nary fulfilment which you have achieved in all the other work you have undertaken in the development of your state, and with that wish and with thanks on behalf of our Association I would close with an invitation to you all to attend our meetings; and I would express particularly the hope that all of you who are interested in broad discussions and deep-thought views of scientific problems will take advantage of the opportunity to hear the address of our retiring President, which will be the central and most interesting event of our proceedings. With thanks, therefore, for your courtesy and kindness, and expression of pleasure on behalf of all the members of the Association who are here, I will now close my reply to the hospitable welcomes which have been made us.

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## *SOME POINTS IN THE EARLY HISTORY AND PRESENT CONDITION OF THE TEACHING OF CHEMISTRY IN THE MEDICAL SCHOOLS OF THE UNITED STATES.**

In the scientific awakening of the latter part of the eighteenth century medicine was not the last of the great departments of human learning to take on new vigor. As in earlier years it drew largely from alchemical philosophy for the enrichment of its materia medica, and for the justification of a crude therapy, so now the great teachers of physic stood ready to accept the rapidly developing facts and generalizations of the new chemistry, and to apply them in the noble task of elevating a dogmatic empiricism to the plane of a scientific system. From the time of Paracelsus, alchemy, and its offspring, chemistry, had been but the handmaids of medicine, and much of the skill of the workers in these fields was devoted to the preparation of remedies for various diseases. But, from the labors of Priestley, Scheele, Watt, Cavendish and Lavoisier, the relations were reversed, and the chemists and the apothecaries, the cooks in the kitchen of the doctor, seemed ready to usurp the proud positions of their former masters. The nature of oxidation and the phenomena of respiration changes explained, it was clear that medicine must now depend largely on the development of chemistry for its rational groundwork.

After the downfall of the old iatro-chemistry with its empiricism and evident hollowness, our science had fallen into disrepute in the great European centers of medical learning, and physicians were somewhat slow in taking up the new ideas. But, the way once opened, the development spread rapidly, almost too rapidly in fact, because of the danger always attending hasty generalization.

The educational influences at work in the American colonies in those days were almost wholly English, and the earliest medical schools established here were modeled after those of Great Britain. We find, therefore, that in each one of the medical schools founded in the pioneer days of attempt in professional education a chair of chemistry was provided for as furnishing a necessary part of the medical student's education. Indeed, the first chair of chemistry of any kind to be filled in this country was that in the medical school of the University of Pennsylvania, and the occupant was Dr. Benjamin Rush, a man justly famous in the early history of American medicine, but not known on account of any chemical writings. This was in 1769, and the position was held by him until 1789. In the autumn of that year Dr. Rush was transferred to another department, and Dr. James Hutchinson was elected to fill the place. The latter died in 1793, and Dr. John Carson was appointed his successor in January, 1794, but died

* Address of the Vice-president and Chairman of Section C, Chemistry, at the Denver meeting of the American Association for the Advancement of Science.

without serving. In this year Priestley came to America, and lived for a short time in Philadelphia. He was offered the chair, but after some delay declined it on account of poor health and the desire to lead a quiet life in a rural country, which he found later on the banks of the Susquehanna at Northumberland.

In July, 1795, the place was again filled by Dr. James Woodhouse, who served until 1809. His successor was John Redman Coxe, who was among the earliest writers on chemistry in this country, since he published in 1811 a small work entitled, 'Observations on Combustion and Acidification; with a Theory of these Processes founded on the Conjunction of the Phlogistic and Antiphlogistic Doctrines.' Dr. Coxe was followed by Robert Hare, who was a man of great ability and a credit to the new country. Hare made numerous discoveries himself, some of them of permanent importance, and besides rendered a service to students by bringing out an American edition of Henry's chemistry. Some years later he published a text-book on chemistry himself for the use of the medical students of the University of Pennsylvania. As Hare's position was unquestionably the most important one of the kind in the country, it may be well to give a few moments' attention to his work as typical of the best of the period.

Hare began his career at a time which, from one point of view, might be considered as very unfavorable for the development of chemistry in America. The early aspirations of the founders of the Philadelphia College had failed of realization because, as must be recognized, they were beyond the practical sympathies or comprehension of the masses. The requirements for the attainment of the degree of Doctor of Physic were relatively, and in some respects, perhaps, absolutely, far in advance of those of the present time, and this the colonies were not ready for. Then came the Revolution, followed by a long period of political discussion and rapid internal development, and finally another bloody war. This left the country poor and yet farther behind again in the sphere of intellectual development. The great European wars of the same period had not hindered scientific discovery or cultivation in France and England, at least. Through these years of turmoil, the beginning which had been made in the few American centers where chemistry was taught had come almost to a standstill, and Hare entered upon what might appear a field of little promise. But the man was an independent thinker, and the example of Berthollet, Dalton, Davy, Berzelius, Gay Lussac, Humboldt and others was not lost on him. He began his work as a private student and partly in conjunction with the elder Silliman, who came to him before beginning at Yale, and while yet a young man attracted considerable attention by the discovery of the oxy-hydrogen blowpipe, a description of which was published in 1802. Later he constructed a new form of galvanic cell with very large plates which was known as the calorimotor or deflagrator, and this gave him no small reputation abroad as well as at home.

Hare's theoretical explanations of phenomena observed were not always correct, and in some of the many polemics in which he took part he certainly defended the weaker side of the argument, but in looking through his writings one cannot but be impressed with the ingenuity he displayed in contriving experiments to illustrate simple principles.

One of the best known works of chemistry of this time was that of Dr. Henry, of Manchester. The last American edition of this was brought out by Hare, and was used in his own classes and elsewhere in the United States. Later he brought out a book of his own with the title, 'A Compendium of the Course of Chemical Instruction in the Medical Department of the University of Pennsylvania, by Robert Hare, M.D. For the use of his Pupils.' There were four editions of this. The last appeared in 1840–43. In the preface of this book I find this curious passage, which reads as if it might have been written yesterday: "A chemical class in a medical school usually consists of individuals who differ widely with respect to their taste for chemistry, and in opinion as to the extent to which it may be practicable or expedient for them to learn it," etc.

With this idea of the difficulty of the subject and of the slight inclination on the part of many medical students to master it, Hare prepared a work in simple style containing an unusually large number of experimental illustrations and practical suggestions for the pupil. How successful he was with students it is now impossible to say, but that he impressed himself as a powerful teacher I have been assured by one who remembered him in his later years. He remained with the University until 1847, and died in 1858. He continued actively engaged in scientific work to the time of his death, and contributed numerous articles to the journals. No less than 150 were published in *Silliman's Journal*. That his work was respected abroad as well as at home is shown by the fact that he maintained an active correspondence with Faraday, Liebig and other great men of the day, and that we find frequent reference to his articles in contemporary writers and in the earlier volumes of the *Jahresbericht*.

While Hare was prominent in Philadelphia, Silliman, Gorham and Mitchill were developing the departments of medical chemistry in Yale, Harvard Medical School and Columbia. In the last two medical schools chemistry was taught almost as early as in Philadelphia, but apparently with less vigor, while at Yale it was taken up later.

In 1802 Benjamin Silliman, then a young man, was appointed to the chair of chemistry at Yale, and before beginning work he visited other schools in search of ideas. Prior to 1800 there seems to have been but a single chair of chemistry in the country outside of the medical schools, and this was held by Dr. John MacLean at Princeton. Silliman went there first and profited by what he saw. Later he went to Philadelphia, where he met Woodhouse, Priestley, Hare and others. Hare seems to have made the greatest impression on him, and they worked often together. In the next few years Silliman visited Europe, and on his return to New Haven aroused much enthusiasm among the scientific and medical men. It was largely through his influence that a medical school was established at Yale, and of this he became the first professor of chemistry and pharmacy. The Medical Institution of Yale College, as it was called, was chartered October, 1810, and four professorships were provided for, 'the first of chemistry and pharmacy; the second of the theory and practice of medicine; the third of anatomy, surgery and midwifery; the fourth of materia medica and botany.' It will be noticed that the chair of chemistry is here mentioned first, doubtless a tribute to Silliman's reputation and influence. He continued to give instruction to medical as well as to general students for many years, and through his writings and the journal he established he became the best known scientific man of the day in America. Silliman's interests, however, were in lines remote from medicine, and he therefore failed to exert here the influence enjoyed by his friend Hare.

The Medical School of Harvard College was established in 1782, and in 1783 Dr. Aaron Dexter was made the professor of chemistry and materia medica, his time being devoted to teaching general and medical chemistry. It does not appear that he published any researches or did much to advance his science, but he was a man of personal popularity, and it was through his influence that the Erving professorship was founded by Major Erving, who was one of his patients. Dexter served until 1816 and was followed by Dr. John Gorham, a man of marked ability, who published a number of researches showing skill and understanding, and who must be given credit for bringing out the first original book on chemistry published in this country. The two large volumes compare very favorably with the work of his European contemporaries. Gorham, who was recognized as a power in the medical school, now moved to Boston, and his reputation was of the first order among his colleagues. He laid the foundation for the excellence in a department which has steadily grown in importance to the present time. Gorham was followed by Dr. John White Webster in 1827, an alumnus of Harvard, and a man of promise who increased the reputation of the university, and especially of the medical school by his original scientific contributions and by editing several well-known foreign works. His text-book on chemistry on the plan of the work of Brandes has considerable merit. The fate of Webster in connection with the Webster-Parkman tragedy of 1850 is probably known to all here.

In New York the old King's College had become Columbia College, and in 1792 established its first professorship of chemistry. This was in the medical school, and Dr. Samuel Lathan Mitchill was given the chair. It was this man who introduced the Lavoisier nomenclature in the United States, and in consequence was engaged in many controversies with Priestley. In 1798 he established the *New York Medical Repository*, and managed it for many years. It was the first medical journal started in this country, and exerted no little influence, receiving contributions in general science as well as in medicine.

In 1807 a charter was granted to the College of Physicians and Surgeons in New York, and in 1811 Dr. William James Macnevin was made professor of chemistry. He was a man of marked ability, having taken the medical degree at the age of twenty in Vienna. Several scientific contributions from his pen are found in the journals of the time, and among other things he wrote 'An Exposition of the Atomic Theory,' which attracted much attention.

It will not be necessary to trace the history of chemical teaching in the other early medical institutions, as practically nothing of consequence is found recorded. The schools referred to were far in advance of those established elsewhere, and have in a large measure maintained their superiority to the present time.

For many years chemistry was taught to medical students by lectures only, and the introduction of even simple laboratory work is of comparatively recent date. In Harvard Medical School, for example, laboratory courses were not given until 1872.

It would be a discouraging task to try to follow the development of chemical teaching in medical colleges down to the present time. Few institutions were blessed with such men as Hare, Silliman or Gorham, who exerted an influence of priceless value on medical men now rapidly passing away. Owing to peculiar causes which I need not try to explain here, medical schools multiplied very rapidly in the United States, and in most of them the chair of chemistry was considered in the light of a necessary evil. As a matter of form chemistry had to be taught, but how it was taught and how it was followed by the students, were questions of wholly secondary importance. It has long been the custom in the medical schools of this country to divide the chairs into the theoretical and the practical. The American boy has been taught to hold practical things in the highest esteem, and chemistry was not practical. Professors and students alike felt it, and it is hard to tell who was the most to blame for the warped and stunted conception of chemistry held even at the present time by the great majority of medical men of this country. It is likely that much of the fault lay in the weak and wholly unsatisfactory manner in which chemistry was presented for fifty years in most of our medical schools. The professor of chemistry was usually a physician who, as a rule, was not considered sufficiently strong to fill the chair of practice, obstetrics or surgery, but who might teach acceptably the less important branch of chemistry. For the convenience of such teachers a peculiar system of chemistry called 'medical chemistry' was developed, and in some places persists to the present time. The idea that a man trained outside of a medical school could teach the kind of chemistry which medical students really needed was of slow development in the United States, and in some quarters fails yet of recognition. But for part of the trouble we must go farther back. While students in general courses were taught the elements of the sciences, languages and mathematics by recitations and quizzes, medical students, with far weaker preliminary training, were supposed to be able to absorb the essential facts of a great department of human knowledge from lectures alone. The lecture system is responsible for much of the superficiality in the old-fashioned medical schools, and no real progress was made until it began to be recognized that a medical student must be taught as other students are. With the gradual dawn of this notion it became finally possible to introduce into medical colleges rational chemical instruction, and the laughable farce of presenting the so-called medical chemistry to students ignorant of general chemistry will in time be a thing of the past.

This medical chemistry to which I call your attention was often a curious combination of the good and the absurd. Admitting that the student should know something about the chemistry of the blood, the bile and the urine, something about the nature of food stuffs and the processes of digestion, it was thought sufficient to present all these matters to him in condensed, so-called 'practical' form, and without first requiring a solid preliminary training in general and inorganic chemistry. It was considered the correct thing to memorize a lot of definitions, and to learn to recite in parrot fashion a number of empirical organic formulas. It must be admitted, however, that the fault was not confined to medical schools alone.

Chemistry in general may be studied from two standpoints. First, as in the college of liberal arts, as a fundamental discipline, regardless of the possible application which one may make of it. On the other hand, it may be pursued as a necessary preliminary to the understanding of something else, and in this case its mastery becomes all-important. One would naturally suppose that in the latter case the science would be much more thoroughly cultivated than in the former, but this is not always true. The discrepancy is perhaps most glaringly apparent in the chemical work of the medical schools. It cannot be expected of course that the chemistry offered to the medical student of to-day should be, as in the time of Hare, Gorham and the elder Silliman, more complete than that given to other students; this would be impossible and wholly unnecessary, as chemistry is now a great specialty with numerous departments branching in all directions and a literature as voluminous as that of scientific medicine itself. But this much should be reasonably expected, that the medical student's elementary chemistry should be at least as thorough as that of the student in liberal arts. It seems absurd to think that a man preparing, possibly, for law or theology or commerce, or studying without thought of any specialty should be made to acquire a fuller, more accurate knowledge of chemistry than that expected of the future medical man. If chemistry is of value at all, it certainly is to the doctor, rather than to the preacher, lawyer or man of business, yet in the United States in the last fifty years, the doctor's training in chemistry has been, on the average, less exacting than that of the other classes mentioned. If any one is disposed to doubt what I say let him compare the numerous 'Essentials of chemistry for the medical student' with the text-books used in other schools in the same science. It is anomalous that the doctor's chemistry should be usually the weakest of all.

But we are gradually emerging from this discouraging situation, and the improved condition is mainly due to the recognition of this fundamental truth, that there is not one kind of elementary chemistry for the doctor, another for the lawyer and a third for the preacher. There is no royal road to the acquisition of the necessary groundwork, and the medical man's elements must be learned through the same kind of patient effort that is required of other men. In the best of the medical schools of the country to-day chemistry is no longer taught by practitioners of medicine, and an honest effort is being made to present the subject as it is presented to beginners in schools of science. Such a course of laboratory and recitation work should require at least ten hours each week through a year of eight months to cover the work preliminary to the proper study of medical or physiological chemistry in the second year.

This leads me to explain what I consider the minimum work in preparatory chemistry for the medical student, and the character of this work. First, he should have the usual lecture or recitation course of about seventy-five lessons in general and inorganic chemistry, with especial attention paid to the theoretical groundwork. A discussion of the common inorganic salts is of less importance. This work should be followed or accompanied by a laboratory course in experiments, including the preparation of a few pure substances. In most of our schools the value of preparation work has not been sufficiently recognized, the time which might be spent there going usually to qualitative analysis which I believe is correspondingly overestimated. Inorganic qualitative analysis for most students becomes a mechanical routine in which the important element of discipline is wanting. As in the future work of the physician this branch of analysis finds little or no application, I believe the time given to it in preparatory medical work may be greatly curtailed. During the past twenty years, in which I have given instruction to medical students, I have had abundant opportunity to observe this fact, that men who have entered with training in experiments and preparations and no qualitative analysis make as a rule far better progress than do those whose laboratory work has been wholly analytical. Many of our colleges still begin their laboratory work with qualitative analysis, which, perhaps, is a relic of concession to the old utilitarian notion, and I am convinced that for the average student the time so spent is largely wasted. On the other hand, volumetric analysis may be made a medium of imparting important knowledge in fundamental principles, and I believe it should find early presentation in all our courses, general as well as medical, that it should precede rather than follow gravimetric analysis as is customary. In the case of the medical student the importance of volumetric analysis is twofold. Not only is it a valuable discipline in itself, and discipline is above all what is needed in preparatory medical training, but it also becomes an instrument of practical application in the physician's subsequent work. In his practical routine labor of a clinical nature the physician is constantly called upon to make a few qualitative tests which are soon learned and easily followed. He should be in a position to make a wider range of quantitative tests, and these, almost of necessity, must be volumetric. The preparatory medical course should provide this skill, not merely in a mechanical way, but by giving a thoroughly rigorous drill in the few fundamental principles of volumetric analysis. The statement I have just made may provoke a smile, inasmuch as I may appear to be giving advice on a matter which everyone well understands, and suggesting a course which is commonly already everywhere in practice. But it has been my experience that the matter is by no means as simple as it looks. The apparently elementary relations in volumetric analysis are not fully grasped by the general class of students, even by those who devote far more time to laboratory chemistry than is the case with the medical students of our best schools. In support of this I must state that in the last fifteen or twenty years it has been my fortune to instruct hundreds of medical students who had already had laboratory training in chemistry in excellent schools, well-known state universities among the number. While these men have often brought sufficient knowledge of facts, they have as often been very deficient in acquaintance with principles, leaving them unable to deal with cases presenting slight variation in conditions from those of their former practice. Our methods of instruction fail as long as they allow the memorization of facts and isolated methods to take the place of a study of principles. I am often asked what the value of this or that inorganic volumetric process is to the medical student, and my answer is that it illustrates a principle not readily learned in any other way. And it is safe to say that almost any one of these illustrative methods may find practical application in the physician's own work. The titration of weak acids, for example, is now a common operation in connection with the examination of stomach contents, and the permanganate titration has come into common use in the most accurate process we have for the estimation of uric acid.

I trust that I have made myself understood in insisting that the groundwork of the medical man's education in chemistry should be in the group of topics usually classed as inorganic, and this largely because of the superior advantages of this branch of the science in the presentation of general principles. I feel, therefore, like combating strongly the notion often expressed by medical men that students in medicine should not be required to 'waste' time on inorganic chemistry.

A few words as to the place of general organic chemistry in the preparatory or first year course. The subject is one of such large proportions that at best only an outline can be attempted in the first year course, but that much should at least be given. Leaving the major portion of the discussion of the sugars and other carbohydrates, the fats and the products of fermentation to be taken up with physiological chemistry proper in the second year, I believe that a fairly satisfactory outline may be given in about thirty lessons in the first year course. Remember, I am not writing this for men who expect to be chemists, and I am describing the minimum requirement which I should insist upon. In a short course of the kind it will be necessary to omit many things often supposed to be of prime importance in the so-called medical chemistry. I have seen text-books for medical students abounding in descriptions of processes for making many of the modern synthetic remedies along with discussions of the supposed structural formulas of these compounds. This knowledge is interesting, but it is far from essential, as few principles are cleared up by it which cannot be presented to the student in more tangible form. It should be further remembered that there is a distinction between chemistry and materia medica, and much matter presented to students as chemistry properly belongs in the other field. The time spent in memorizing the empirical formulas of the medicinal alkaloids and of the host of antipyretics, hypnotics, etc., might better be given to a study of principles. Of course I would not be understood as urging that the medical student need not be taught the constitution of any organic compounds, but I merely claim that there is a limit to the amount of this knowledge which may be considered practical or profitable.

I have spoken of the work just described as first year medical work, as it may be taken before entering the medical school or in the first year of the course in medicine. The time is not far distant when all the courses I have described, and doubtless more, will be required for admission to the best schools. At present Harvard Medical School has such a requirement, and other institutions have it under consideration. Many colleges of liberal arts and technical schools offer now a so-called preparatory medical year in which chemistry is the principal topic. Certificates for such a year's work admit to the second year of many of the medical schools of the country. In my experience the plan is not yet a satisfactory one, as the chemistry courses taken under these conditions seems to be lacking in rigor and discipline. They seem to be followed under the notion that medical school chemistry is so completely lacking in thoroughness that anything may be pursued as its equivalent.

In the last few years students have begun to present high school certificates for chemistry work as equivalent to that in the first year of the medical school. The courses taken in the high school at first sight may appear to be more than equivalent to those in the beginning year of the medical course, but a careful consideration of many cases has convinced me that in general it would be very unwise to grant credit in the medical school for work apparently done in the high school in chemistry. At the age at which boys and girls now do their chemistry work in most of the high schools it is quite impossible that the subject can be properly mastered. In my opinion the superficial courses now given in science in hundreds, perhaps thousands, of high schools throughout the country constitute one of the weakest spots in our system of public education. The attempt is often made to cram more chemistry into the high school boy at sixteen than many of our smaller colleges find possible at twenty. In much of this work the glorification of the teacher, not the true edification of the pupil, seems to be the prime object in mind, and the result is deplorable. With these facts in view, I always feel justified in rejecting the application of the student for advanced standing on account of high school work in chemistry. I am therefore inclined to the opinion that under existing conditions the medical student's work in general and inorganic chemistry can be best done either as a part of a thorough and required college course, or after entering the medical school itself, and that wherever done it should be characterized by a much more systematic and painstaking drill in fundamental principles than seems now to be the case in many institutions.

It is not my intention to enter upon a

discussion of what the course in physiological chemistry should be in medical schools. At present this often consists of a laboratory course in urine analysis only, along with a few lectures on subjects belonging to materia medica, pathology or practice rather than to chemistry. In many of the larger and more progressive schools this work is broadened out so as to include experimental studies in the sugars, the fats, the albumins, the processes and products of digestion and the examination of milk, blood, the gastric juice, bile, etc. There is a great diversity of opinion as to how much of this work may profitably be taught in the medical school. It is my own view that it is all out of place if it is not preceded by the proper drill in general chemistry to enable the student to really understand what he is doing. Without this clear understanding the laboratory course in physiological chemistry, which looks so well on paper, and which fills a good amount of space in the college announcement, degenerates into a mere mechanical routine, and becomes as valueless from the standpoint of discipline as is the justly condemned 'test-tube drill' in qualitative analysis. If the student is so illy prepared for his work that the operation of stirring a heated mixture of alkali solution and fat means simply 'making soap,' he might just as well spend his time in turning a grind-stone, as far as intellectual benefit is concerned. Unless he can connect this operation with many similar ones, and with the other processes of splitting fats, the experiment fails of its object. I am firmly of the opinion that the explanation of the low value placed on chemistry by many medical men may be found in the fact that in their own student days they have been forced through this kind of a routine course lacking the preliminary knowledge that would enable them to comprehend it. I maintain then that unless the student has been properly and systematically prepared in the elements of organic and inorganic chemistry, much of the matter presented to him in physiology and physiological chemistry must remain practically meaningless. As Professor Remsen well says: "It is difficult to see how, without some such general introductory study, the technical chemist and the student of medicine can comprehend what is usually put before them under the heads of applied organic chemistry and medical chemistry." (Preface to 'Organic Chemistry.') But, on the other hand, supposing that the medical student has been successfully prepared in an elementary preliminary course such as I outlined above, there is much indeed that he can really master in physiological chemistry proper. It is not necessary that he should be able to make many elaborate quantitative experiments. Most of the really important reactions in the study of the fats, the sugars and the proteids may be mastered with the aid of comparatively simple qualitative and a few volumetric tests. He will be able to demonstrate understandingly the essential facts connected with most of the digestive and other ferment changes, and to follow variations in excretion corresponding to variations in food consumption, or depending on pathological conditions. This carries the medical student as far as he is ordinarily called upon to go. Anything beyond this naturally belongs to the specialist, and besides would consume more time than can be usually spared from the medical course.

From a perusal of many of our text-books on physiology and physiological chemistry, the student is very apt to draw erroneous conclusions as to the nature of some of the reactions in this department of science. For simplicity in didactic presentation the teacher or writer is too apt to show everything in an ideal way. A great many dogmatic assertions are made, for example, concerning the digestion of the starches and the proteids, and the student almost expects to separate and recognize the half dozen or more beautiful products lying between corn starch and malt sugar, or the different hemis and antis, pros and paras in the still more complicated proteid family. The teacher who is not himself an investigator is but too ready to become an idealist, and to present all these intricate details in systematic tables and diagrams as he thinks they ought to be, and perhaps are, rather than as the original experimenters have actually been able to find them. The student must be warned against this, and not the least valuable function of the laboratory work in physiological chemistry in my judgment is to show him the inherent difficulties in much of our research work. An honest recognition of limitations will guard him against many future mistakes, against the preposterous analyses, for example, made by many young medical men while serving as hospital internes or in other capacity. I said a moment ago that there is much which may be easily and accurately learned in physiological chemistry by the medical student. It is evident that there is much more which in the ordinary college course cannot be mastered, and against pretended knowledge here the student cannot be too earnestly warned.

Physiological chemistry is in some institutions recognized as a distinct discipline, independent of medicine. This is true of the chair in several of the great European universities, and of at least one of the older American schools. Physiological chemistry is thus presented as is general biology or comparative anatomy. But in the great majority of cases it is looked upon as forming a part of medical rather than of general discipline, and doubtless for years to come the medical school will have many advantages in properly presenting the work. Inasmuch as no small part of the material employed in the laboratory demonstrations in the later parts of the course must be drawn from hospitals and clinics, it would seem that the effort sometimes made by other schools to give the equivalent of the medical school's work in this field must be in part futile. I am forced to the conclusion, from several practical considerations, that the student of medicine should not as a rule attempt to take physiological chemistry as a preliminary study outside the medical college. There is generally something lacking in such courses which the student recognizes often only after it is too late to recover lost ground.

Occasionally the work in physiological chemistry is given as a part of the course in physiology, but this, I believe, is a mistake, as the study is often curtailed to a consideration of a few physiological problems instead of being treated as an independent science of broad dimensions. With the present rapid expansion of this field of effort, the work calls for the attention of the specialist in chemistry rather than in physiology. This is necessarily true with respect to research study, and it is becoming equally true as regards the matter of proper didactic presentation. Much of the valuable pioneer investigation in physiological chemistry was done by physiologists, but in its later development the chemist alone can be expected to follow the accumulating mass of detail, and to sift out that which is of permanent value. It requires often rare judgment to decide how much of the newer knowledge is suitable for laboratory or class study, for no one wants to burden the already overtaxed student with a load of premature generalizations. While much of the latest work is always interesting to the specialist, it may often be quite unimportant to the student, and where to draw the proper line of separation between the new and the old calls for the teacher's maturest judgment. This same idea should be kept in mind in estimating the value of research work for the average professional student. The training of medical students in the United States is a vastly different thing in theory and in practice both from what it is in Germany, from which land we draw so many of our ideals. We give the title of 'Doctor' to the product of our schools, but in reality we are producing *practitioners* of medicine and in the shortest possible time. The man really learned in medicine should be able to present an original research, as the German idea assumes, but the practitioner may be just as successful in actual contact with disease without this skill. I would not be understood as underestimating the value of high scientific training for medical men. Indeed in certain specialties the medical man's success depends almost wholly on his preeminent scientific knowledge acquired by long and minute study. But there is still room for the general practitioner in medicine, and in my judgment he is, and should still remain, the most useful member of the profession. The American medical school is mainly concerned in the training of men of this class rather than of those with more special knowledge, and broad culture is of more importance here than minute acquaintance with bacteriology, physiological chemistry or histology. This is an age in which we are constantly called upon to do something new, regardless of whether the new thing is really needed or not. This criticism applies to research problems in physiological chemistry given to medical students as well as it applies in any other field. It will often be found that the teacher's interests rather than those of the student receive the first consideration, and this is certainly without justification in view of what I have said about the true field of work in American schools.

The teacher who attempts the proper presentation of general and physiological chemistry in a medical school has indeed no easy task. His work is made doubly hard by the fact alluded to above, that chemistry among the older medical men is still looked upon as a comparatively useless study, and from his preceptor's office the embryo doctor often brings this notion to the medical school. To combat this idea honestly, and to put his science before the medical student as it would be presented in a scientific or general course to freshmen or sophomores, requires the full time and energy of any man, and often little room will be left for research investigation, or, what is to some more alluring, the emoluments of commercial or expert work. But the sacrifice, if indeed it may be called such, is worth the effort. There are about 25,000 medical students in the United States, and the number graduated each year is not far from 5,000, in all schools. The number of registered physicians is about 1 to 636 for the whole population. It is no small matter to be able to make the proper impression on the minds of these men, and positions as teachers in the growing medical schools of the country have been perhaps too long overlooked by the better class of chemical graduates in search of academic openings. There is a field here which is worthy of fuller cultivation.

While I have intimated above that the possibilities for research work in chemistry for the average medical student or teacher are limited, and necessarily so, I am far from underestimating such work. While it is indeed true that in many quarters a trifling research on some trivial point of wholly artificial interest may be more highly prized than is the most painstaking and successful effort in class-work, and while it is also true that the layman, or professional man of little experience as well, may often be deceived as to the real value of such efforts, it is likewise a fact that there is always a proper appreciation of original investigation in lines of human interest. There is no more inviting field for labor of this kind than is found in the chemistry of life. The greatest problems in the scientific medicine of the future are undoubtedly chemical problems. Indeed there are no more important or inviting problems to be found in any line of study than are here presented, and the investigator will find in them enough to tax the skill and ingenuity of the most learned for years to come. This work naturally and properly belongs to the physiological chemist, and that it must be done before much further advance can be made in scientific medicine is already recognized by leading medical men. The idea was clearly presented by the Dean of the Northwestern University Medical School in the address on Medicine at the recent meeting of the American Medical Association at St. Paul, and we find it brought forward more or less emphatically elsewhere.

The chemical difference between certain of the tissues in health and disease may be very minute in some instances, but in other cases it is certainly more pronounced and capable of demonstration. This problem will unquestionably prove one of the most interesting for future investigators. We have long had considerable acquaintance with the products of renal excretion, somewhat less with the products formed or active in the stomach, and very much less with the complex reactions taking place in the lower stretches of the intestines. Investigation here is probably fully as important as in either of the other cases, but from its inherent difficulties has been but little developed. As the analysis of the urine gives us our most certain data for the diagnosis of diabetes and various renal disorders, so, it may be expected, will the rational chemical examination of the intestinal excretion prove of equal value in the exact diagnosis of other bodily ailments. There is certainly as close a connection in the one case as in the other. These questions are purely practical, and will some day claim the attention of skilled and accurate analysts.

In the field of theoretical investigations the possibilities are even greater. Almost nothing, for example, is known of the steps in nitrogenous metabolism. Between the ingested albumin and the excreted urea and uric acid is a long distance yet to be traveled by the chemical investigator; a few of the possible resting places on the way are known, but the relations of one to the other are yet extremely obscure.

Scarcely less obscure in its fundamental bearings, although seemingly less intricate, is the question of the nature and mode of action of the soluble ferments or enzymes. This is the problem of chemistry rather than of biology, as the question of the production of these substances is merely an incidental one. The epoch-marking work of Buchner in separating the active enzyme from the cells of yeast has gone far to break down the old and artificial distinction between the soluble and insoluble ferments, and to show that all these so-called vital processes are accomplished through what are essentially chemical means. It has long been supposed that in their mode of action the work of the enzyme is purely analytical, but since the interesting observations of Croft Hill on the formation of maltose from dextrose have been confirmed by O. Emmerling, who found, however, that it was isomaltose that was produced, we have opened up a new line of possible investigation which may throw light on some of the processes taking place within the animal body, where it was assumed by Liebig and others that *syntheses* do not take place.

Lately a fruitful line of investigation has been suggested by Bredig in his work on the 'inorganic ferments,' where he shows that colloidal platinum in its oxidationassisting behavior presents the closest analogy to some of the common organic enzymes. The colloidal metallic solutions seem to be affected by the same kinds of poisons which are known to impede the action of the soluble ferments, and to recover finally in about the same way. All these matters become of the greatest interest to the physiological chemist when we recollect that nearly all the body processes are doubtless enzymic in their character, and that the toxines or disease producers are probably chemical agents of the same class.

But it was not my intention to discuss new discoveries in chemistry. I merely wished to emphasize the fact that the fields of physical chemistry and synthetic organic chemistry are not the only ones to claim the serious thought of active investigators. I wished to suggest that the chemistry bearing on the problems of life itself presents no less interesting possibilities, and that it is worthy of more enthusiastic cultivation in our American schools. While it is doubtless true that the elementary practical instruction given in chemistry to American medical students is now equal to or possibly more systematic and thorough than that given in the majority of European schools, I wish to express the hope that in the further development of our medical colleges research work may find fuller recognition, and that in the solution of the great problems hinted at our American scholars may contribute their rightful share of effort, and in the end reap the corresponding measure of reward.

NORTHWESTERN UNIVERSITY. J. H. LONG.

## SCIENTIFIC BOOKS.

*Research Papers from the Kent Chemical Laboratory of Yale University.* Vols. I. and II. Edited by PROFESSOR FRANK AUSTIN GOOCH. New York, Charles Scribner & Sons.

The present occasion of the collected publication of these valuable papers is the coming of the two-hundredth anniversary of the founding of Yale University. The two volumes under consideration, containing an aggregate of 108 papers and 804 pages, form part of a series of Yale Bicentennial Publications. They form also a highly creditable evidence of the chemical activity in Yale College and a worthy tribute to the memory of Albert Emmet Kent, who endowed the laboratory. They cover a period of only thirteen years, the time which has elapsed since the completion of the building.

All except three of the papers included in the volume have already appeared elsewhere, chiefly in the *American Journal of Science* and the *American Chemical Journal;* and many of them have been translated into German and have been published in the *Zeitschrift für anorganische Chemie.* Hence the contents of the volume will be no surprise to chemists; the papers consist primarily either of proposals of new analytical methods or else of careful amplifications and revisions of old methods. In every case series of test-analyses are given, performed under varying conditions; hence a clear idea is afforded of the chemical error of each process. The papers cover too wide a variety of subjects to admit of detailed mention here; iodometry receives more extensive treatment than any other one subject. The value of the collection is much increased by admirably copious classified indexes.

Besides the names of the eminent director, Dr. Gooch, and his chief assistant, Dr. Browning, those of students too numerous to mention, including four ladies, are to be found at the headings of the separate papers.

The chief lack which some will feel on studying this work is the absence of frequent appeal to modern theory for assistance. As Dr. van't Hoff has pointed out, inorganic chemistry attains its greatest significance when viewed from the standpoint of modern physical chemistry. But in spite of this lack, the careful empirical investigations are so full of essential facts that no student of analytical chemistry can afford to be unfamiliar with them. The present bringing together of the scattered articles will facilitate access to these facts.

THEODORE WM. RICHARDS.

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