, in discussing the place of science in colleges, and in pleading for a higher standard in it, said, "The so-called scientific course * * * seems to have been originated to supply a long felt want, viz., a short cut through college, thus gaining in time and eliminating the heavy studies. If the man had neither brains enough nor an inclination to graduate from the classical course in four years he entered the scientific course and graduated in three." Yet in the face of this poor beginning the scientific courses rapidly became stronger and, under the influence of such men as Jordan, Coulter, Noyes, and others were made to approach the classical courses in content and in mental requirement.

The influence of these men in raising the standard of scientific education until it approached that of the classical was partly through the students who, after graduation, went into the high schools of the state as teachers, and there created an interest in science among the pupils. These in turn demanded a scientific education when they entered the college walls. Partly their influence was exerted through the college association of the state. This was an organization composed of the presidents of the colleges in the state together with a few professors selected from the colleges. In their annual meetings formal papers were read covering this phase of education, as well as others, and thorough discussion was had of the arguments advanced in the papers. From some of these papers and discussions I have quoted. A third influence, which is still powerful, was the Indiana Academy of Science which was founded in 1885. Here the professors from the different colleges presented a resume of the scientific work which was being done; and in the earlier years at least, students were encouraged to study some problem in

the junior and senior years and present the results of their work at the meetings. In some ways it is unfortunate that this method of stimulating interest and efficiency in things scientific is being superceded by the more prosaic method of formal instruction. A roster of the membership of the Academy contains names of men and women of which any state might well be proud: Presidents of universities, experts in government work, scientific educators in many fields and of a national reputation; and research men who were and still are at the head of their respective fields of investigation. Still a fourth influence tending to the strengthening of chemical training in the colleges during the eighties and late seventies was that many graduates of our colleges went to European universities for their graduate work and became enthusiastic in research. Later they returned to the colleges where their enthusiasm diffused itself through the student body.

To obtain a clear idea of the changing attitude towards the science of chemistry one has only to study the catalogues of the colleges of the state and observe the changes which the curricula have undergone through the years. Only a few of these stretching back through the earlier decades was I able to consult. It would be interesting to have a detailed comparison of all of them between 1840 and 1890. But with only a few exceptions those that were consulted followed along the same lines, and it is reasonable to suppose that others followed in nearly the same path. To make the comparison more striking it is only necessary to recall that in most of the colleges of Indiana today four years of chemistry may be taken, the time per week varying from six to sixteen or more hours.

Before 1885 it is safe to say that, in most of the colleges chemistry was one of several subjects taught by one professor. Often this subject was not the one which the instructor was best fitted to teach. It must be said, however, that often such a man made up in interest and enthusiasm what he lacked in technical knowledge. Quite commonly there were no laboratories; or if there were they were equipped with apparatus for only the most rudimentary study of the subject. It is said that some courses were completed without the performance of a single experiment either by the student or the instructor.

In 1857, under Professor Hovey, Wabash college required two terms of chemistry in the senior year. Two years later one of the few books of reference mentioned in the catalogue is Webster's dictionary. In 1867 a scientific course was established. In this course no Greek was required but, in its place, somewhat more work in science and modern languages was allowed. For some years this course was under the ban of the faculty and those who chose it were considered to be less meritorious and able men. In 1877 a year of work was given to the science men—two terms in the sophomore year and one in the senior. By 1888 two years could be taken, and these by juniors and seniors.. This represented the maximum possible.

In 1879 Asbury college (Depauw later) gave two terms only of chemistry. In 1882 a chair of chemistry and physiology was created. In 1886 a student

could take two terms as freshman, two as junior and three as a senior. In 1891 three or even four years might be taken.

In 1878, at Butler college, H. Jamison was professor of chemistry, toxicology and children's diseases. Chemistry was given from one to three terms in different courses and was taught by Professor Thrasher, professor of mathematics and astronomy, and by D. S. Jordan, Professor of natural history. In 1887 there was one year of chemistry for all students; and in 1890-92 it was required in junior year and elective in the senior. At the State Normal in 1885 one term was given, in 1892 one term each of general chemistry, organic and qualitive analysis.

At Rose Polytechnic Institute a professor of chemistry was selected in 1882, Chas. A. Cotton. In the inaugural address he states that chemistry includes laboratory practice. The course was four hours of chemistry and physics in the sophomore year and one hour in the senior year. In 1884 it is stated that chemistry is largely conducted by dictation exercises in the laboratory. The work was given in the last three years. In this year a division of practical chemistry was made. Fifty lectures and recitations were given to the freshmen, and "an improved course in reading." A new laboratory was provided, consisting of four rooms; one each for qualitative and quantitative analysis, a balance room and an office. After this year chemistry could be taken in all four years. The statistics for Indiana University were not available.

At Purdue, under the leadership of Professor Wiley, a school of chemistry was established about 1874, in which three or even four years of chemistry could be taken. The first term of the first year was given over to illustrated lectures on the subject. Beyond this term chemistry was elective. But those who elected it were given much time in the laboratory. The fourth year was designed to teach chemical technology, metallurgy and didactic chemistry. For a number of years no one elected the fourth year and the laboratory was not equipped for its teaching. The degree of Bachelor of Chemistry was given for three years of chemistry, and of Doctor of Chemistry for completing the four years course. In 1876 there were five lectures a week for the first two years. In the first year there were five hours of laboratory work; in the second ten and in the third year six to eight hours per day were required for laboratory alone. In 1883 the school of chemistry had been discontinued and a smaller amount of work in chemistry offered. In 1887, under Dr. Nef, the work was clearly divided into lectures, recitations and laboratory practice with the practical applications of chemistry made prominent. For a number of years before this the work seems to have been confined to the junior and senior years; but in 1891 the work could again be taken in the sophomore year with some extra elective work allowed.

The method and kind of instruction were also themes of discussion and matters of development. When the courses were short and equipment meager the teaching was largely by means of the text book, the professor, perhaps,

performing some of the simpler experiments by way of illustrations. Later the extreme opposite method was used, only laboratory work being thought of value. In 1881 a discussion was had by the College Association in which very decided views were promulgated. Professor John L. Campbell read a paper in which he advocated, for physics, a combination of lecture, recitation and laboratory work. Professor Wiley took the extreme view that, for chemistry, laboratory work was the all important thing; that the first day in the laboratory should be research, as should be every day following. He said nothing should be told the student; neither should he read anything. He was to go into the laboratory and discover things which, to him at least, were entirely new; investigate nature. While a number agreed with Wiley the consensus of opinion seem to be that Professor Campbell's method was preferable. This may give some idea of the confusion of thought that was in the air relative to the place of chemistry in those transition years between the pure classical education and the new science. Quite rapidly, however, the chemical courses became standardized and took their places beside the classical, equal in extent, almost equal in content. Each received something from the other. The scientist came to understand that education is to make men as well as chemists, and the classical man learned that there is a human and practical side to all education.

While chemistry and the other pure sciences are fairly well standardized as means of educational development it is probable that the practical applications of chemistry can be better worked out so as to be used in a better way as an instrument in the development of the student. On the contrary some of the more practical applications of science as taught in our colleges, such as agriculture and home economics, are about at the stage of development of chemistry thirty or forty years ago. And they are lowering the general standard of scientific education now in the same way that chemistry lowered the standard in the earlier stages of its development, and somewhat for the same reason. Their methods of attacking problems presented are not sufficiently mental, thorough and developing. Instead of using the practical things, with which they must deal, to develop educational qualities in the student, the forms of education are being used to teach some practical things which, in themselves, are of little educational value. The two methods are not identical and cannot be superimposed.

A roster of the men who were most conspicuous in the transition period of which I have spoken may not be out of place. In addition to the brothers Owen and E. T. Cox, State Geologists, there may be mentioned T. C. VanNuys, head of the Department of Chemistry, Indiana University; H. W. Wiley, Professor of Chemistry, Purdue, State Chemist of Indiana, head of the Bureau of Chemistry, U. S. Department of Agriculture. President of the American Chemical Society; P. S. Baker, Professor of Chemistry, DePauw; J. U. Nef, Professor of Chemistry, Purdue, head of the Department of Chemistry, University of Chicago; W. A. Noyes, Professor of Chemistry, Rose

Polytechnic Institute, head of the Division of Chemistry, Bureau of Standards, head of the Department of Chemistry, University of Illinois, editor of the American Chemical Journal; R. B. Warder, Professor of Chemistry, Purdue; W. E. Stone, Professor of Chemistry and President, Purdue; Alexander Smith, Professor of Chemistry at Wabash and in the University of Chicago, Administrative Head of the Department of Chemistry, Columbia University, President of the American Chemical Society. There may have been, and probably were, others of whom I do not know or of whose work I am not able to judge correctly. Certainly there are many others who, in a somewhat less conspicuous way, exerted an equal or even greater influence in shaping chemical thought during the thirty years following the civil war.

In this brief paper I have tried to point out—especially to the younger chemists—some of the recruiting stations, and some of the battle fields upon which chemical freedom in Indiana was won. The wars of yesterday have but given strength and wisdom for the struggle tomorrow. These struggles will not be against classicism or ignorance or superstition or the indifference and opposition of the state. Its war now is and will be to establish correct standards for the air we breathe; for the water we drink; for the food we eat, for the medicines we need; for the drinks we enjoy; for the fuels we burn and the minerals we mine; for the chemicals we manufacture; for the soil we till, and for the dyes with which we beautify the world. The borders of chemical science must be enlarged. Youth must be taught the value of truth; of the sacredness of natural law, and of the power of the mind trained to habits of exact thought and logical deduction. In co-operation with the classics and the other sciences, pure and applied, our science must attempt to unfold the highest qualities of man—his intellectual, moral and religious nature.