to be explained as before stated, by the inclusion of the bacterial surface border with the undecomposed interior. It appears that the ammoniacal nitrogen, determined by any one of several methods, increases regularly with bacterial decomposition. Yet it cannot be said positively that it is characteristic of bacterial hydrolysis only, since the ammoniacal nitrogen increases to some extent in acid and alkali hydrolysis and peptic and pancreatic digestion of proteins. The relationship between the ammoniacal nitrogen produced by the agents mentioned requires further study. In the absence of the other hydrolytic agents, the production of ammoniacal nitrogen can be definitely ascribed to bacteria.

Total Solids in Cold Water Extract.—On the whole the total solids in the cold water extract appear to increase with the age of the meat and hence with the increase of decomposition. This increase is not marked except in the oldest samples, and even then does not reach a very high figure.

Ash in Cold Water Extract.—The figures as would be expected are nearly constant throughout.

Total Nitrogen in Cold Water Extract.—There is a fairly regular increase in the nitrogen in the cold water extract from the beginning to the end of both experiments. The increase is altogether greater (as in other experiments also) than the increase in total solids.

Coagulable Nitrogen in Cold Water Extract.—The coagulable nitrogen shows, on the whole, a tendency to increase, although this is not regular and never reaches a larger amount. It is most marked in the oldest samples.

Albumose Nitrogen in the Cold Water Extract.—The albumose nitrogen determined by the zinc sulphate method increases, although somewhat irregularly, with the age of the samples. The total amount is never large and this would indicate that the albumoses are rather quickly transformed into simpler substances—those we have grouped under the term "meat bases."

"Meat Base" Nitrogen.—The "meat-base" nitrogen gradually increases with increasing age and decomposition.

Acidity.—It is doubtful whether in a product like meat, the lean of which is composed almost entirely of proteins, any fermentation could result in decidedly altering the reaction provided the indicator used is sensitive to weak acids as well as to ammonia. The fermentations of carbo-

hydrates and fats produce acids, but these compounds contain no nitrogen or basic groups.

While there are some contradictory figures in the analyses of the samples which were frozen after being stored at 2–4°C., from the results the conclusion may fairly be drawn that freezing of meats at –9° to –12°C. arrests bacterial decomposition but can not in any degree restore the product to its original condition.

ADDRESSES.

THE EFFICIENCY AND DEFICIENCIES OF THE COLLEGE-TRAINED CHEMIST, WHEN TESTED IN THE TECHNICAL FIELD.¹

BY WILLIAM H. NICHOLS.

The subject which has been assigned to me as part of this symposium is one which I would hardly have dared to bring forward of my own motion. It must involve us occasionally in statements which are not complimentary to either student or professor, but which are nevertheless true. Of course there is much that is of a more agreeable character, and this is naturally the more attractive side; but if it were the whole question, we would have reached perfection, and instead of a discussion we might satisfy ourselves with a summing up of our accomplishments, ending with a genial benediction, and go away with a snug feeling of thankfulness that we were not as other men. I cannot, however, forget my own experience while a student of chemistry and its applications, and the painful failures which ensued while subsequently endeavoring to put my learning into practice; and it is conceivable that these recollections may have had an undue influence on the result of my observations of others for a period of nearly forty years ensuing, during which time I have come in familiar contact with many college-bred chemists. The gradual though steady improvement in processes and methods to be noted, indicates the constant tendency to greater efficiency, while the comparative slowness of this improvement is doubtless partly due to some of the deficiencies in the preparation for the work. When I compare the attainments of recent graduates with my own when I went out into the world in 1870, I readily notice how much farther along the college work has brought them, and how much better prepared even the dullest or laziest of them is, than any of the students of my day. This applies to analytical and research work, as well as to chemical engineering, which then was extremely rudimentary and commonplace, usually given over to men who had been brought up in the works and without any scientific training.

The college course, of necessity, must be more or less general. With a hundred or more students of varying attainments and ability, it is impracticable to treat them as units, although I am aware that frequently all that is possible is done in this direction, particularly in the upper classes. From the technical point of view, there are three great fields in chemistry, and the student should himself decide which of these he intends to occupy. If he does not

¹ Read at Baltimore meeting, American Chemical Society, December 29, 1908.

do this of his own accord, his instructor should, I think, do it for him, after he has become acquainted with the student's measure. If during the ordinary course, the student or professor has not been able to make this selection, a post-graduate year should follow, always provided that the student's work shows that he has not been mistaken in selecting chemistry as a profession. In many cases it would be a kindness to suggest the taking up of some less exacting science, and some of the deficiencies are doubtless due to this effort to make synthetically a chemist out of impossible elements.

The three fields alluded to are those of analysis, research and technology or engineering. The first is of course essential to both of the others, and yet it is a pursuit by itself, and many follow it all their lives, either in works laboratories or as public analysts. As a rule, in this department, originality is not essential, the work being one of detail constantly repeated. Naturally, there are exceptions, and many of the best analytical processes have been worked out by men of this class. While this is not the highest branch of the science, it is at least the foundation, or more properly speaking, the root. There is no reason why any college should be deficient here, as it is only a question of professor and laboratory. Of course the institution cannot be held responsible for the student's inability or unwillingness to absorb what is generally so well given, although it may be criticized for not weeding out the stupid or lazy, and thus make needed room for others who hold out more promise. But certainly, it must be the fault of the college or professor, if a man be allowed to graduate who is not a good analyst, fitted to go on with routine work even while admitting that some institutions give a far better preparation than others. The science is open to all, but some men have a much better ability than others to impart knowledge that will be comprehended and absorbed.

The second of the fields alluded to as being open to the chemical student, while embracing the first, is of far greater importance and extent. I allude to the field of research. If during the college course, the student has not received some inspiration in this direction, there is a "screw loose," somewhere. If it be approximately true that if a man finishing the chemical course be not a good analyst, it is probably his own fault; it is, I fear, equally true that if he be not imbued with a determination to put his knowledge to uses that will produce new results, it is because his instructor has not been a man filled with an enthusiasm which he must communicate. A teacher of chemistry who imparts the dry facts of the science without holding out alluring glimpses of its future possibilities, is robbing his charges of their rights, for chemistry is the great science of the future, on which the welfare of the world, if not the very lives of its inhabitants, will depend more than on any other. But it must not be forgotten that research in chemistry must be conducted on common sense principles, and these include fixed purposes and objectives. Research on general principles is apt to produce general haziness and absolute lack of concrete useful results. But here we must make two subdivisions, lest we lose sight of the value of the magnificent work done in abstract research. It is very easy for us to understand the value of research which immediately results in the production of a new article, or an improved method of making an old one; but it is not so easy to appreciate

the bearing of an abstract research which simply adds certain knowledge to our store, or opens to us some new law, which in our present state of ignorance has no bearing that we can discern, but the knowledge of which will be essential to some great discovery of the future, which in its turn will lead to others and still others *ad infinitum*. The purpose of this paper is not to discuss the importance of chemical research, which is one of the most attractive subjects I can imagine. Hence, I must not dwell too long upon it. I think I have said enough, however, to remind us of the responsibility under which instructors labor in this regard. The man who for four or five years each has a number of receptive minds looking to him for light, falls far short of his duty and opportunity if among those minds he has not stirred up, according to the measure, an intense desire for working into the future. The field of chemical research, both abstract and concrete, being one of the most important that the human mind can engage in, it is gratifying to feel, as I do, that there has been a steady improvement in this regard, in the training of men fresh from college, which indicates that instructors in many cases are fully alive to the importance of the subject, even if they appreciate that much remains to be done.

The third field alluded to for the chemical student, is that including applied chemistry, so called, and chemical engineering. The former of these two subdivisions covers a much larger territory than the latter. While thirty years ago, the use of a chemist in the ordinary manufacturing establishment was the exception, it is at present, I am happy to say, the rule. This is now so well known, and the reasons or rather necessities for it are so well understood, that nothing more than the allusion is needed. There is no reason, so far as I can see, why college and technical schools are not pretty well equipped to furnish men trained to be of great service in this field, not only for the careful watching and control of the work, but for research in the special lines looking to improvements and economies. Almost all kinds of manufacturing establishments are open to the teaching staff and students alike, and the best practice employed in nearly all industries is well understood within the college walls. Details of cost and production are generally ascertainable, and the professor's lectures may be kept fairly well up to date. Therefore, there is little reason why the graduate chemist who has had this line of work in mind, should not soon become useful, and thereafter steadily improve. In addition to his knowledge of chemistry, the more he knows of engineering the better, particularly if it be of a nature to enable him to apply his chemical knowledge to the needs of the particular establishment. The general manufacturer need have no hesitation in adding to his staff, graduates in applied chemistry of many of our institutions.

With chemical engineering, the case is somewhat different. As I said at the beginning, thirty-five or forty years ago, work coming under this head, was in this country performed almost exclusively by practical men brought up in the works, whose deductions were the result of experience unenlightened by theory. It was, of necessity, somewhat crude, but good enough for practical purposes while every chemical manufacturer was in the same boat. The advent of the college-trained man changed all this, and the uneducated engineer has been gradually relegated to the background and for obvious reasons. The advantage the college-trained man had

was in his knowledge of the theory of chemistry. His disadvantage frequently, was his utter lack of engineering knowledge to enable him to apply it practically. The theory was of more value than the rough engineering without it, for engineering ability of high order has long been obtainable, and thus, theory could have a respectable application. There have been brilliant cases where both existed in the same individual, but I am compelled to say, that as far as my observation goes, this has not been general or even common. Now it must not be forgotten that the converse of this proposition may be true, though I do not think equally so. If the chemist may look to the engineer for assistance, why may not the relation be reversed? My answer to that is that it may be and generally is, in manufacturing establishments of a general character. In the chemical works, however, where the highest application of the theory is aimed at, chemistry should be the guide, and engineering the servant. If the chemist can also be the engineer, so much the better, and so much more likely will he be to bring his theory to fruition. And just here is where a great difficulty presents itself. The theory of chemistry is open to any who desire it, and who have the capacity to absorb it. This is hardly true of its application in the manufacture of chemicals. The student of Electrical Engineering has not only the theory at his command, but his text books have the latest practice, and he may visit the newest plants, and study them to his heart's content. So also with the student in Civil, Mining or Mechanical Engineering. These may in addition have their Summer Schools and field work, with the opportunity thus afforded for actual work under the most favorable conditions. In addition, the instructors are frequently employed in consulting capacity, and are thus up to date in many of the finer details of what has been accomplished, and what is being considered for future accomplishment.

It is not so with the student of Chemical Engineering. His text books contain, frequently, old processes and sketches of antiquated plants, or details accessible only after the process itself has been discarded or the plant abandoned for something better. His instructor is frequently in no better situation; and his lectures are sometimes, I fear, records of what used to be. I do not see how this state of affairs can be greatly changed, until chemical manufacturers open their works to both professor and student, a course which the exigencies of competition would seem to be likely to postpone indefinitely.

What, then, shall we teach our students who are preparing for this field? First of all—chemistry, all they can absorb. After this, as much Electrical and Mechanical engineering as possible, for both branches have come far to the front in modern chemical works. The chemical manufacturer who takes the graduate into his works will thus be able to make his instruction partake more of the nature of post-graduate work than is now so frequently the case.

A discussion of this question would fall far short of completeness if we did not take into consideration other matters than simply chemistry and engineering. The whole question of education in general has merited and received an immense amount of attention, particularly during recent years. While naturally, there have been many views, differing in detail, and sometimes widely divergent, it is, I think generally admitted as the consensus of opinion, that the object

of education is to make the most that is possible out of the material in hand, on the lines for which the student is more especially adapted. This education received at college or elsewhere, is the foundation upon which the real education of the student is to be based; which real education can only be acquired in after life, as the result of study, experience and association with others. The college has done its work when it has provided the student with the best possible foundation, and naturally his future depends to a large extent upon himself.

This preliminary education, if it may be so termed, would lack what the student has a right to expect, if it ceases when it has made him a good chemist with ambition for research and even with a good knowledge of engineering, which have been cited in what precedes, as the three necessities of the college curriculum for the production of chemists.

There is no reason, after all, why a chemist should not be qualified to assume the general duties of citizenship as well as the members of any other profession; and therefore, during his college course he must have something more than pure science. No man can fulfil the possibilities of his life if he be altogether one-sided or lop-sided; the educator should endeavor, so far as possible, to round out all of the faculties of the man. To do this, culture studies must not be omitted; particularly such culture studies as would tend to elevate the literary, the artistic or even the imaginative side of the student.

In preparing a man for life in the chemical field, he should be filled with the idea that any position in that field is open to him if he have capacity, industry and honesty, and he should look for attaining no position that is lower than the highest. This he cannot hope to do unless by the absorption of culture studies, he has prepared his aesthetic side as well as his scientific, although, perhaps, not to so great an extent.

I am well aware of the limitations imposed upon by the necessarily short time the student has in college—usually four years, rarely more than five—in which to acquire all that a man needs in the scientific line to become useful in his chosen profession of chemistry. I am aware that a good deal of work will have to be added if he is to have the engineering knowledge which I have alluded to, and have his mind cultivated by literature and kindred branches; and I imagine that the criticism will be made that it is impossible for any man to do the amount of work necessary to accomplish this result. It seems to me that the answer to this is, that with the modern idea that education is only begun in college, there is no reason why such tendencies should not be produced in the mind of the student, so that all of the necessities of a rounded education should follow by his own later work. It is only necessary to allude to that honored man who has recently announced his intention of retiring from the presidency of Harvard University, and who, although a chemist, rose to a position of great power in other fields, as instanced by his latest office; or to that other college president, who, while a great chemist, has presided with such dignity and force over the University which has been such an honor to this City of Baltimore. There are many other instances which will occur to you, but these two will suffice to show the possibilities to which men educated as chemists have a right to expect to attain.

To sum up briefly what I have so imperfectly expressed;

there is no reason why any college should not turn out good analysts and research chemists. If the graduates fail in these particulars, it is largely due to inefficient work of the professor or the college itself. There is sufficient reason why colleges should fail in turning out good chemical engineers, and for this failure I do not think they should be held altogether accountable, provided they do what they can in the direction of furnishing engineering attainments to the chemists. I believe that nearly all colleges are more or less deficient in the culture work which is given to their chemical students, and I see no reason why this deficiency should continue. They have the means at their command and should insist upon the student availing himself of them.

But after all, the greatest deficiency will be found to reside in the student himself, who either wilfully or from lack of ability, does not take full advantage of the opportunities afforded. In this respect the chemical student is no exception to the general rule the world over, and I suppose that to the end of time, brains, carefully cultivated and backed by initiative, will be at a premium.

THE UNTILLED FIELD OF CHEMISTRY.

Address of the Chairman of the Division of Industrial Chemists and Chemical Engineers, Baltimore, December 29, 1908.

By ARTHUR D. LITTLE.

Two years ago, upon a similar occasion, it was my privilege to address many of you and to point out some of the relationships existing between the chemist and the community. In so doing, there naturally devolved upon me the pleasant duty of recalling to your minds a few of the great and more significant achievements of members of our profession by way of indicating, although briefly and most inadequately, something of the extent to which the chemist has already placed the community in his debt. It is good for any body of men, animated by a common purpose, to take, from time to time, mental stock of what they have accomplished and of the relation in which they really stand to their environment. Whereas in our own case, the record is one of which we all may well be proud, its contemplation brings a new sense of the dignity of the work itself, a pride of fellowship and an incentive to increased endeavor.

We move, however, in a world where it is easy to take much for granted, where symbols and conventions quickly come to take the place of the realities they represent. Our mental processes are apt to run along the line of least resistance and the apparent and the obvious obscure the fundamental truths. This being so, we can well afford to leave our achievements in the security of the past while we consider for the moment the things we have left undone.

The volume of chemical literature has become so great, so many compounds have been described and classified, so many methods have been laid down, so much of detail confronts the student, and his field of study has been so subdivided as to suggest and foster the delusion that the total sum of chemical knowledge must be vast indeed. Vast in its detail perhaps it is, but lacking in those fundamental unities which out of the confusion of detail bring wisdom. Chemistry still awaits its Newton. It still justifies the estimate of Kant who said of it more than 100 years ago:

"Chemistry is a science, but not a science in the highest sense of that word; that is, a knowledge of nature reduced to mathematical mechanics."

Despite the immense amount of dry detail which we have accumulated and in some measure correlated, chemistry is still in the imaginative era where generalizations are more the result of happy inspiration than of close mathematical analysis.

Chemistry concerns itself with the changes which matter undergoes in its varying relations to certain forms of energy and yet we do not know what matter is nor have we any conception of the real nature of energy. One has only to state in their ultimate terms the problems confronting us to bring a realization of how very far from their solution we still stand. They are, for instance, thus summarized by Karl Pearson:

What is it that moves?

Why does it move?

How does it move?

Where, yet, I ask you is their answer to be found in chemistry?

We have built our science upon the assumption that matter, whatever that may be, is composed of indivisible atoms, of a comfortable and ultimate simplicity, only to find that the atom is in fact divisible and that its structure is undoubtedly complex beyond imagination. As to those phases of energy which are concerned with chemical change, even so great a philosophical chemist as Ostwald says: "Chemical energy is to us the least known of all the various forms, as we can measure neither it nor any of its factors directly. The only means of obtaining information regarding it is to transform it into another species of energy."

So we have gone on for a hundred and fifty years transforming chemical energy into electrical energy or into heat, making minutely refined measurements of the relatively small amounts of energy appearing in our processes, while wholly unconscious all this time of the stupendous stores of potential energy which we now vaguely begin to realize are bound up in matter.

Our study of matter has led us to teach that it manifests itself in some seventy distinct and separate forms which we call elements, and yet our very definition of an element is a confession of our failure. An element is something which we have not been able to decompose into anything simpler. We have discovered some curious and interesting relationships between the elements which point to their common origin. In his heart each one of us believes that they must have had a common origin and that the cycles of development which they exhibit can have resulted only from the action of a periodic variable upon a constant and yet we very rarely even consider the question of their genesis or why their properties are what they are. We are content to regard them as so many distinct creations. The discovery of a new element is hailed as marking an epoch in the history of our science when our real business should be the elimination of the elements as such.

In their interactions, the elements, as we know them, manifest valences and selective affinities which determine the course of all chemical change and yet we are without an acceptable working hypothesis of the cause and nature of either valence or chemical affinity. Our ideas regarding the constitution of the molecules of many compounds have been developed in great detail and have led us to so many happy conclusions which the facts have verified as to justify our belief that these ideas must rest upon a substantial