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OF

RUSSELL HENRY CHITTENDEN

1856–1943

BY

HUBERT BRADFORD VICKERY

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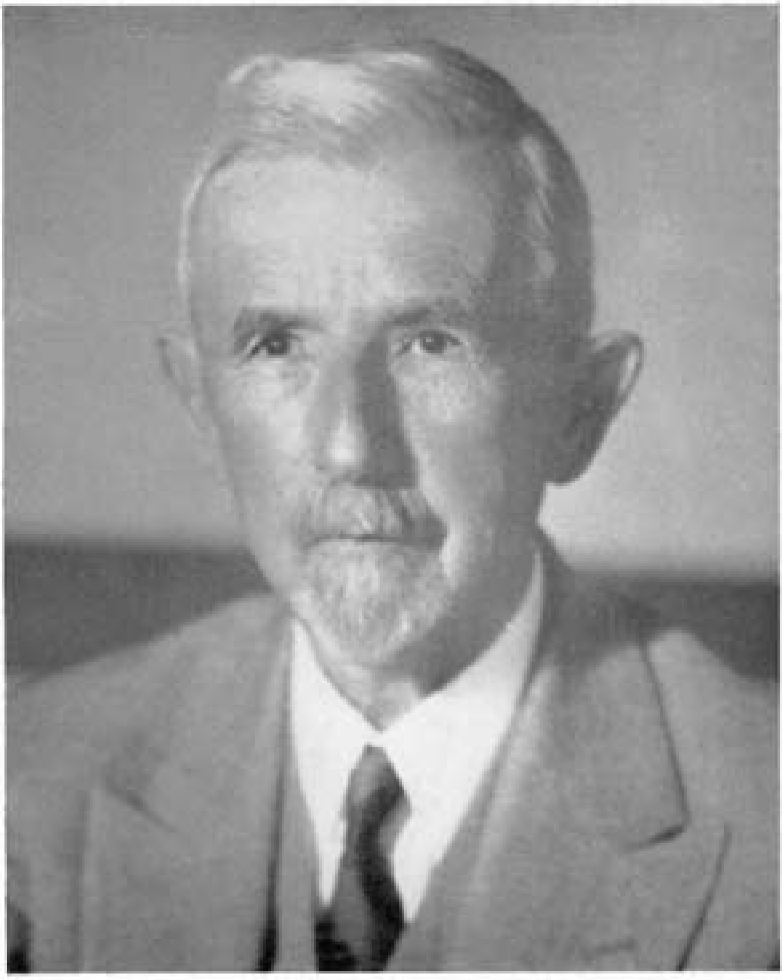

Russell H. Chittenden

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From time to time in the field of scientific endeavor there is developed a man whose attainments, contributions, personality, and qualities of leadership are such as to dominate the contemporary scene and do much to shape the future course of human progress. A very few, the most eminent, play their part upon an international stage and in one way or another affect the lives of all, but there is a small and less widely known group to whom the common man owes a debt that he could never repay even if he were aware of its existence. To this group belonged Russell Henry Chittenden, professor of physiological chemistry in the Sheffield Scientific School of Yale University from 1882 until his retirement in 1922, and for twenty-one years thereafter the dean of American biochemistry. At the time of his death on December 26, 1943, he had been for more than fifty-three years a member of the National Academy of Sciences.

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[1] A wealth of information concerning Chittenden is available from his own writings. Much use has been made of statements in his "History of the Sheffield Scientific School" and in his monograph, "The Development of Physiological Chemistry in the United States." In addition he filed a brief personal record with the National Academy, some of which has been quoted, but this information has frequently been supplemented by reference to a manuscript autobiography entitled "Sixty Years of Service in Science" prepared as he says "for my children and grandchildren" and finished in 1936. The writer is deeply indebted to Miss Edith R. Chittenden for the privilege of consulting and quoting from this comprehensive family document. The original hand-written manuscript is deposited in the Yale Library.

Use has also been made of a manuscript, "The First Twenty-Five Years of the American Society of Biological Chemists" which at the present writing is in the process of publication and for the loan of which the writer is indebted to the Editorial Office of the Journal of Biological Chemistry.

A complete set of "Studies from the Laboratory of Physiological Chemistry, Sheffield Scientific School," edited by Chittenden and formerly the property of S. W. Johnson, as well as reprints of many of Chittenden's papers, including copies of his first paper on glycogen and glycocoll and of one of the papers published during his first visit to Kühne's laboratory, are in the files of the writer's laboratory.

The advice and assistance of Dean Charles H. Warren of the Sheffield Scientific School is gratefully acknowledged.

Ancestry. Chittenden's ancestry can be traced through eight generations of Connecticut forebears to a William Chittenden and his wife Joanna Sheaffe who migrated from the parish of Marden near Cranbrook, Kent, in England, to Guilford, Connecticut, in 1639. Family tradition tells that this William had served as an officer in the Low Countries during the Thirty Years War and had attained the rank of major. Because of the persecution of religious non-conformists in England, he joined a small group of gentlemen who emigrated to Connecticut where he later occupied a prominent position in the settlement at Guilford, being lieutenant of the train-band, magistrate of the plantation, and deputy in the General Court, and was also elected fourteen times as deputy to the Jurisdiction Court in New Haven. His inventory at the time of his death shows him to have become a prosperous citizen of his adopted country.

There were ten children of whom one, Nathaniel, established a line of four successive Nathaniels all save the first of whom lived in the town of Killingworth, Connecticut. Three of the sons of the last Nathaniel, one of whom was named John, served in the army during the Revolution. John later became the father of eleven children, one of whom, Alfred Chittenden, was Russell Chittenden's grandfather. He was a farmer in Westbrook, Connecticut, whose farm, near the Clinton town line, was remembered with deep affection by his distinguished grandson. As a boy, Russell Chittenden made frequent visits to the farm and in his old age wrote an entertaining account of his early impressions of the activities such as spinning, weaving, candle making, and the preparation of soap, maple sugar, and sorghum sirup.

Horace Horatio Chittenden, the son of Alfred, was born in 1829 in Westbrook. In 1851 he married Emily Eliza Doane of Westbrook and moved to New Haven a few years later, where their only child Russell Henry was born on February 18th, 1856. The father had been educated in primary and secondary schools in Westbrook and New London and in turn taught school for a short time. Finding this unprofitable, he turned to industry and was employed in a small manufacturing plant near Saybrook for a few years. After the move to New Haven, he became the superintendent of a plant concerned with the clothing industry. His son records that he was a man of considerable natural ability with a strong bent toward the invention of mechanical appliances, some of which were patented. He lived to the great age of 94, dying in 1923, the year after his son's retirement from the directorship of the Sheffield Scientific School at Yale.

Education. Russell Henry Chittenden left an extensive record of his boyhood and early education. He wrote that he "grew up in New Haven in a pleasant but simple home, an only child, and consequently somewhat self-centered and inclined to magnify my own importance". He was "not greatly inclined to mingle with other children, but preferred the quiet of my own home with a tendency to play alone; altogether too serious, with a fondness for books and stories, with a rather vivid imagination for a child and an ambition to be a minister or a doctor".

His education is described as follows: "At first, a small private school, followed by the public school until September 1870, when I entered a private school in New Haven to prepare for college (French's School). Languages appealed to me and were relatively easy of acquirement. Latin, Greek, French, and Spanish I studied for a time, having in mind entrance to Yale College. Mathematics I liked less but had no great difficulty with it. The only science I had at that time was a little natural philosophy. Circumstances at home were such that it was desirable for me to earn a little money. Consequently, even when in the public school, I worked most days from four to six in the afternoon in a manufacturing plant, where my father was the superintendent, running a small machine for erasing pencil marks on cards. I also had a portion of the garden for my own use and on that I raised during several years large quantities of strawberries from the sale of which I gained considerable money. At the close of the first year in French's School my parents were no longer able to pay anything on my tuition account, but when Mr. French learned that I intended to discontinue my studies there, he proposed that I should come early mornings and dust out the school room and in addition take charge of a class of the younger boys in Latin, mathematics, and geography. This I did and thus earned my tuition during the next year to June, 1872."

Elsewhere Chittenden has recorded that Thomas B. Osborne was one of the boys he taught at French's School.

Chittenden described the steps that were taken to provide for a college education as follows: "I had begun to realize, however, that with my lack of money, spending four years in Yale College was going to be a difficult matter and two or three years additional in a professional school (for I had by then made up my mind to go into medicine) would together make a load which I could not possibly carry. It was a serious situation for me. I was loath to give up the idea of a thorough education, for, although only sixteen years of age, I realized fully that if I was to succeed in medicine I must have a proper preparation.

"Mr. French, who took great interest in me, suggested that I go to Professor S. W. Johnson of the Sheffield Scientific School for advice and he kindly went with me. Professor Johnson made it very clear that for a boy going into medicine the ideal preparation was the study of chemistry, physics, biology, etc., rather than the classical course of those days. Unfortunately, I did not have enough of the higher mathematics to pass the entrance examinations for the freshman class in the Scientific School, although I could have passed all the requirements for Yale College. Professor Johnson suggested that the best plan for me was to enter the Scientific School as a special student, devoting all my time at first to chemistry with some German.

"Consequently, in September, 1872, I entered the Scientific School at Yale, taking all the branches of chemistry offered to first and second year students and at the end of the first term gained the prize for excellence in qualitative analysis. At the close of the first year what money I had was nearly exhausted and I did not see how I was to continue. Quite unexpectedly, however, Professor Brush asked me to serve as an assistant in the chemical laboratory for my tuition and laboratory charges so that I was able to go on, aided somewhat by tutoring backward students. Eventually, I succeeded in making up the mathematics for entrance, together with all the studies of the course, doing nearly two years' work in one, and gained the degree of Bachelor of Philosophy in June, 1875, at the age of nineteen years and four months."

Further details concerning his senior year have been given by Chittenden in his autobiography. "In those early days it was one of the requirements for graduation that the candidate present a satisfactory thesis involving a certain amount of original work, as evidence of his ability to use some of the knowledge he had gained, to think straight, and to interpret aright such data as might be collected. In a science like chemistry some problem requiring experimental work, not too difficult of solution, was usually selected on the advice of the professor, and I went to Professor Johnson for some suggestion as to what might be suitable for me to attempt. After a little thought he said that he was very fond of scallops and that when they had them for dinner any left over were usually warmed up by the cook for his special benefit and he had noticed that when served a second time they always seemed sweeter than at first. 'Now', said he, 'suppose you try and find out what there is in scallops that would explain this fact.'

"In this simple fashion the problem was set for me and I began work at once, giving to it all the time I could afford. Turning first to the literature bearing on the chemical composition of mollusks I found that practically nothing was known concerning the composition of this edible muscle of the bivalve *Pecten irradians,* that being its scientific name, so that I had a clear field. It proved an interesting and profitable study for it brought to light certain facts quite new to science, of considerable physiological significance, and incidentally it explained Professor Johnson's experience."

Chittenden prepared an account of his experiments which appeared under the title "On glycogen and glycocoll in the muscular tissue of *Pecten irradians*" in the *American Journal* *of Science* in 1875. To his surprise and delight, the paper was shortly afterwards republished in England in the *Chemical News*. Possibly because of this, Professor Johnson suggested that Chittenden should translate the paper into German and submit it to Liebig's *Annalen*, and with Johnson's help this was accomplished. As later events were to prove, this step had a most important effect upon his subsequent career, and it furnishes a striking example of the good judgment of his friend and teacher.

Of his experiences during the year when, still an undergraduate, he was placed in charge of the teaching of physiological chemistry, Chittenden writes: "My services as assistant in the chemical laboratory had given me some experience and also a certain amount of courage so that I started in determined to justify the confidence that apparently had been placed on my ability to carry the work. There were six students taking the course, which extended through one-third of the college year, with five laboratory periods of three hours each week, and one recitation a week. I have had many tasks in life that called for all the strength and determination that were in me, but never before or since have I had quite such a feeling of apprehension as remained with me for many weeks as I started in on this new adventure. To be sure, there were available the advice and support of Professor Johnson, but he was a very busy man whose time and thought were given almost entirely to his own particular work, and I realized that the responsibility was mine and I was expected to shoulder it.

"By much special reading and by much preliminary experimentation I managed to pilot the class through the term with a reasonable degree of success, so much so that the following year the faculty arranged for the construction of a fairly well equipped laboratory better adapted for experimental work and the course became a permanent fixture in the curriculum of the 'Biological Course of Studies,' preparatory to the study of medicine. At that date I had no realization we were making history, or that physiological chemistry was destined to develop into a department of biological science of the highest importance in the discovery and explanation of many of the hitherto unknown processes of life. Today, laboratories and courses of physiological chemistry are to be found in most of our American universities and medical schools, while research laboratories devoted to work in this subject are equally conspicuous, but in 1875 the small laboratory in New Haven was the only one in this country, hence it seems proper to state that the Sheffield Laboratory of Physiological Chemistry, as it came to be called, represents the birthplace in America of this growing science."

A further word of explanation concerning this laboratory may not be amiss. It was a new departure in education primarily designed for the benefit of students who later proposed to take up the study of medicine. A few years earlier the Governing Board of the Scientific School had voted to arrange a course of studies especially adapted to the needs of these men and, as a result, a course in biology was instituted. The entire course of study included mathematics, physics, chemistry, and botany, in the first year, qualitative and quantitative analysis, organic chemistry with relation to physiology and medicine, botany, zoology, and history, English and modern languages in the second year, and more specialized topics in biology such as comparative anatomy, embryology, medicinal botany and so forth in the third and final year. By 1874, the importance of the course was becoming recognized and its scope was widened. One of the steps taken was the appointment of Chittenden as an assistant in physiological chemistry, a post that he filled for several years.

Study in Germany. Chittenden soon came to appreciate the need of advanced education, especially of training in the techniques of physiological experimentation and a year of study in Germany was an obvious necessity. He made plans to study under Hoppe-Seyler at Strassburg and letters of introduction and other credentials from Yale addressed to the officials at that university were accordingly procured. Upon arrival in Strassburg in the summer of 1878, however, he was disappointed to find the laboratory crowded, the buildings old and shabby, and neither university nor city to have that undefinable quality of "atmosphere" so valuable to a young and impecunious but ambitious student. The Strassburg so recently taken over by its German overlords was far from attractive. As he later wrote,[2] "Intuition is not to be wholly ignored, and I went on to Heidelberg with the feeling deep in my heart that the place where such men as Gmelin, Tiedemann, Bunsen, Kirchoff, Helmholtz, and Kühne had worked should give inspiration and opportunity, and that there would be found an environment more in harmony with my needs. The situation was somewhat awkward, but assuming a confidence that was not wholly felt, Kühne was sought and the hope expressed that a place might be found in his laboratory. His reception was a gracious one, but it was not difficult to see that the young American, with his imperfect command of German and with his lack of the customary credentials, presented a case quite out of the ordinary, and the outcome seemed dubious. It was explained that all necessary credentials would be forthcoming from America as soon as possible, but that did not seem to interest Kühne particularly. He appeared more interested in the visiting card he held in his hand, and much to the writer's surprise he said, 'Are you the Chittenden who published in Liebig's *Annalen* a year or two ago an article on glycogen and glycocoll?' . . . Going into his library, he came back with the volume of the *Annalen* containing the article and commented on the fact that glycocoll had never before been found free in Nature and that the presence of such large amounts of glycogen in an invertebrate muscle was an interesting and suggestive observation. The atmosphere was completely changed, and my spirits rose accordingly, reaching a still higher level when Kühne remarked that he would find a place for me in the laboratory at once. . . . After a month in the laboratory, Kühne asked me if I would like to serve as his assistant in the lecture demonstrations. Naturally, this came as a great surprise, but was accepted with alacrity, for while in a sense it was an empty honor, it led to a certain standing in the laboratory and, what was of greater importance, the very definite advantage of viewing close at

[2] "Development," p. 30.

hand all operations and experiments, in the carrying out of which Kühne was a master hand."

Besides attending Kühne's lectures in physiology, as well as those of Bunsen in chemistry, and occasional other lectures in anatomy, surgery, and pathology, Chittenden carried out three separate researches during the year at Heidelberg. Two of these were histo-chemical studies respectively on the sarcolemma of the frog sartorius muscle and on the epithelium of the eye and the third was on the formation of hypoxanthine from albumin. He had the pleasant experience of finding that, although his knowledge of physiology was elementary, his fundamental training in chemistry was far superior to that of his German, Russian, and British colleagues in the laboratory. The invitation he received to assist at lecture demonstrations probably came from Kühne's recognition of this fact. Furthermore, Kühne took pains to see that his gifted American student should meet distinguished visitors to the laboratory and often invited him to luncheons or dinners that he gave for them. Thus he met such men as Hugo Kronecker, Carl Voit, R. Heidenhain, Alexander Schmidt, Sir John Burden-Sanderson, Sir Michael Foster, Sir Henry Roscoe and Sir Lauder Brunton, and formed relations with some of them which were followed up in later years.

He also took occasion to visit many German laboratories and thus came into contact with Fresenius, both father and son, with Pflüger, Ludwig Drechsel, and with du Bois-Reymond, and his later distinguished student Baumann. Perhaps the climax was a visit to Göttingen where he met the elderly Wöhler who was a living link with Berzelius and the earliest days of organic chemistry. As he says, "The memories of these active workers, all leaders in their respective fields, have been of great value all through my life, for they have enabled me to visualize in a manner I could not otherwise have done the personality back of the scientific investigation that came from their laboratories as the years progressed."

Early Years of Teaching and Investigation. When Chittenden returned from his studies at Heidelberg in the fall of 1879, he again took up his teaching in the tiny laboratory at Yale. At the spring commencement in 1880 he was awarded the degree of Doctor of Philosophy, the first such degree in physiological chemistry given by an American university. The requirements were evidently far less formalized in those days than they later became. Chittenden's dissertation consisted of the paper on glycogen and glycocoll in the muscle of the scallop published in 1875, and another paper published the following year on the oxidation of glycogen with bromine and with silver oxide. Whether or not any special examinations were held he does not record.

Chittenden's appointment as Professor of Physiological Chemistry in 1882 at the age of twenty-five is an evidence of the impression his attainments had made on the group of strong and enthusiastic men who made up the faculty of the Sheffield Scientific School. Within a year he became a member of the Governing Board and, upon the reorganization of that body the following year with the appointment of a Director of the school in the person of Professor George J. Brush, he was elected the permanent Secretary of the Board.

The laboratory of physiological chemistry, that in 1874 had consisted of one room, by 1886 occupied the greater part of the second floor of Sheffield Hall. Here undergraduate students taking the biological course, and graduate students both of the Scientific School and of Yale College, worked side by side. In the fall of 1889 the laboratory was moved into the former residence of Mr. Joseph E. Sheffield, the great benefactor of the School, where it occupied the entire first floor. In later years, as buildings became available for the other departments that also were accommodated in the Sheffield mansion, the laboratory expanded into the whole building, where it still remained at the time of Chittenden's retirement in 1922.

In the early years, Chittenden offered a one hour full year's course in physiology, with demonstrations and experiments, an eight hour laboratory course in physiological chemistry for a half year and a short lecture course in toxicology. These courses were attended by from 35 to 40 students of the Scientific

School and sometimes by as many as 25 seniors from the College as well as by a large group of juniors. By the mid-nineties there were as many as 200 undergraduate students taking physiology.

In addition, there were sometimes 12 graduate students doing advanced work since it was Chittenden's practice to urge unusually gifted students to remain for a year or so after graduation and undertake some special problem before going on to their medical training. By 1900, 11 candidates had successfully fulfilled the requirements for the degree of Doctor of Philosophy in physiological chemistry, and most of these had served for a period as assistants in the teaching. Two of them, Lafayette B. Mendel and Yandell Henderson, who obtained their graduate degrees respectively in 1893 and 1898, became distinguished teachers at Yale, the former as Chittenden's successor, the latter as Professor of Physiology, and both later became members of the National Academy.

Although the biological course was established at the Sheffield Scientific School with the special needs of the men preparing for medicine in mind, Chittenden early held the view, and strenuously maintained it throughout his life, that physiological chemistry is a true biological science just as are zoology, botany, or morphology. In 1930, he wrote:[3] "Morphology and physiology were the two main divisions of biology, the one dealing with form and structure, the other with function. Physiological chemistry was to be considered simply as a part of physiology, having to do with the study of the chemical functions of the living organism, animal or vegetable, as the case might be. This being so there was justification for the development of physiological chemistry in a broad biological course of study that aimed to present a more or less complete picture of the phenomena of life. Moreover, the environment so provided tended to emphasize the true position of physiological chemistry as a biological subject not restricted to the necessities of any branch of applied science. To limit the study of physiological chemistry to the needs of medicine, for example, would be to defeat the

[3] "Development," pp. 36-37 and p. 324.

end in view, *viz.*, the expansion of physiological knowledge in all its varied aspects. Medicine in the end would profit most from a broad development of physiological chemistry, realizing that every new fact brought to light is in time liable to contribute something to that fund of knowledge which is of direct use, hence of practical value, to the everyday practitioner of medicine." . . . "The main point, however is that physiological chemistry should be recognized and treated as a pure science unhampered in its growth by any form of application. A science, whether it be biological or physical, to undergo a well-rounded development should have perfect freedom to progress and expand in any and all directions without regard to possible applications. Applications will come fast enough as the science advances, but just so soon as a science feels the pressure of an influence tending to limit its activities to any given channel then there is danger of a one-sided development with a restraining effect upon the growth of the science as a whole. This is a danger, as the writer sees it, which threatens the broad development of physiological chemistry in this country."

With these views in mind, Chittenden rigidly maintained the standards of training in his laboratory and imbued his graduate students with his ideals of their mission not merely to serve as teachers of a branch of learning later useful to the practitioner of medicine, but as scientists and investigators in their own right in a vitally important field of intellectual endeavor.

By 1898 Chittenden had attained wide recognition as a teacher and investigator. As early as 1885 the College of Physicians and Surgeons of Columbia had notified the Director of the Scientific School that students who had prepared for medicine in the School, and later studied medicine at Columbia, were in future to be allowed six months' credit on their three-year course. This was clear evidence of the success of the courses in biological science with which Chittenden had been associated and it was followed, in 1898, by an invitation to establish a department of physiological chemistry at Columbia. Although strongly tempted by the generous offers that were made, he found himself unable to sever his connection at Yale.

As a compromise, he undertook to set up the department and supervise it for as long as might be necessary. Accordingly in the fall of 1898 he transferred a group of advanced students, among them W. J. Gies and A. N. Richards, to New York to act as instructors in charge of the laboratory and himself lectured once a week during the college year. This arrangement continued for five years, when the full responsibility was turned over to Gies.

Administrator. The year 1898 marked still another change in Chittenden's activities and responsibilities. The tiny scientific school, which was organized in 1847 with the appointment of John Pitkin Norton as professor of agricultural chemistry and animal and vegetable physiology and of Benjamin Silliman, Jr., as professor of practical chemistry, had passed through many trials. During the early years, the appointments of professors of science usually ended with the significant words, "it being understood that the support of this professor is in no case to be chargeable to the existing funds or revenues of the College." Financial worries had been largely dispelled fifty years later, however. Many gifts, and especially the bequests of Joseph E. Sheffield, had placed the school on a firm foundation; new buildings had been erected, the faculty had expanded, and the student body was growing rapidly. The attitude of the College, at first scarcely more than tolerant, had undergone a change and science was gaining recognition as an essential component of a liberal education. In 1898, George J. Brush, who had been successively student (1848), professor of metallurgy (1855), secretary, treasurer, executive officer (1872), and director (1883) of the school, resigned his active responsibilities. Chittenden was elected as his successor for the conventional term of five years, but served continuously as director until he retired in 1922. He was at the same time appointed treasurer of the Scientific School, a position he held until 1919 when the office lapsed.

Chittenden accepted these appointments with many misgivings. He grasped the fact that the School was on the brink of a wide expansion in facilities, since such expansion had become vitally necessary, and he foresaw that the position of director would interfere seriously with his scientific work if it did not entail giving it up completely. This he regarded as being wholly out of the question. After much consideration he finally decided to accept the new responsibilities but with the distinct understanding that his scientific work and some teaching were to be continued.

Chittenden thus entered upon a career which, as time went on, made steadily increasing demands upon him. Nevertheless, he continued his courses of lectures in the physiology of nutrition and in experimental toxicology until the college year 1915-16; the following year the former course was offered with Chittenden and Underhill as instructors, and, in 1917, both were omitted. Subsequently these courses were taught by others.

As the administrative head of the School, Chittenden was in large part responsible for the expansion of facilities and the enlargement of the faculty that were soon brought about. In 1897 there was a faculty of 71 of whom 20 were full professors. The student body numbered 610, 105 of these being advanced students pursuing graduate studies. There were five buildings and the students had the use of the University museum and library. The buildings were, however, strictly utilitarian; there were no dormitories nor facilities for social intercourse among the students, and inevitably the School suffered by comparison with the far more lavish equipment available to the academic students whose life was centered around the beautiful campus only a short distance away. Chittenden recognized that the students were placed at a disadvantage by these conditions and immediately took steps to have them corrected. By 1903, through the enlistment of the interest of many friends of the School, Byers Memorial Hall was ready to serve as a focus of all social and religious activities, and the following year the first unit of the Vanderbilt dormitory was built. The second unit was completed in 1906.

The more pressing social needs of the students were thus cared for but the educational needs were not neglected. The teaching of science at Yale had always been the particular responsibility of the Scientific School. It had grown from very small beginnings in the late forties and with little help on the part of the College until most fields of scientific endeavor were represented. When, on occasion, duplication of effort was threatened by discussion of the appointment to the College faculty of a professor of some branch of science, Chittenden vigorously opposed such an appointment until he had been convinced that the interests of the School were not to be encroached upon and that the students of both parts of the University should have equal opportunity to pursue their scientific studies. Duplication there was, of course, to some extent. Elementary chemistry, physical chemistry, and analytical chemistry were taught to academic students at the Kent Chemical Laboratory of the College (opened in 1888) as well as at the Sheffield Chemical Laboratory owing to the numbers of students applying for these courses. But in general the more advanced courses in science and especially those in organic chemistry and in the applications of chemistry to engineering and to biological science remained an exclusive activity of the School.

The most pressing problem at the beginning of Chittenden's administration was the provision of better class room and laboratory facilities and of equipment for training in engineering. Kirtland Hall was completed in 1903 to care for geology, mineralogy, and physiography, and the Hammond Laboratory for mining and metallurgy was opened in 1906. As time went on, still other laboratories and class-room structures were added.

Under Chittenden there was also developed a strong faculty in the humanities since it was held that a broad training was as essential to the future scientist, physician, or engineer as it was to the future banker, business man, or lawyer. English, modern languages, history, economics, and non-scientific subjects had formed a part of the curriculum since the earliest days; the purpose of the course of studies had been from the beginning to give a "liberal education with a leaning towards science, a general training rather than specialization." The main difference, as the School developed in the first decade of the present century, was in the attention paid to the influences of man's environment upon his economic life and to the evolution of society and of industrial organization. To Chittenden, as Director, fell the responsibility for decisions on educational policy, on appointments, and on the equipment needed to bring about these changes in the academic life of the institution. His discharge of these duties and the success that attended his efforts mark him as one of the outstanding administrators of this period in American education.

Until the reorganization of the University in 1919, Chittenden was also treasurer of the School, and the administration of all of its finances lay entirely within his powers. His office collected fees, tuition charges and rentals of dormitory rooms, as well as the income from investments, paid for supplies and labor, and met the payroll for junior instructors and assistants. Monthly settlements were made with the University treasurer for the salaries of professors and higher instructors and, at the end of the year, as treasurer of the Board of Trustees of the Sheffield Scientific School, a position he had held since 1904, Chittenden balanced accounts with the University treasurer from the income available to them. He took pride in the fact that the School was financially independent. The privileges of the University library, gymnasium, and of the physics and biology laboratories which were enjoyed by the Scientific School students, were privileges that were paid for, and these fees often required a substantial fraction of the income of the School.

During the years leading up to America's participation in the first World War, increasing costs and fixed income gradually led to a situation in which recurring annual deficits were encountered. The condition was one that affected all of the schools of the University alike and fundamental measures were called for. As a result of much thought on the part of all concerned, a complete reorganization of the University was brought about in 1919 under which the teaching of the many subjects was consolidated into University departments and laboratories. Members of the several departmental staffs were assigned to that school in which their principal teaching was done and the distinction between a professor in the Sheffield Scientific School and one in Yale College tended to disappear. The four-year course was made uniform throughout, but all undergraduates spent the first year in a single group, the common freshman year, with its own faculty and dean, and then made their choice of emphasis upon science or arts in their later studies. Graduates of the School received the Bachelor of Science degree on completion of their course of study, and post-graduate instruction was restricted to the Graduate School.

Chittenden took a leading part in the debates and negotiations that led up to this change. The final plan adopted was a compromise between what he really wished for and what was attainable. Some of the characteristics that made the School a separate entity within the University were sacrificed but the fundamental ideals were unchanged. The teaching of science was maintained at the same high level, and the final outcome was an improvement of conditions throughout the University. Before he resigned at the age of 66 to become Director and Professor Emeritus, the construction of the huge Sterling Chemistry Laboratory and of the Sterling Hall of Medicine (occupied in 1922 and 1923 respectively) had been decided upon. All of the courses in chemistry, including chemical engineering, found their home in the former, while physiological chemistry, although greatly to Chittenden's personal regret, migrated under Mendel to the Medical School campus. But even in this location, physiological chemistry was not to lose its identity as an independent discipline. Under the reorganization, students could pass at will from school to school to obtain what they needed. Thus science undergraduates of the Scientific School found their way to the Hall of Medicine where they mingled with the medical students in their classes, and graduate students in physiological chemistry managed to cover the long mile and more to the chemistry laboratory for their essential courses and laboratory work in organic and physical chemistry. The vital point that physiological chemistry was taught for its own sake, not as a branch of applied science and an adjunct to a medical education, was rigidly maintained. Both Chittenden and Mendel insisted on this.

Scientific Work. Chittenden's more important scientific work falls into two main categories. During the early years of his teaching career, he became interested in the action of enzymes in the processes through which the food passes after ingestion. He began with studies of the diastatic action of the saliva and then continued with a long series of investigations, partly in collaboration with Kühne, of the effects of the proteolytic enzymes. This finally led to the more general field of nutrition and included fundamental investigations that prepared the way for the outstanding work of his successor Mendel. Chittenden's own studies of the protein requirement of man led to a complete revolution in scientific thought on the subject and were regarded by him as his greatest achievement.

The second main category includes his investigations in the field of toxicology. These were initiated when he was called upon to assist his teacher Johnson in connection with the analytical work involved in a study of a case of arsenical poisoning. An improved analytical method was developed and later widely applied in obtaining evidence for the courts. In turn, other heavy metals were studied and then organic drugs; this led to the long-continued investigation of the effect of alcohol on the human body and ultimately to the work on sodium benzoate and other addenda to human food carried out while he was a member of the Referee Board of the Secretary of Agriculture.

Chittenden's first paper, published in 1875, on glycogen and glycocoll in the muscle of the common scallop, has already been mentioned although perhaps sufficient emphasis has not been laid upon the true brilliance of this accomplishment. The value of his observations was fully appreciated by Kühne, who was probably the greatest contemporary authority on the biochemistry of glycogen, and it has been shown how this paper provided Chittenden with the freedom of Kühne's laboratory.

In the summer of 1882, at the invitation of Kühne, he returned to Heidelberg and began a collaboration with his former teacher that was most unusual if not unique in the history of

American science of the period. The fundamental problem was to ascertain the chemical mechanism whereby protein ingested by the animal was rendered available to the organism. The effects of the proteolytic "ferments", as they were at that time usually called, although Kühne had coined the term "enzyme" in 1878, were understood to a certain extent, but Kühne had become convinced that the protein molecule was made up of two approximately equal parts, one of which was comparatively resistant to hydrolysis either by acids or enzymes, and was accordingly called the "anti-group", while the other part that was easily decomposed by these agents was called the "hemi-group." It seemed desirable to study the nature of the products that could be isolated from digests of the chief kinds of protein in the hope that information could be obtained on the stages through which these substances pass in the animal body. The soluble products of digestion, the proteoses and peptones, were produced by tryptic digestion and these were, in part at least, diffusible substances and could therefore pass through the membranes of the digestive tract. Contemporary physiology held that the purpose of the action of pepsin and trypsin was to transform proteins into soluble and diffusible substances adapted for absorption into the circulating blood. But these transformations were not considered to be very extensive, it being the common view that any decomposition beyond the stage at which solubility had been reached would be both unnecessary and wasteful. Kühne and Chittenden undertook to find out how far the enzymatic decompositions did, in fact, go.

The plan of investigation that was drawn up called for parallel experimentation in the Heidelberg laboratory and in New Haven with exchange of all information, and for publication of joint papers. Six collaborative papers appeared in the interval between 1883 and 1890 which dealt in turn with the products that could be isolated from digests prepared from albumins of various origins, from globulins, and from myosin. The last of these papers deals with the extraordinarily resistant protein preparation called neurokeratin that was obtained from brain and nerve tissue. These papers were published in German in the *Zeitschrift für Biologie* and, with the exception of the first, also in English in the *American Chemical Journal* or the *Transactions of the Connecticut Academy*. Meanwhile Chittenden and his students extended the investigations in New Haven to casein, elastin, gelatin, and, in the last paper of the series, which was Mendel's dissertation for the Ph.D. degree in 1893, to the crystalline seed globulin edestin.

All of these papers are notable for the care with which the various products of digestion were isolated and "purified", and especially for the high quality of the analytical work that was carried out upon the materials. Study of these products threw much light on the complexity both of the protein molecule and of the processes whereby it is decomposed in the body, and Chittenden himself in later years regarded the work as one of his most important contributions to scientific knowledge.

That these contributions have been almost entirely forgotten by present-day biochemistry is due to a combination of circumstances. The greatest single blow was doubtless the discovery of the enzyme erepsin by Cohnheim in 1901. This at once transferred interest from the diffusible peptones and proteoses to the amino acids as the significant intermediates in digestion and removed the foundation upon which much of the work had been based. At the same time, the great development of amino acid chemistry at the hands of Fischer, the suggestion of an acceptable hypothesis of protein constitution by Hofmeister, and the demonstration by Kossel that proteins could be analytically characterized by the accurate determination of the basic amino acids, together with increasing appreciation of the fundamental work of Osborne on the preparation and analysis of proteins combined to overshadow the work of Kühne and his school in Europe and that of Chittenden in this country. Chittenden had the misfortune to enter the field of protein chemistry about twenty years before the development of the techniques and hypotheses that later made this field of investigation so generously rewarding.

This is not to be understood as a criticism of his work and still less of the devotion with which it was carried out. Much of lasting value was indeed accomplished. General appreciation of the immense complexity of the protein molecule was not to come for many years; Fischer himself thought of proteins as substances of a molecular weight of not more than a few thousand units, and valid measurements of this quantity had to wait for the work of Sörensen in 1918 and of Svedberg ten years later. What Chittenden and Kühne did establish is that enzyme digestion is a gradual process and it became clear from their studies that the intermediate products form a mixture that defied and still defies all attempts at rational analysis. They threw much light on the process of digestion in the animal body and laid a firm technical foundation for the study of the action of enzymes on proteins which in later years was to prove of the greatest value.

Chittenden himself kept up with the more modern advances in protein chemistry but he preserved his critical faculties. In his Sigma Xi lecture delivered in 1908 in a number of western universities, he pointed out clearly that an acid hydrolysate of a protein is not the equivalent in nutrition of an enzymatic hydrolysate, inasmuch as nutritive failure occurs when the former is employed as the sole source of nitrogen in the diet. It was not until Osborne and Mendel in 1914 demonstrated that tryptophane, which is destroyed during acid hydrolysis, is an essential amino acid in nutrition that this observation received its explanation.

Parallel with the early work on the digestion of proteins, a series of investigations was carried out in Chittenden's laboratory on the enzymatic digestion of starch. The first paper appeared in 1881 and publications were submitted at intervals for several years thereafter. Much attention was paid to the effect of the addition of acid and of alkali to the digesting mixture and a brief glance at these papers shows how close the authors came to an appreciation of the effects of acidity on the action of enzymes. Beyond a certain point progress was indeed impossible in the absence of a rational theory of acidity, but this was not to come until a generation later.

During the last decade of the century, a great deal of time was occupied in Chittenden's laboratory in the study of the alcohol problem. The work was initiated as part of the investigations of the "Commitee of Fifty" which had been organized because of the widely held view that the compulsory teaching in the public schools of what was termed "scientific temperance education" was, as one writer put it, "neither scientific, nor temperate nor instructive." This group, originally organized in 1893, included leaders in education, in the church and in business, and numbered such men as Bowditch of Harvard, Atwater of Wesleyan, Welch of Johns Hopkins as well as Chittenden who, together with a few others, were given charge of the physiological and pathological investigations.

The studies carried on in Chittenden's laboratory were finally summarized in a two-volume publication sponsored by the Committee and published in 1903 under the title "Physiological Aspects of the Liquor Problem." This was a fundamental contribution to the knowledge of the effects of alcohol and was calculated to provide scientific evidence in a field that had previously been largely dominated by prejudice.

Even more significant, however, were the studies on the protein requirement of man which were begun at this time—investigations which led to a complete revolution in common thinking on the subject and gained attention and comment, some of it far from friendly, throughout the intellectual world. These studies had a somewhat unusual origin. Through correspondence with Sir Michael Foster in 1902, Chittenden had learned of an American, Mr. Horace Fletcher, for years a resident of Venice, who had been the subject of scientific study in Europe because of his claims that health could be maintained by slow and deliberate eating with particular attention to mastication. Fletcher had been examined in a number of laboratories, including that of Foster, and Foster now suggested that studies in Chittenden's laboratory might be initiated. Accordingly Fletcher was invited to come to New Haven. He was a man of broad culture and considerable wealth, an enthusiast concerning his health habits and most cooperative in the matter of physiological tests. Chittenden entertained him in his home for many months making close observations, and soon noted that the intake of protein was remarkably low. Nevertheless, although a middle aged man, Fletcher could compete to advantage with young athletes in the gymnasium, and was manifestly in excellent physical condition. In his autobiography Chittenden wrote of him: "Considering his years, he was on the whole a remarkable exhibit, and not being versed in physiology to any extent it was natural perhaps that he should ascribe his fine physical condition to some hypothetical deglutition center, which was to be considered as a normal safeguard of health. There was no ground for belief in the existence of a center controlling mastication and deglutition in the sense in which he used the term, so that to me the chewing business became unimportant, except in so far as it tends to diminish the craving for food and thus results in the appetite being satisfied by a small amount. Hence to me the center of interest shifted at once to the question, how much do we really know as to the amount of food the human body requires to meet daily needs under the different conditions of life, especially of protein food? Excessive chewing of the protein constituents of the food certainly could have little effect on their ultimate utilization and hence could have value only in reducing the amount consumed. These were the thoughts that led to my planning the investigations."

Chittenden enlisted governmental and other aid. A detachment of volunteers from the Hospital Corps of the United States Army was detailed to New Haven, together with a physician officer in charge, to act as the subjects of the experiment. Grants were procured from the Carnegie Institution of Washington, the Bache Fund of the National Academy of Sciences, and many private donations were received, including a substantial one from Mr. Fletcher.

Meanwhile Chittenden had been warned by medical friends of the possible harmful effects of the dietary experiments he contemplated, and accordingly took a step which shows his entire confidence in the work he was about to do. A year in advance of the beginning of the elaborately planned experiment, he himself went on the low protein diet he proposed to use. He recorded that his weight dropped from 143 to 127 pounds over a period of seven months, but at that point appeared to reach equilibrium. He recovered from a rheumatic trouble in the knee joint which had failed to respond to previous treatment, and minor difficulties such as bilious attacks and headaches disappeared. His power of endurance increased if anything and, by the fall of 1903 when the main experiment was to begin, he was convinced that no danger was to be apprehended. During this period his protein intake had been about 40 gm. daily, instead of the 118 gm. called for by the Voit standard.

The final results of the experiment were presented to the National Academy of Sciences and were published in book form in 1904. The men had been maintained in perfect health with a marked increase in physical powers for five months on a diet that yielded 50 gm. of protein and 2500-2600 calories per day.

The later extension of these experiments, carried out with dogs, gave support to his views that the essential level of protein intake is far smaller than had hitherto been supposed, but many observations were recorded of failures when highly restricted diets were employed. The problem was thus more subtle than it appeared at first, and a full explanation was not obtained until the doctrine of essential amino acids had been stated by Osborne and Mendel in 1914 and the existence of vitamins had been recognized.

In 1908, Chittenden was summoned by President Roosevelt to act, together with Doctors Ira Remsen, J. H. Long, A. E. Taylor, and C. A. Herter, as a Referee Board to aid the Secretary of Agriculture in enforcing the Food and Drugs Act of 1906. The duties of this group were to consider scientific questions referred to them by the Secretary and to make reports of their findings. They were to act independently and entirely according to the results of their enquiries without consideration of the effects upon any vested interests.

The first question proposed to them in 1908 was the hotly debated one concerning the safety of the use of benzoic acid or its salts as preservatives in food products. The experiments carried out in New Haven, in which human subjects received daily doses of benzoates far in excess of the quantities likely to be encountered in any food offered for sale, showed that there were no deleterious effects. These experiments were confirmed in their entirety by parallel ones carried out independently by Herter and by Long, and the results were published as Report No. 88 of the U. S. Department of Agriculture.

This report attracted the widest attention and was violently attacked in many quarters. The duties and powers of the Board were completely misunderstood by the press and many attempts were made to discredit this body, although without significant effect since the Secretary ruled that, in view of the scientific results, the use of sodium benzoate as a preservative is permissible in foods provided that the container or package is plainly labeled to show its presence and the quantity included.

Later questions of the Secretary involved studies of the effects of saccharin, of the practice of using sulfur dioxide or sulfites as preservatives, especially in the dried fruit industry of California, of the admissibility of aluminum salts in baking powders, and, finally, of the practice of using copper salts to improve the green color of certain vegetables, especially canned peas. Each of these matters was attacked experimentally with the most thorough attention to detail and to the practical problems involved. Each report was used in drawing up the final official decision upon the question and, when the Board resigned in 1915, they received the thanks of the Secretary for their "skillful and faithful service." Chittenden recorded his reactions to these labors in his autobiography: "Only one who has knowledge of, and experience with, the methods of chemico-physiological research required in such lines of investigation as the Referee Board carried through during the seven years of its existence can have a full appreciation of the extent of the burden and the degree of responsibility the several members of the Board carried during that somewhat hectic period. The authorities at Washington, from the President down, were most kind and considerate in their treatment of the Board; we were made to feel that we were performing a most useful service, of value to the people of the United States and to other countries as well, since pure food laws everywhere, if justice is to prevail, must be predicated upon accurate knowledge and not based on preconceived notions and faulty reasoning. The Referee Board, following the precept of Marcus Aurelius, were in 'search after truth by which man never yet was harmed, but he is harmed who abideth on still in his deception and ignorance.' The Board had the satisfaction of knowing that in the course of their efforts they had uncovered truths of several kinds, by which deception and ignorance could be swept away."

War-time Experiences. During the years leading up to American participation in the first World War, the problem of procuring the necessary foodstuffs for export to England, France, and Italy became increasingly difficult. The calculations of food needed by these countries were based upon certain assumptions regarding the essential calorie intake and one of the grave problems, which became the more acute as the success of the German submarine warfare increased, was the extent to which, in view of the scarcity of food, a general economy in nutrition could be carried without danger to health. This and other related problems which demanded solution led to the formation of the Inter-Allied Scientific Food Commission composed of eight members, two each from the three chief European allies and Chittenden and Professor Graham Lusk of Cornell Medical College as delegates from America. The first formal meeting of this group was to be held in Paris, but Chittenden and Lusk proceeded to England in February 1918 where, after a stormy and unpleasant passage of twenty days under the worst of war conditions, they met with the authorities of the British Food Ministry.

It soon developed that there was going to be strong opposition to any substantial reduction in the ration of meats and fats in Britain, a ration based upon the assumption that 4000 calories per day were required by the average man, and Chittenden and Lusk found that their view that 3000 calories or less were all that were really essential was decidedly unpopular. Another serious difficulty was that breadstuffs were not being rationed in Britain inasmuch as the authorities had apparently adopted the principle that the diverse energy requirements of different individuals could most efficiently be made up if bread were unrationed. Accordingly, in spite of the shortage of shipping space, large importations of cereals were called for in addition to huge quantities of meat.

Every facility was given to the two Americans to observe the workings of the rationing system and to see the provisions made for the feeding of workers. Conferences were held with officials of the Food Ministry and with the Food Committee of the Royal Society. On one occasion, Chittenden was asked to preside at a large public meeting at the Royal Institution, in the place of Lord Rhondda who had fallen ill, and took occasion to point out the efforts that were being made in America to economize on food in the effort to provide enough for the Allies.

During their stay in London, the American representatives also experienced several air raids and finally learned to take these philosophically and stay in their hotel rooms. Before proceeding to Paris for the first official meeting of the Commission, they had come to the conclusion, on the evidence offered by the members of the Royal Society Committee as well as by others, that the working people of England were as well if not better fed than they had been in peace time, and that nutritional disaster was not seriously to be feared even if the ration were to be reduced to a level commensurate with the Americans' views of the true requirements of food for the average man.

They arrived in Paris on March 22, the day before the first shells from "Big Bertha" were fired from behind the front 70 miles away, and witnessed the bitterness which this random bombardment aroused in the people. They were impressed with the increased strictness of the rationing of food in France, as compared with Britain, and especially with the rationing of bread. On March 26, the first meeting of the Commission took place and again they detected in the opening addresses the anxiety regarding the dangers both social and military that might arise from a possible scarcity of food. The debates centered around the fundamental problem of the calorie requirement of an adequate diet. The American representatives presented data to show that a total intake per person might well be as low as 2300 calories per day and still meet all physiological needs, although supplementation to a somewhat higher level should be allowed for the heavy worker. Chittenden supported these views with data on food consumption in Germany as well as from his own experiments. The French delegates were prepared to accept a low minimum ration as the basis of computation of food requirements, but the British delegates were obviously concerned with the possibility of social unrest if serious restrictions of food imports were recommended by the Commission. After much debate, a compromise was finally reached which provided for 3300 calories "as purchased" as the basis for the average man doing average physical work, with the express statement that a reduction of 10 per cent might be borne for some time without injury to health should such a reduction become necessary. Other questions debated concerned the allowances for the different categories of the population and the vital problem of the best use of cereals.

After sessions lasting for a week, the Commission adjourned for a month when they planned to meet again in Rome. These later meetings were devoted to the consideration of the composition of the population so that the factors could be computed with which to express the needs of an actual population in terms of the hypothetical "average man", and to the exact quantities of foodstuffs that must be imported to provide for these needs. Throughout, Chittenden and Lusk stressed the desirability, for the civilian population at least, of living at a lower level of basal metabolism than was customary under normal conditions, and repeatedly pointed out that experiment had shown that this could be done without sacrifice of the capacity to work and without danger to the organism. In this they were at the same time fulfilling their functions as physiologists interested in promoting the newly ascertained facts of human nutrition and as representatives of the country that must produce and export a large share of the food that was to be used by the allied peoples.

The final sessions of the Commission were held in London in June. Statistical details of crop production and food requirements both in America and in the allied countries were considered and policies were elaborated in preparation for the final reports. Out of the deliberations came the conviction that national laboratories for the study of human nutrition should be established in which the problems that arise in connection with the food supply of each country should be the subject of investigation, since it had become clear that there was insufficient definite information available anywhere concerning the most economical use of foodstuffs either for the feeding of man or of animals.

The last weeks in London were also occupied with many social activities of which perhaps the most interesting was an invitation to both of the American representatives to dine with the Royal Society Dining Club, the organization from which the Royal Society itself grew. The charter granted by King Charles II in 1662 was the formal recognition of a group of distinguished men whose habit it had been for several years to dine together occasionally for the purpose of discussing science. The membership was limited to forty and the club had a continuous history from its inception. Chittenden investigated the records and found that up to 1902 only six Americans had been invited dinner guests of the club, the first of these being Benjamin Franklin in 1757. The others had been Alexander D. Bache, Franklin's grandson and later the first president of the National Academy, in 1837, Louis Agassiz in 1840, Arnold Hague in 1880, George J. Brush in 1886, and Alexander Agassiz in 1898.

Editor. A discussion of Chittenden's contributions to science would be incomplete without reference to his activities as an editor. At the very beginning of his career at Yale, he was invited by Remsen to prepare for the *American Chemical Journal* reports on the state of knowledge of physiological chemistry. This involved the complete review of the current literature and the discussion of its bearing, and the publication of these reports enabled Remsen's journal to fulfill the function of present-day abstract and review journals at least to some extent.

As research papers by Chittenden and his students began to accumulate, these were collected, and since many were printed in the *Transactions of the Connecticut Academy*, a journal published in New Haven, it was easy to have them paged separately and bound for convenient distribution and exchange. The edition printed was about 200. The first volume appeared in paper covers in 1885 under the title "Studies from the Laboratory of Physiological Chemistry, Sheffield Scientific School of Yale College, for the year 1884-85", the second volume in 1887, and a third in 1889. Some of the papers included in these volumes were in fact reprinted, the originals having been first published in the *American Chemical Journal*, the *Zeitschrift für Biologie*, or the *Journal of Physiology*. The issue of the publications of the laboratory in this form was then suspended, but the practice of binding together reprints of papers from the laboratory was taken up in 1904.

During the years 1885 and 1886, Chittenden served as the American associate editor of Maly's *Jahresbericht über die Fortschritte der Thierchemie* and his name is found on the title page of Volume 15 for the year 1886. In 1890 he became an associate editor of the *Journal of Physiology* and served until 1902, his name appearing on the title page for the last time in Volume 27. In 1886, he was asked to revise the definitions in general biology, physiology, and physiological chemistry for a new edition of *Webster's International Dictionary*, a task to which he returned in 1896 when still another edition of this dictionary was in preparation. Also in 1896, he was asked to be one of the original associate editors of the *Journal of Experimental Medicine*, first published in that year under the editorship of Dr. W. H. Welch; he retained his connection with this journal until 1905.

When the *American Journal of Physiology* was started in 1898, Chittenden was invited to be one of the editors. He served in this capacity for many years; his name appeared for the last time on the title page of Volume 24 in 1909, but he still gave occasional assistance until 1914 when the ownership of the journal was taken over by the American Physiological Society.

Retirement. Chittenden's years of retirement were happy ones. Few are so fortunate as to be able to see the principles that have been fought for through the years develop and flourish as it was his good fortune to do. He had brought back with him from Germany an ideal of teaching through doing that he made the basis of his courses, and physiological chemistry was started, literally from zero at the beginning of his teaching career, and was fostered until it grew and branched in innumerable unanticipated directions. His students carried his methods and principles to almost every other medical school in the country so that when, in 1930, his monograph "The Development of Physiological Chemistry in the United States" appeared, he was able to make out an implied argument, challenged of course by some, that physiological chemistry as represented by its present-day faculties in the medical schools of this country grew almost in its entirety from seeds planted in New Haven. This was an entertaining theme for one who had devoted his life to Yale, and Chittenden did full justice to it.

He spent many happy hours also in writing his two volume "History of the Sheffield Scientific School," published by the Yale Press in 1928. His intimate familiarity with the group of older men who were responsible for the founding of the school, as well as his dominating position in its fortunes in the later years, enabled him to embellish this work with lively anecdote and description, with authentic and often somewhat startling fact, and to present the whole in a matrix of his own hard-headed philosophy that makes it eminently readable even to those who have not attended Yale University. The development of a great institution of learning is never a smooth and continuous function of time. The grim battles that were fought and sometimes won, sometimes lost, are fully described, and it is clear that at times the chips were widely scattered indeed.

Among the papers left at the time of his death in 1943 were two manuscripts, one of which was an autobiography which gives a full account of his early life, especially his experiences in Germany, and also of his later scientific work. The story of his experiences while a member of the Referee Board from 1908 to 1915 is especially entertaining in view of the misunderstanding of the functions of this body on the part of the general public and the abuse to which it was subjected in the press. The other manuscript is an account of the first twenty-five years of the American Society of Biological Chemists, which is to be published through the agency of this society in the near future. It contains a full discussion of the origin of the society and the story of its broad service to science from its foundation in December 1906, when Chittenden became the first president, until the meeting of 1931. It includes brief biographical notes concerning the original group of men who met to form the society and of those who subsequently were elected to the office of president, as well as accounts of the successive meetings. Particular attention is given to the somewhat unusual relationship of the society to the *Journal of Biological Chemistry* and of how this relationship developed.

Chittenden's retirement thus by no means implied cessation of activity. He retained his membership on the Board of Trustees of the School and fulfilled the duties of treasurer until June 1930. He had thus participated in the deliberations of this body for thirty years and had acted as treasurer since 1904. He frequently attended University social functions such as dinners for distinguished visitors and lectures, and on a few occasions sat with the department of physiological chemistry in the oral examinations of candidates for the doctor's degree. Here his calm wisdom and broad knowledge, together with his extreme fairness and concern for the best interests of the candidate, were most clearly shown. One of his last public addresses was made in 1936 when the friends and associates of the late Professor Mendel gathered to do honor to the memory of his successor and former pupil.

Chittenden was a man of great personal dignity. He was short and slim, always immaculately dressed, and wore a neatly trimmed pointed black beard which became grey only late in life. His eyes were piercing and direct and had the power to transfix the guilty student or the opponent in debate in a manner seldom forgotten or twice risked. In the laboratory, he was definitely the master. He gave his directions for work to be done clearly and fully and expected and exacted nothing short of the best efforts of his students and assistants. By the same token, he also gave of his best to them. In the classroom at recitation or lecture, he dominated the scene with his forceful personality and incisive statements. His lectures were masterpieces of lucid presentation and his classes were enjoyed or feared according to the capacities or preparation of his students.

He carried these qualities of dignity and incisiveness into the meetings with the faculty or with the University boards of which he was a member. There is a story that on one occasion the late Dean Jones of the College was dared by one of the more frivolous members of the Board to address Chittenden by his first name during the meeting. Chittenden stared at him for nearly a minute before his face finally broke into a smile.

Although perhaps difficult to get to know, when Chittenden had once given his confidence he became a lasting and loyal friend. Even those with whom he most frequently came into conflict in his administration of the affairs of the Scientific School acknowledged their entire respect and admiration and received both in return. He identified his own interests with those of the School and of its students, and ever maintained that these last were the more important. Essentially a kindly man, he was always willing to devote his full attention to the problems of the student. As late as 1940, he was approached by a graduate student who had been assigned the task of preparing an account of the work of Kühne; he gladly gave her a long interview in which he described incidents of the early days in Heidelberg that illustrated the personality of his revered teacher, and led her to an appreciation of his broad and varied interests and accomplishments that found their expression in a distinguished essay.

Honors. Chittenden was the recipient of many honors in recognition of his eminence in his chosen field. He was elected to the National Academy in 1890 at the unusually early age of thirty-four, and at the time of his death was by eleven years the senior of the surviving members in length of membership.[4] He was a member of the American Philosophical Society, a Fellow of the American Academy of Arts and Sciences, a corresponding member of the Société de Biologie of Paris, and a member of the Société des Sciences Médicales et Naturelles de Bruxelles and an honorary member of the Medical Society of the State of New York. In 1930 he was made an Honorary Fellow of the New York Academy of Medicine. He received honorary degrees from the University of Toronto (LL.D. 1903), from the University of Pennsylvania (Sc.D. 1904), from the University of Birmingham (LL.D. 1911), from Washington University (LL.D. 1915), and from Yale (LL.D. 1922). In 1934, the Connecticut State Medical Society conferred on him the degree of Doctor of Medicine *in honoris causa,* a unique honor which had not previously been bestowed for more than a century.

He was president of the American Society of Naturalists in 1893, of the American Physiological Society 1895 to 1904, of the American Society of Biological Chemists in 1907, and as has been mentioned, served on the Referee Board of Consulting Scientific Experts to the Secretary of Agriculture from 1908 to 1915. During the war, he was a member of the Advisory Committee on Food Utilization and member of the Executive Committee of the National Research Council in 1917 and United

[4] Chittenden was an active member of the Academy for 53 years and 8 months. Only one other person, Addison E. Verrill, elected in 1872, died Dec. 10, 1926, was a member for a longer period, but Verrill was transferred to the roll of members emeriti in 1924, so that his period of active membership was a little shorter than Chittenden's.

States Representative on the Inter-Allied Scientific Food Commission in 1918.

Family. Chittenden married Gertrude Louise Baldwin of Litchfield, Connecticut, in 1877. There were three children, an unmarried daughter Edith Russell who lives in New Haven, a son Alfred Knight, who died in 1930 without issue, and a daughter Lilla Millard, who married Dr. Henry Gray Barbour of New Haven and had two sons and a daughter. She died in 1943. Chittenden's affection for these children and grandchildren is well shown by the care that he lavished upon the autobiography that he wrote for them towards the end of his life. He took this self-imposed task as seriously and conscientiously as he had any of his previous assignments, but, since there was no restraint upon his choice of material, was able to write with a freedom and charm and humor that he rarely achieved elsewhere. It is a fascinating and wholly enjoyable document.

Bibliography. The attached bibliography is founded upon a list of papers, deposited with the National Academy, which contains those items that Chittenden himself regarded as sufficiently important to be recorded. Many of these references have been verified and where necessary completed. A few items have been added from abstract journals and the list has been completed by the addition of material published since it was made out.

KEY TO ABBREVIATIONS USED IN BIBLIOGRAPHY

Am. Chem. J. = American Chemical Journal
Am. J. Med. Sci. = American Journal of Medical Sciences
Am. J. Physiol. = American Journal of Physiology
Am. J. Sci. = American Journal of Science
Am. Med. = American Medicine
Am. Nat. = American Naturalist
Ann. = Liebig's Annalen
Boston Med. and Surg. J. = Boston Medical and Surgical Journal
Brit. Med. J. = British Medical Journal
Centr. Physiol. = Zentralblatt für Physiologie
Century Mag. = Century Magazine
Chem. News = Chemical News
Dietetic and Hyg. Gaz. = Dietetic and Hygienic Gazette
J. Am. Med. Assn. = Journal, American Medical Association
J. Exp. Med. = Journal of Experimental Medicine
J. Physiol. = Journal of Physiology
Med. Comm. Mass. Med. Soc. = Medical Communications of the Massachusetts Medical Society
Med. News = Medical News
Med. Rec. = Medical Record
Medico-legal J. = Medico-legal Journal
Nat. Acad. Sci. Biogr. Mem. = National Academy of Sciences, Biographical Memoirs
N. Y. Med. J. = New York Medical Journal
Phila. Mo. Med. J. = Philadelphia Monthly Medical Journal
Pop. Sci. Mo. = Popular Science Monthly
Proc. Am. Physiol. Soc. = Proceedings, American Physiological Society
Proc. Am. Soc. Biol. Chem. = Proceedings, American Society of Biological Chemists
Proc. Nat. Acad. Sci. = Proceedings, National Academy of Sciences
Ref. Handb. Med. Sci. = Reference Handbook of Medical Science
Studies from Lab. Physiol. Chem., Yale Univ. = Studies from Laboratory of Physiological Chemistry of Yale University
Trans. Congr. Am. Phys. and Surg. = Transactions, Congress of American Physicians and Surgeons
Trans. Conn. Acad. = Transactions, Connecticut Academy of Sciences
Univ. Penn. Med. Bull. = University of Pennsylvania Medical Bulletin
Yale J. Biol. Med. = Yale Journal of Biology and Medicine
Z. Biol. = Zeitschrift für Biologie.

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