THE DEVELOPMENT OF CHEMICAL CURRICULA IN THE UNITED STATES.
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Sir:

I am submitting herewith for your approval, a thesis entitled "The Development of Chemical Curricula in the United States."

The attempt has been made to obtain information direct from the catalogs and other publications of the colleges, but failing generally in this, I have resorted largely to authors who have written on general, or specialized educational subjects.

Special attention has been given to Rensselaer Polytechnic Institute since it was the first in its class in the field in the United States; its chemical curriculum, as developed during the first twenty-five years, was imitated by the later foundations; and came to be, either directly, or indirectly, the pattern in the great expansion in scientific schools in the period following the Civil War.

Respectfully yours,
The word bachelor in its most general sense signifies a young man. The word, however, as it possesses several widely distinct applications, has passed through many meanings, and its ultimate origin is still involved in a certain amount of obscurity.

The Latin "baccalarius" was applied to the tenant of a baccalaria (from baccalia—a herd of cows—bacca being a Low Latin variant of vacca), which was presumably at first a grazing farm and was practically the same as a "vaselleria", the fief of a sub-vassal. Just, however, as the character and size of the baccalaria varied in different ages, so the word baccalarius changed its significance. In the eighth century it was applied to the rustici, whether men or women—baccalariae—who worked for the tenant of a mansus. Throughout all its meanings the word has retained the idea of subordination suggested in its origin. Thus it came to be applied to various categories of persons as follows:—Ecclesiastics of an inferior grade, young monks, or even recently appointed canons; those belonging to the lowest stage of knighthood,—knights bachelors were either poor vassals who could not afford to take the field under their own banner, or knights too young to support the responsibility and dignity of knights' bannerets; and those holding the preliminary degree of a university, enabling them to proceed to that of master which alone entitled them to teach. In this sense the word baccalarius or baccalaureus first appears at the University of Paris in the thirteenth (13th) century, in the system of degrees established under the auspices of Pope Gregory IX as applied to scholars still in statu pupillari. There were two classes of bachelors at this time, one— theological candidates passed for admission to the divinity course, and those having completed the divinity course were entitled to proceed to the higher degrees.
In modern colleges and universities the significance of the degree of bachelor, in relation to the others varies; in some English universities the bachelor can proceed to his mastership by simply retaining his name on books and paying certain fees, in others, and all colleges and universities in the United States, the completion of a further course of study is necessary.

**SCHOOLS OF APPLIED SCIENCE AND INSTITUTES OF TECHNOLOGY.**

The earliest establishment of this type of school occurred in France and Germany. In France, the École des Ponts et Chaussées, originally started in 1747 as a drawing school, was organized in 1760 for the training of engineers for government service. In 1794 the celebrated École Polytechnique was founded, primarily to fit men for the engineer and artillery corps of the French Army. Not only has this school done much to set the standard of scientific training for the state service, but from the fact that many of its graduates have engaged in private work, it has exerted a strong influence upon general industrial practice. In Germany, the first institution that approached a modern engineering school was the School of Sächsische Bergakademie Mines founded at Freiberg in 1824, in order to develop engineers for working the mines in the neighborhood. Later in the century came the great development of pure science in the German Universities, and following this came an era of equal activity in the field of applied science, which quickly resulted in the widespread establishment of polytechnics or Technische Hochschulen. Rivalry between the various states (in Germany) played a part in the spread of these schools, each state striving to outdo the others in magnificence of buildings and completeness of equipment. These institutions, which often had their beginnings in secondary technical or trade schools, have now become foundations coordinate with the universities, requiring equal academic preparation for admission and representing specialized courses in engineering, applied and industrial chemistry, and other highly technical branches.

Great Britain awakened
more slowly to the need of technical education than other European countries, the chief stimulus being interest aroused by the London Exhibition of 1851. In 1861 a Royal Commission on Technical Instruction was appointed to investigate the entire subject. Among other results of this awakening was the foundation of the City and Guilds of London Institute, formed by a union of many of the wealthy corporations of the old London guilds. The most important of the schools established by this organization, the Central Institution of the City and Guilds of London Institute, a well-organized school of technology, now forms a part of the Imperial College of Science and Technology, and is recognized as a school of the University of London.

In the United States the development of the school of technology has been exceedingly rapid, and has resulted in a type of institution that in some respects is the superior of anything to be found abroad.

At the beginning of the nineteenth century, the study of the physical sciences in the United States was in its infancy. All branches were included under the terms Natural Philosophy and Natural History. Their meaning was not well defined, although under the latter was generally included all of what was then known of astronomy, physics, chemistry, botany, and geology. Scarcely any provision was made for scientific instruction in any of the colleges of the country. Astronomy, physics, chemistry, and botany had indeed been taught during the preceding century in a few institutions of learning, a department of Mathematics and Natural Philosophy having been created at Harvard College as early as 1727, a professorship of Botany in Columbia (Kings College) in 1792, and a chair of Chemistry at Princeton in 1795. Instruction in physics and chemistry had also been given at the University of Pennsylvania and Dartmouth College. This list includes all the colleges which had given the physical sciences more than an insignificant place in their curriculums. Even in these the instruction was
given by lectures, supplemented at times by experiments which the teachers performed; and anything approaching laboratory work by the student was almost wholly unknown. When Professor Silliman was elected, in 1801, to the Chair of Chemistry, Geology, and Mineralogy at Yale College, he visited Dr. Maclean, who was professor of Chemistry at Princeton, and there for the first time saw experiments in chemistry performed.

With the general awakening to the value of the natural sciences, during the first quarter of the century, came provision for their study in other of the academic schools of the country. Within that time courses in various branches were inaugurated at Yale, Williams, Bowdoin, Dickinson, William and Mary, and Hobart Colleges, and in the Universities of Georgia, North Carolina and South Carolina. Facilities for practical work by the students were still wanting in nearly all of them, though the apparatus used for illustration had grown in quantity and variety. A chemical laboratory, already mentioned, was in existence at Princeton, one was fitted up at Williams College in 1821, and one at Harvard shortly after this date. They were all, of course, crude and unpretending compared with those thickly scattered over the country today. Nor were the steps taken in the study of Science always forward. There was organized in the University of Pennsylvania, in 1816, a Department of Natural Science "with five professors; and annual courses of lectures, to be publicly delivered, were required by the regulations. The courses of instruction embraced natural philosophy, botany, natural history, mineralogy, chemistry applied to agriculture and the arts, and comparative anatomy. The support given by the public, however, was not sufficient to compensate for the efforts put forth, the professors were badly paid, and the department soon fell into neglect. It was abolished shortly after the establishment of Franklin Institute, in 1824, which rendered, it was said at the time, such a department in the university 'unnecessary'."
Thomas Jefferson proposed a school of technical philosophy, to be main-
tained wholly at public expense, where certain of the higher branches should be
taught in abridged form to meet practical wants. In a letter to Joseph C. Ca-
bell he wrote, "To such a school will come the mariner, carpenter, shipwright,
pump-maker, clock-maker, machinist, optician, metallurgist, founder, cutler,
druggist, brewer, vintner, distiller, dyer, painter, bleacher, soap-maker, tanner,
powder-maker, salt-maker, glass-maker, to learn as much as shall be necessary to
pursue their art understandingly, of the sciences of geometry, mechanics, statics,
hydrostatics, hydraulics, hydrodynamics, navigation, astronomy, geography, optics,
pneumatics, acoustics, physics, chemistry, natural history, botany, mineralogy,
and pharmacy." John Adams believed that the State should make provision for this
purpose, as is shown by the following extract from the Constitution of Massachu-
setts, of which he was principal author: "...............to encourage private soci-
eties and public institutions, rewards and immunities for the promotion of agri-
culture, arts, sciences, commerce, trades, manufactures, and a natural history of
the country."

These opinions give an impetus to the diffusion of scientific knowledge
among the people of this country. During the first quarter of the nineteenth,
three (3) schools were established in the United States. For each of these the
distinction has been claimed of being the first school created in any English-
speaking country for the purpose of teaching science. The earliest was estab-
lished in Norwich, Vermont, in 1819, by Captain Alden Partridge, a graduate of
the United States Military Academy, and its Superintendent during the years 1815-1817.
It was called the American Literary, Scientific and Military Academy, and was prob-
bably more of a military academy than a school of science, being largely modeled
after West Point. The curriculum included various languages, English literature,
science, as much as was then known of engineering, and the military subjects.
Students were admitted at as early an age as nine years. The Academy was moved to Middletown, Connecticut, in 1825, was incorporated in that State, but was disbanded in 1829. In the meantime, Captain Partridge had left the Academy, and had opened, in Norwich, a small preparatory school. When the Academy was disbanded in Connecticut, he took its name again for this last school, which in 1834 was chartered by the legislature of Vermont as Norwich University. In 1866, the University was moved to Northfield, Vermont.

The second school was incorporated under the name of the Gardiner Lyceum, in Gardiner, Maine, in 1822, and opened in 1823 by Benjamin Hale, a graduate of Bowdoin College. The object of this institution was to give instruction in those branches which were most intimately connected with the arts, and to teach them as the foundation of the arts. The general scholar might learn the general laws of chemistry at other schools, but here the student must be instructed particularly in the chemistry of agriculture and the arts; they were not merely to be able to repeat and demonstrate a few laws of mechanics, but must learn the application of the laws. The curriculum included various branches of pure mathematics, and natural science, mensuration, surveying, navigation, and theoretical and practical mechanics. The Lyceum existed for about ten years when it was discontinued due to the withdrawal of a legislative appropriation.

The third school was founded in Troy, New York, by Stephen Van Rensselaer in 1824. It was called the Rensselaer School, and was originated for the purpose of teaching the application of science to the common purposes of life. Norwich University is a continuation of the second school founded by Captain Partridge in 1827, and even though the name, "American Literary, Scientific, and Military Academy" was appropriated, it was applied to a different institution. If this can be allowed, then the Rensselaer Polytechnic Institute is the first school of science, which has had a continuous existence, to be established in any English-speaking country.
THE EARLY HISTORY OF RENSSELAER POLYTECHNIC INSTITUTE

Stephen Van Rensselaer, in a letter to Dr. Samuel Blatchford, states, "I have established a school at the north end of Troy, in Rensselaer County, in the Building usually called the Old Bark Place....... Having procured a suitable building advantageously located............... it now remains to establish a system of organization adapted to the object. You will excuse me if I attach too much consequence to the undertaking. But it appears to me that a board of trustees to decide upon the manner of granting certificates of qualifications, to regulate the government of students, et cetera, is essential. I, therefore, take the liberty to appoint you a member and president of a board of trustees for this purpose." .......

He continues, "as a few regulations are immediately necessary in order to present the school to the public, it seems necessary that I should make the following orders, subject to be altered by the trustees after the end of the first term. ..........

"Order 3. I appoint Amos Eaton, of Troy, professor of chemistry and experimental philosophy, and lecturer on geology, land surveying, and the laws regulating town officers and jurors. This office to be denominated the senior professorship.

"Order 4. I appoint Lewis C. Beck, of Albany, professor of mineralogy, botany, and zoology, and lecturer on the social duties peculiar to farmers and mechanics. This office to be denominated the junior professorship.

"Order 5. The first term is to commence on the first Monday in January (1825) next, to continue fifteen weeks.....". In addition to the payment of the tuition fees each student was to pay for the chemical substances they used and any damage done to apparatus. The tuition fees went to the professors as the reward of their services.
The first meeting of the Board was held December 29, 1824, and the institution was then named the "Rensselaer School", and, in accordance with further instructions in the letter referred to, it was:

"RESOLVED, THAT persons attending the courses of instruction...... be distributed into three classes, viz.: a Day Class, an Afternoon Class and an Evening Class.

"The exercises of the Day Class, for six hours in each day, except Sunday, shall consist of experiments in chemistry, performed by themselves, and in giving explanations, or the rationale of the experiments; and they shall undergo daily examinations and alternately become examiners themselves. Each member of this class shall pay twenty-five ($25) dollars a term, and at the end of each term shall be examined for his certificate.

"The Afternoon Class shall consist of those who may have previously attended one or more courses of lectures on chemistry...... They will hear no afternoon lectures; but their exercises will consist of a course of experiments in chemistry, performed by themselves, as above, with the rationale, conducted under the superintendence of the senior professor. These exercises will occupy three hours in the afternoon of each week-day except Saturday. Each member of this class shall pay ten ($10) dollars a term, and at the end of each term undergo an examination for his certificate.

"The Evening Class will attend lectures, on three evenings of each week, for ten weeks. This course of lectures will embrace chemistry, experimental philosophy, and the outlines of mineralogy, geology, botany, and zoology......... Members of this class will not be examined at the end of the term, but may have certificates of attendance."

There were to be two terms in each year, each term to extend for twelve or fifteen weeks. The summer term to commence in May, and the winter term in January. During the summer term the students were taught the elementary principles of chemistry, experimental philosophy, and natural history, with their application
to agriculture, manufactures, and the arts. Privately owned farms and workshops were on record as places of scholastic exercise for the students, it being recognized that under these conditions the application of the sciences would be most thoroughly grasped. During the winter term students were required to give lectures, by turns, on all the branches taught in the summer term. An annual commencement was held in April, at the end of the winter term, at which time the diplomas were conferred on the students who had qualified.

After nearly two years successful trial, the institution was incorporated by the State of New York. At this time an amendment was adopted providing for the division of the school-year into three terms, to be known as the Fall Term, Winter Term and Spring Term. The fall term beginning on the third Wednesday in July and continuing fifteen weeks. In this term each student was required to give five lectures each week on systematic botany, demonstrated with specimens, for the first three weeks, and might either collect, analyze and preserve specimens of plants, or examine the operations of artists and manufacturers at the school workshops, under the direction of a professor or assistant, who would explain the scientific principles involved. Four hours each week-day was to be given to either option. For the remaining twelve weeks, each student gave fifteen lectures on mineralogy and zoology, demonstrated with specimens; fifteen lectures on chemical powers and non-metallic substances; fifteen lectures on natural philosophy, including astronomy; and fifteen lectures on metalloids, metals, soils, manures, mineral waters, and animal and vegetable matter. --- All fully illustrated with experiments which he performed himself. Inspection of the various near-by industrial establishments was continued, the time devoted to this work to be four hours each Saturday morning.

During the Winter Term, recitations were required in rhetoric, logic, geography, and the mathematics deemed necessary for studying surveying, mensuration and performing the more common astronomical calculations. This term began on the third Wednesday in November and continued twelve weeks.
The last Wednesday in June ended the Spring Term, and this was also the
date of the annual commencement. Each student, during the first six weeks of this
term, gave ten lectures on experimental philosophy; ten lectures on chemical powers
and on non-metallic substances; and ten lectures on the metalloids, metals, soils
and mineral waters. For the remainder of the term the students were exercised in
the application of the sciences enumerated to the analysis of selected specimens
of soils, manures, animal and vegetable substances, ores, and mineral waters. Four
hours each day was given over to the examination of the operations of agriculturists
on designated farms; to practical land-surveying and general mensuration; to calcula-
tions upon the application of water-power and steam as made in the works in the
vicinity; and to the examination of the laws of hydrostatics and hydrodynamics ex-
emplified by the locks, canals, aqueducts, and natural water-falls surrounding the
institution.

No candidate under the age of seventeen was admitted to the full years' course, and no degree could be conferred on any one less than eighteen years of age. The degree of "Bachelor of Arts in Rensselaer School" was conferred, upon finishing the one year course, and qualifying in the examinations. These examinations were made by a board of examiners composed of from three to six persons appointed by the trustees, and none of the members of these boards should be connected with the school. The "Master of Arts in Rensselaer School" might be conferred after the expiration of three years from the receipt of the A.B. (r.s.) degree, or if the student attended a second annual course at the school. In using the abbreviation for either of these degrees it was required that the letters "(r.s.)" be added. An examination of the catalog of graduates discloses no instance in which the A.M. (r.s.) was conferred. One of the Articles of the by-laws provided after receiving a degree, a person ever after remained a member of the school, and must, every three years, report his occupation to the trustees.
The catalog issued in April 1826 contains the names of twenty-five students, and this number was not exceeded up to 1834. The small number of students was partly due to the standard required for entrance to the regular course, and while I have found no specified entrance requirement—except as to age—at various times nearly half of the students were graduates of other colleges.

Rensselaer School became "Rensselaer Institute" in the latter part of 1833.

The Bachelor of Arts (A.B. (r.s.)) was the only degree conferred to the end of session 1833-1834, although most of the subjects of instruction were of a scientific nature, and a large amount of time, increasing each year, was devoted to what would be termed the engineering subjects. In 1835, a department of Mathematical Arts was established as a branch of the Institute, for the purpose of giving instruction in Engineering and Technology. Graduates in the department of Mathematical Arts were to receive the degree of Civil Engineer (C. E.). It was also decided that the degree of Bachelor of Natural Science (B.N.S.) should be conferred instead of the Bachelor of Arts. The courses were one year in length in both branches; one student received the Civil Engineer, C.E., degree, and five the Bachelor of Natural Science, B.N.S., degree in this year.

In an announcement dated October 14, 1835, the Agent—Amos Eaton—after listing the faculty, continues:

"Instruction wholly practical, illustrated by Experiments and Specimens, is given 40 weeks in each year. Five days in each week the forenoon exercises are from 8 A.M. to 1 P.M.

"Winter Session commences the third Wednesday in November, and continues 16 weeks. During the first 12 weeks, each forenoon is devoted to practical Mathematics, Arithmetical and Geometrical, During the last four weeks extemporaneous speaking on the subjects of Logic, Rhetoric, Geology, Geography,
and History, is the forenoon exercise. Throughout the whole session the afternoon exercises are Composition, and in fair weather, exercises in various Mathematical Arts. A course of lectures on National and Municipal Law is given by the Senior Professor.

"Summer Session commences on the last Wednesday in April, and continues 24 weeks; ending with Commencement.

"Students of the Natural Science Department are instructed as follows:

"Three weeks, wholly practical Botany, with specimens. Four weeks, Zoology, including organic remains; and Physiology, including the elements of Organic Chemistry.

"Three and a half weeks, Geology and Mineralogy, with specimens.

"Three weeks, traveling between Connecticut River and Schoharie Kill, for making collections to be preserved by each student, and exhibited at examinations; also for improving in the knowledge of Natural History and Mathematical Arts.

"Ten weeks, Chemistry and Natural Philosophy.

"Half a week, preparing for examinations and Commencement.

"The afternoons of all fair days are devoted to Surveying, Engineering, and various Mathematical Arts—also to Mineralizing, Botanizing, and to collecting and preserving subjects in Zoology).

The outline for the students of the "Engineering Corps" then followed.

"The Rensselaer degree of Bachelor of Natural Science is conferred on all qualified persons of 17 years or upwards. The Rensselaer degree of Civil Engineer is conferred on candidates of 17 years and upwards, who are well qualified in that department. Candidate are admitted to the institute who have a good knowledge of Arithmetic, and can understand good authors readily, and can
compose with considerable facility."

"One year is sufficient for obtaining the Rensselaer degree of Bachelor of Natural Science, or of Civil Engineer, for a candidate who is well prepared to enter. Graduates of Colleges may succeed by close application during the 24 weeks of the Summer term.

"Candidates may commence the course at the beginning of any sub-term; but the third Wednesday of November to be preferred, unless the candidate is a graduate of a regular College or otherwise well instructed in general Mathematics and Literature.

"The degree of Master of Arts is conferred after two years of practical application."

Among the older graduates of Rensselear, when natural history, geology, and chemistry were the leading subjects of study, were the following:

Ebemezer Emmons, Geologist.
Asa Fitch, Naturalist; New York State Entomologist.
Douglas Houghton, Geologist; Chief of the Corps of geologists and Naturalists of the Michigan Survey.
John L. Riddell, Physicist & Chemist; Professor in the University of Louisiana, etc.
James Hall, Geologist; New York State Paleontologist.
Abraham Sager, Natural History; Professor in the University of Maryland, Chemical Inspector of Drugs & Chemicals for the port of Baltimore.
Robert Peter, Naturalist; Professor in the Transylvania University, Ky.
John Wright, Naturalist; of the Michigan Corps of Geologists and Naturalists,
Professor in Rensselaer Institute.
Ezra S. Carr, Chemist; Professor in the University of Iowa.
Eben N. Horsford, Chemist; Professor in the Lawrence Scientific School.

George H. Cook, a graduate of the Institute was appointed Senior Professor in 1842 to fill the place made vacant by the death of Amos Eaton. After somewhat extending the courses of study he resigned in 1846 to become State Geologist of New Jersey. Benjamin Franklin Greene, also a graduate, and, at the time, Professor of Mathematics and Natural Philosophy in Washington College, Maryland, was appointed Senior Professor.

The acceptance of the direction of the Institute by B. F. Greene marks an epoch in the history of the school. With the exception of its founders and Amos Eaton, it owes more to him than any other person. Up to this date the course had been one year in duration, and although this length of time spent at the school did not necessarily insure the acquirement of either of the degrees, which were given only after satisfactory examinations had been passed, the average student who came reasonably well prepared could complete either of the courses in this length of time.

After a careful study of the scientific and technical institutions of Europe, Professor Greene thoroughly reorganized the curriculum. Some modification and enlargement of the courses had taken place between 1846 and 1849, but during 1849 and 1850 came the greatest reorganization and expansion in the History of the Institute. To quote from "The Rensselaer Polytechnic Institute; Its Reorganization in 1849-50; Its Plans and Hopes for the Future."

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"The managers of the Institute therefore resolved that their field should be narrowed and more thoroughly cultivated; that, indeed, their educational objects
should be restricted to matters immediately cognate to Architecture and Engineering; that, moreover, for a somewhat irregular and for the most part optional course, requiring but a single year for its accomplishment, they would substitute a carefully considered curriculum which should require at least three full years of systematic and thorough training; and that finally, they would demand the application of the strictest examination tests to the successive parts of the course prescribed, not only in respect to the translation of students from lower to higher classes, but especially in all cases of ultimate graduation with professional degrees. It was in accordance with such views as these that, in 1849-50, this institution was wholly reorganized upon the basis of a general polytechnic institute when it received the distinctive addition to its title, under which it has since been more or less generally known."

"......................it was resolved that, of the entire Institute curriculum, they would at first proceed to develop the General Course....."

In an act passed by the Legislature, March 8, 1850, the Trustees were given the power to confer the degree of Civil Engineer, Topographical Engineer, and Bachelor of Science. The full amount of the reorganization was not applied to the Natural Science course at this time, or for some years, as the curriculum for 1854 will show.

**First Year**

**First Term.**


General Physics ..................Molecular Forces--Thermotics.

Graphics .........................Geometrical Drawing; Elementary Drawing.

Geodesy .........................Line Surveying; Theory; Field Work.

English Composition .............The Course (Commenced).

French Language ................The Course; French Grammar.
Second Term.

Mathematics................Trigonometry--Higher Algebra.

General Chemistry..............Non-Metallic Chemistry.

Graphics.......................Topographical Drawing; General Topography;
Maps of Farm Surveys.

Geodesy..........................Line Surveying; Theory (Finished); Office Work.

Natural History...............Botany.

English Composition...........The Course (continued)

French Language...............The Course; Translations from French into English.

Second Year.

First Term.

General Physics................Electricity.

General Chemistry..............Metallic Chemistry.

Natural History...............Mineralogy.

Geology and Physical Geography, Physical Geography.

Practical Geology.............The Course.

Graphics.........................Geometrical Drawing; Architectural

Industrial Physics...............Practical Pneumatics--Practical Thermotics.

Philosophy of Mind.............The Course (commenced)

English Composition...........The Course (Finished)

French Language...............Reading French Scientific Authors.

German Language...............The Course; German Grammar.

Second Term.

Natural History...............Zoology.

Geology and Physical Geography,Geology

General Chemistry...............Organic Chemistry.

Natural History applied to the

Arts..............................The Course.
The mode of study at this time contained the essential features of that which characterized the beginnings of the school. The students took full notes of the lectures delivered by the professors and afterwards studied the subjects by the aid of their notes, their own practical exercises, and books of reference. The next day they were interrogated by the instructors and after the interrogation were divided into small sections which assembled in different rooms. Each student then delivered an extemporaneous lecture upon the subject under consideration, the lecture was afterwards criticised by the other members of his section and by an officer styled a "Repeater", who, under the direction of the professor at the head of the department, took charge of the several sections. The Repeaters were generally resident graduates, or students who were members of the highest class in the institution.

Lectures and text-books were both used in most of the courses. Among the text-books may be mentioned: Davies' Legendre's Geometry, Davies' Bourdon's Algebra, Chauvenet's Trigonometry, Church's Analytical Geometry, Church's Calculus, Mahan's Industrial Drawing, Davies' Shades, Shadows and Perspective; Davies' Descriptive Geometry, Jopling's Isometric Perspective, Davies' Surveying, Simms' Mathematical Instruments, Gummere's Astronomy, Hitchcock's Geology, Davy's Mineralogy, Gray's Botany, Gregory's Elements of Chemistry, Mills' Qualitative Analysis, Fresenius' Quantitive Analysis, Morfit's Chemical Manipulations, Bird's Natural Philosophy, Bartlett's Acoustics and Optics, Bartlett's Analytical Mechanics, Weisbach's Mechanics of
Machinery and Engineering, Pambour's Theory of the Steam Engine, Moseley's Mechanical Principles of Engineering and Architecture, Morin's Aide-Mémoire de Mécanique Practique, Haupt's Bridge Construction, Mahan's Civil Engineering, and D'Aubuisson's Traité d'Hydraulique.

Applicants for admission were required to be at least sixteen years old, but few attempted to enter at this age. They were required to be well prepared in geography, English composition, arithmetic, including the metric system; plane geometry, and algebra to equations of the second degree.

In 1860 the course in Natural Science was made three years in length. In 1862, a preparatory class—equivalent to a sub-freshman class—which had existed in the Institute for some years, became Division D. Admission to Division D required the candidate to be not less than fifteen years of age, and to pass examinations in geography, English grammar, arithmetic, and algebra through equations of the first degree. During the scholastic year 1862-3 each of the courses was made four years in length.

There were only a few scattering graduates in the course of Natural Science after 1850, at which time, the Institute became more distinctly a school of Civil Engineering. There was a lapse of fourteen years—1872 to 1885 inclusive—in which no Bachelor of Science degree was conferred. The course was revived in 1885, and in 1909 the name "General Science" displaced that of "Natural Science."
Practical instruction in the mathematical, physical, and natural sciences, upon a more extended plan than that pursued in the undergraduate department of Harvard College had been a subject of discussion previous to the time of President Everett. In addition to the scientific men connected with the College, and the largest Library in the country there were valuable collections of apparatus numerous specimens of Natural History, a Botanic Garden, and an Observatory of the first rank. In his inaugural address, April 30th, 1846, President Everett announced the project of a separate scientific School as follows:—

"It is a question well worthy to be entertained, whether the time is not arrived when a considerable expansion may be given to our system, of a two-fold character; first by establishing a philosophical faculty, in which the various branches of science and literature should be cultivated beyond the limits of an academical course, with a view to a complete liberal education, and secondly, by organizing a school of theoretical and practical science, for the purpose especially of teaching its application to the arts of life, and of furnishing a supply of skillful engineers and of persons well qualified to explore and bring to light the inexhaustible natural treasures of the Country, and to guide its vast industrial energies in their rapid development."

About this time a vacancy occurred in the Rumford Professorship. The position was filled by the election of Professor Eben Norton Horsford, who soon after his arrival in Cambridge, submitted to the corporation a plan for the erection and furnishing of a laboratory for instruction in chemistry, and its application to the arts. This plan was laid before Abbot Lawrence whose letter of response dated June 7th, 1847 is quoted in part as follows:—
"For several years I have seen and felt the pressing want in our community (and, in fact, in the whole country) of an increased number of men educated in the practical sciences. Elementary education, appears to be well provided for in Massachusetts. There is, however, a deficiency in the means for higher education in certain branches of knowledge - - - - - - - - - - .

"We have already in the United States a large body of young men who have received a classical education, many of whom find it difficult to obtain a livelihood in what are termed the learned professions. I believe the time has arrived when we should make an effort to diversify the occupations of our people and develop more fully their strong mental and physical resources throughout the Union. We have, perhaps, stronger motives in New England than in any other part of our Country to encourage scientific pursuits, from the fact that we must hereafter look for our main support to the pursuit of commerce, manufactures and the mechanic arts; to which it becomes our duty, in my humble judgment, to make all the appliances of science within our power - - - - - - .

"I have thought that the three great practical branches to which a scientific education is to be applied amongst us are, first, Engineering; second Mining, in its extended sense, including Metallurgy; third the invention and manufacture of machinery. These must be deemed kindred branches, starting from the same point, depending in many respects on the same principles, and gradually diverging to their more special applications. Mathematics, especially in their application to the construction and combination of machinery; Chemistry, the foundation of knowledge, and an all important study for the mining engineer, and the key to the processes by which the rude ore becomes tenacious and ductile metal; Geology, Mineralogy and the other sciences investigating the properties and uses of materials employed in the arts; Carpentry, Masonry, Architecture, and Drawing, are all studies which should be pursued to a greater or less extent, in one or all of these principal divisions."
The Admission Requirements in 1854.

"Candidates for admission must have attained the age of eighteen (18) years, have received a good common English education, and be qualified to pursue to advantage the causes of study which they propose to give their attention. They will be admitted only at the commencement of a term, except in extraordinary cases.

"The number and choice of studies are optional on the part of the students, who will, however, be counselled on these points by the professors; but a punctual attendance on all prescribed exercises will be required."

The Course in Chemistry.

"Professor Horsford will receive special students to the course of instruction in Experimental Chemistry and research, who will give their attendance in the laboratory from nine o'clock A. M. till five o'clock P. M.

"The course will include instruction in -

"Theoretical and Experimental Chemistry, and Systematic Qualitative and Quantitative Analysis, in all their branches;

"Pharmaceutical Preparations for the Laboratory and Apothecary, and the methods for the determination of the value of drugs generally;

"Mineral assays, Metallurgy, analysis of Soils and Ashes, examination for poisons, manufacture of manures, and the various determinations required in the practice of medicine.

"The solution of problems of research in experimental science and in the applications of science to the arts and manufactures.

"In addition to the practical instruction in Chemistry as an art, in which each Student is necessarily a class by himself, there is a systematic daily exercise, on the blackboard, in the solution and explanation of chemical problems.

"A knowledge of Algebra, Geometry and Trigonometry, and an acquaintance with Stockhardt's Elements of Chemistry, or its equivalent, are required for admission."
Classes were held six days a week, and the two terms were twenty weeks each. Students in chemistry were required to supply themselves, at their own expense, with such apparatus as flasks, corks, tubing, lamps, crucibles, alcohol, platinum, and gold and silver solutions.

"The degree of Bachelor of Science may be conferred upon any student who, having attended the instruction of the School for at least one year, and completed the prescribed course of studies in one or more Departments, shall have passed a satisfactory public examination."

Text Books and Works for Reference.

Will’s Outlines of Chemical Analysis; Fresenius’ Quantitative Analysis; Regnault's Elements of Chemistry; Gmelin’s Handbook of Chemistry.

SHEFFIELD SCIENTIFIC SCHOOL.

In 1846 a Department of Philosophy and Art was established at Yale College to secure better opportunities for scientific instruction of chemists, agriculturists and other students who might or might not have been members of the academical department. It became known as Yale Scientific School. In 1860, a liberal endowment was received from Joseph E. Sheffield in consequence of which the name of Sheffield Scientific School was given. The school, as enlarged and reorganized was almost exactly such a College as was contemplated in the Act of Congress of July 2, 1862, so the Legislature of Connecticut was led to bestow upon this department of Yale College the income of the funds derived from the sale of land scrip. In 1892, Sheffield ceased to receive the funds that had come to it as a Land Grant College.

Admission Requirements and the Course in 1865.

Applicants of sixteen years of age or older, could enter if they had mastered Algebra, Geometry and Trigonometry—besides what were called "the higher English branches." The entrance examinations in these studies were strict, and they were not pursued in the school. Testimonials of good character were also required.
The examinations covered:

Algebra - Davies', as far as "General Theory of Equations".

Geometry - Davis's Legendre.

Plane Trigonometry, including Analytical Trigonometry. (Loomis' or Davies')

The Elements of Natural Philosophy.

Arithmetic, including the metric system of weights and measures.

English Grammar.

Geography.

History of the United States.

Some knowledge of Latin was also recommended.

The regular course of study occupied three years, each year having three terms, two of fourteen and one of twelve weeks. During the Freshman year all students were taught the same subjects. During the second year the students began the specialization in the particular course they wished to pursue.

The Course in Chemistry.

Freshman Year.

First Term:

Mathematics - Davies', Analytical Geometry; Spherical Trigonometry.

Physics. - Silliman's Principles.

English - Exercises in Composition.

Chemistry - Recitation and Laboratory practice.

German - Woodbury's Method and Reader.

Second Term:

English - Rhetoric, Practical Exercises in Elocution.

German - Woodbury continued. Selections from approved authors.

Physics - Silliman's Principles and Adamenical lectures.

Chemistry - Recitation and Laboratory practice.
Mathematics - Descriptive Geometry and Geometrical Drawing.

Third Term:
English - Exercises in Composition.
German - Selections
Physics - Silliman's Principles and Academical Lectures.
Drawing - Free hand practice.

Junior, or Second Year.
Analytical Chemistry - Fresenius' recitations and lectures.
Mineralogy - Dana's System, lectures and practical exercises.
Zoölogy - Lectures and excursions.
French and German.

Senior, or Third Year.
General Chemistry - Academical and Medical Lectures.
Agricultural Chemistry and Physiology - Lectures.
Special Investigation for Graduating Thesis.
Mineralogy - Identification of Species.
Metallurgy - Lectures.
Geology - Dana's Manual recitations and Academical Lectures.
Human Anatomy and Physiology - Academical Lectures.
Mechanics, Steam Engine and other prime Movers. - Lectures.

French -

The course lead to the degree of "Bachelor of Philosophy", conferred by Yale College. The Doctor of Philosophy was conferred upon those who studied for two years after having attained the Bachelor's degree, and who passed a successful examination in at least three higher departments of science.

In efforts to widen the range of College instruction, President Samuel Johnson published, in June 1754, a prospectus which included not only the ordinary subjects of the contemporary English College course, - the ancient languages, logic, rhetoric, and mathematics, but also surveying and navigation, geography and history, husbandry, commerce, and government, the knowledge of all nature and of everything useful for the comfort, convenience, and the elegance of life in the chief manufactures. This was to claim for King's College the entire field of technological, and the non-professional graduate schools of the modern University. The greater part of this field remained untilled, but through the first century of Columbia's existence more attention was devoted to the natural sciences than was customary, at so early a period, in American Colleges. In his review or the history of Columbia, published in 1886, President Barnard declared, "that during the first hundred years of the College, the instruction in physics and chemistry was elementary, and the "natural history", while it figured in the prospectus, was taught hardly more than in name ". In 1830 the Trustees established a "Scientific and Literary course," parallel to the classical course. At the same time they determined to establish sixteen public lectureships, with a range of topics extending over the fields of literature, philosophy, natural science, pure and applied, and the political sciences. The lectures were opened not only to matriculated students, but to the public, on payment of a small fee for each course. The
Lectureships, however, were apparently to be maintained by the fees received from students, and few of them were even temporarily filled. In 1843, the literary and scientific course, which in thirteen years had attracted but forty-nine students, was discontinued. In 1864, the first courses in the School of Mines, Columbia University, were organized, and from this have developed the several schools of applied science of that institution. A course in Chemistry, or Applied Chemistry was not offered until 1880.
Conclusion.

Most of the technical schools date from after 1860; the greatest expansion in the number taking place between 1870 and 1875. In the former year there were seventeen institutions, and seventy-four at the end of the latter. Financially, this large increase was due to aid given by the United States under the Act of Congress, July 2, 1862. These schools, known as the Land Grant Colleges, since their very beginnings have placed special emphasis upon the laboratory method of instruction as opposed to the sole reliance upon textbooks and simple observation in industrial plants. Another feature that has characterized the instruction in many of these institutions is the degree of specialization in the instructing staff made possible by the large numbers of students attending the schools. Without doubt, in Rensselaer, the laboratory method was stressed, but the course at first was designed for the training of teachers of science. Stephen Van Rensselaer, probably without realizing its significance, laid the foundation for a type of school which has had the most marked effect on the industrial development in the United States. The extension of the course by Professor B.F. Greene furnished a basis upon which the chemical curriculum of practically every college in this country is built. When the multiplication of the schools of chemistry came, it was natural, and certainly logical, to outline a course fashoned on a plan that had proven highly successful.
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