PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1910-11

ANNUAL BUSINESS MEETING.

Assembly Room, N. S. Technical College, Halifax;
14th November, 1910.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

The Institute had been called together for the annual business meeting, but as the greater part of the evening had been occupied with a meeting of the Nova Scotia Society of Engineers, to which the Institute's members had been invited, on motion it was resolved that the annual meeting be adjourned to a future date.

ADJOURNED ANNUAL BUSINESS MEETING.

Civil Engineering Lecture Room, N. S. Technical College, Halifax;
12th December, 1910.

THE PRESIDENT, DR. EBENEZER MACKAY, in the chair.

Other members present: WATSON L. BISHOP, MAYNARD BOWMAN, F. W. W. DOANE, DONALD M. FERGUSSON DR. JOHN STEWART, GEORGE R. BANCROFT, S. A. MORTON, PHILIP A. FREEMAN, and HARRY PIERS.

PRESIDENTIAL ADDRESS: (1) Progress of the Institute; (2) Some Achievements of Chemical Synthesis.—By PROFESSOR E. MACKAY, PH. D., Dalhousie University, Halifax.

PROGRESS OF THE INSTITUTE.

We enter this evening upon the forty-ninth session of the work of the Institute of Science. Owing to the postponement of the annual meeting, in order to meet in joint session with the Engineering Society, our formal opening is exceptionally late, and the session in consequence will be comparatively short. Let me express the hope that it will nevertheless prove to be the most prosperous and productive in the history of the Society.

The year closed has been happily free from any losses to our membership through death. Another gratifying feature has been an increase in the average attendance at the monthly meetings. Eleven papers were presented, including two in the department of Biology, three in Geology and Mineralogy, two in Physics and three in Chemistry. The attention of the Society was thus about equally divided between the natural and physical sciences. The Treasurer's report, which will be submitted to you, will show that the financial condition of the Society is more favourable than for either of the two preceding years. A special effort was made during the year to collect membership fees, with the gratifying result that the revenue from this source has been seventy-five per cent greater than that for last year and a hundred per cent greater than that received two years ago.

The outstanding feature of the year has been the installation of the Institute and its property in its present convenient and commodious quarters. In the Autumn, through the courtesy of the Nova Scotia Technical College, we found a permanent place of meeting in the College building: and in May and June the Provincial Science Library, of which the library of the Institute forms nearly eighty per cent, was removed to the new library room in the west wing of the College building, where, at the present rate of growth, the librarian estimates there will be accommodation for seventeen or eighteen years to come. The increased space has made the complete classification and arrangement of the library possible and owing to the untiring efforts of the librarian, Mr. H. Piers, all books are now readily accessible. The Provincial Museum also, as soon as it is practicable to move it, is to find a new and more commodious home in the Technical College. These changes mark an important advance. When they are completed the whole of the large and valuable equipment in museum and library will be for the first time readily accessible to every scientific worker who wishes to use it.

We enter upon the new session of the Institutes' work with a membership of 93 including 74 ordinary and associate and 19 corresponding members. Ten years ago we had 100 ordinary and associate and 25 corresponding members, a total of 125 members. Judged by these statistics, we should have to admit that instead of growing we had declined twenty-five per cent. It is only fair to remember, however, that on account of the successive prunings to which our lists have been subjected in recent years, the decline shown has been nominal rather than real and that our effective membership has probably been maintained. We must also recall that within a few years a flourishing sister society, the Engineering Society, has been organized, and that it appeals in considerable measure to the same constituency as the Institute does. Making due allowance for these considerations, the fact remains that while there has probably been no real decline, we have not grown as we ought. It would be too hasty to draw the conclusion that our younger men are not furnishing their due proportion of investigators. To go no further back than ten years, I can recall at least ten young men who while here contributed one or more papers to the Institute, and of whom few or none are now in the Province. If we could have diverted to our own Transactions the researches which these young men have published since leaving us and which have gone to enlarge the stock of knowledge under other auspices than ours, we should have much less reason to complain of lack of scientific activity. We are, in fact, in this as in some other respects, paying the tribute to larger communities which, it would seem, comparatively small communities are obliged to pay.

Within the last decade the people of Nova Scotia have come to a higher appreciation of the value of scientific education, and the facilities for scientific work have much increased. For evidence of this we have only to look around us at the present moment. The building in which we are meeting and its equipment prove that the public is realizing how indispensable is the service which science renders the community. The Technical College will add considerably to the facilities for scientific instruction and research; and we may look to it with confidence to make large additions to our knowledge—more especially in applied science. In the older provincial colleges, also, the most noteworthy progress in recent years has been in the expansion of the scientific departments, shown in the opening of new laboratories or in important additions to staff and equipment. All this implies that scientific work is receiving more serious attention in our Province now than at any previous time, and the conditions for the growth of a Society devoted to the promotion of scientific research should not at least be less favourable than they have hitherto been. This consideration should stimulate us to energetic efforts in order to realize more fully than we now do the purpose for which the Society exists.

As the purpose of the Institute is to promote research, the true index of its prosperity is not the length of its membership list, but the quality and quantity of its contributions to knowledge. Progress here is more difficult to estimate, but a careful survey of our yearly Transactions leads to the conclusion that we are doing little, if any, more than maintaining the position of ten or twenty years ago. Can we do anything to stimulate progress?

The Institute has in the past endeavoured to promote investigation principally in four ways: (1) by undertaking the publication of scientific investigations; (2) by accumulating a library and making it accessible to all who desire to use it; (3) by associating together those interested in scientific investigation with a view to stimulating individual effort; and (4) by attempting to arouse general interest in scientific work.

It will be admitted that we have not been equally successful in these various directions. We have, in the first place, succeeded in publishing with fair regularity the papers presented to the Society. In regard to our library we can point with satisfaction to our considerable and growing collection of publications of scientific societies, conveniently arranged, within ready access of our place of monthly meeting, and accessible daily not only to our own members but to the general public and especially to students of pure and applied science. The material in our library is, as far as it goes, just the kind which the scientific investigator needs. No library of text-books could take its place, and as it is the kind of library which would not have been collected in this Province but for the efforts of this Society, we have here an achievement in which it may be permitted us to glory. At the same time, as an antidote to excessive pride, we may remember that there are many serious gaps on our shelves and that in particular the most important journals of Physics and Chemistry are conspicuously absent, as these cannot be obtained by exchange but only by purchase.

When we turn to the other two directions specified in which an effort has been made to promote research we do not find the record so successful. The Institute has not yet succeeded in organizing and associating the scientific interests in its territory; and little direct effort has been made to awaken general interest in scientific work.

Now let us consider briefly what it is desirable for us to accomplish in these two directions.

Enthusiasm in advancing science like religious or political enthusiasm, or indeed any other kind, is powerfully promoted by close association and frequent meetings of those of similar ways of thinking. The exhortation of the Apostle to the early Christians not to forsake the assembling of themselves together, was founded upon a knowledge of the needs of human nature. The scientific investigator is cheered and stimulated by frequent association with fellow-workers, and his zeal tends to languish if he finds himself cut off from them. Hence a disproportionately large amount of research work is done in the centres where men meet each other frequently. In this Province we have no large communities; and we can only very imperfectly at best overcome the isolation of individual workers. In order to do what we can in this direction the first step is to have all actual or potential workers so far as possible become members of the Institute. We should carefully survey our territory, district by district, and see that the claims of the Society are placed before every man believed to be interested in scientific work. Every teacher of Science, more especially every teacher of the natural sciences, should be on our membership list. The professional and business men who have become interested in some department of science, the more progressive of our farmers, fruit-growers and fishermen, all these should have an opportunity of identifying themselves with the Institute's work. Men competent to make reliable observations of natural phenomena, who have at the same time both the inclination and opportunity to make them, are not very numerous. The services of all such are needed in the Society. An ideal to be realized would be to have a competent observer in every important district of our territory who would report upon any natural occurrence of scientific interest in his district, for example, on the appearance of any insect pest or other agency destructive to vegetation, or the occurrence of local earthquakes, or of unusual meteorological or celestial phenomena. There is nothing new in the attempt to realize something of this sort. The Education department of Nova Scotia inaugurated a system for the purpose of making phenological observations many years ago and the experience gained by the department would be invaluable in any attemnt to organize a corps of observers among associate members of the Institute. Accordingly, I wish to be understood as speaking with diffidence of what the possibilities in this direction may be. But whether it is practicable to stimulate observation by organization of this kind or not it is certain that we must make a systematic effort of some kind in order to retain the interest and support of non-resident members. It would probably not be difficult to largely increase our membership. Our entrance fee is not formidable, and initiation ceremonies are simple. The real problem is how to maintain an interested and, in consequence, effective membership; and this, it seems to me, can only be done by keeping in frequent communication with members in one way or another. If we were a large and wealthy society, able to issue a monthly or fortnightly journal to all members, the problem would be solved. But our transactions are issued much too seldom to have the desired effect. Hence some other means must be adopted; and to bring the discussion to a practical issue, I would make the following suggestions:—

(1) That reports of our monthly meetings, or of lectures or other functions under the auspices of the Society be sent every member regularly. This might perhaps be done with least trouble and without much expense by making suitable arrangements with the city newspapers.

(2) That if possible there should be held annually a special meeting of the Institute, preferably at some time when there are excursion railway rates to the city; that the programme of this meeting should be made of as great general interest as possible; and that there should be opportunity at it for the discussion of matters specially affecting non-resident members.

(3) That as many competent observers as possible should be organized in observational work, mapped out by and under the direction of the Institute.

That part of the Institutes work designed to awaken public interest in science has not hitherto received much direct attention from the Society. All are agreed, however, that it is important, both as an end in itself, and as a means to the end for which the Society exists.

There are occasions when arousing public interest in scientific matters becomes an imperative duty which a scientific society must not shirk. The advent of the brown tail moth is an example of such an occasion. And other occasions frequently occur offering opportunities to a Scientific Society to be of public service. I am reminded in this connection that not many months ago I heard a city official give an address in which he scoffed at the idea that the common house fly could be a carrier of disease. This example illustrates a dangerous sort of ignorance which a popular scientific lecture on the habits of the house fly might perhaps remove. And if the Institute could occasionally provide such lectures on timely topics it would earn public gratitude, and incidentally do much to educate the public to appreciate the value of scientific work and to become interested in it.

It would be easy to suggest numerous ways of promoting investigation and interest in investigation, which could be made effective if we had unlimited resources to draw upon. But what concerns us most at present is, not what we might do if we had the means but what we can do with the means we have. The Institute is able to look back upon a past of solid achievement; it finds itself at present in a more favourable condition as regards material appliances than it has ever before been. May it not, therefore, look forward with confidence to a future that will be worthy not merely of the achievements, but of the hopes and aspirations of the past?

Some Achievements of Chemical Synthesis.

In addressing you a year ago, I attempted to trace the development of the atomic theory, and to show how its fundamental conception had received striking and unexpected confirmation from recent physical research. This evening I propose inviting your attention to a few achievements of Chemistry in the synthesis of organic compounds. It is a subject which opens up a vast, almost illimitable, field, in which one might wander indefinitely. But in the time at my disposal it will only be possible to glance briefly at a few out of very many notable results obtained; and if, in addition, I succeed in presenting such a general conception of the nature of synthetic problems as may be possible without introducing technicalities, my object will have been attained.

Numerous as the different kinds of substances we meet in Nature may seem to us, they form but a small portion of the vast array of substances known to Chemistry. In other words, by far the greater proportion of existing substances are manufactured. Some of these, like phosphorus or sodium, are elementary substances, and hence their preparation involves the splitting up of the compounds used as raw material. Others, like sulphuric acid, or white lead, or rosaniline are compounds, and so have to be built up from the constituents of the raw materials used in their manufacture. This building up process is chemical synthesis, and it is in this direction that Chemistry has achieved some of its most notable triumphs.

The Chemical elements vary greatly in their capacity for forming compounds. Argon and helium, which cannot combine with anything, illustrate one extreme of this capacity; while carbon, whose compounds number considerably more than a hundred thousand, illustrates the other. The overwhelming superiority of carbon in respect of its compound-forming capacity is one of the cardinal facts of Chemistry. Its compounds include all substances of vegetable and animal origin; thus starch, sugars, fats, and that exceedingly complex group of substances, the proteins, which make up the chief part of the white of egg or the protoplasm of cells, are all compounds of carbon. This great group of substances known as organic compounds, formed the dark continent of early chemical exploration. Until about a century ago only a very few of the most venturesome had dared to enter the territory at all. There was a mysterious something about organic substances which distinguished them from inorganic or mineral compounds, a something which, as a leading chemist of the time said, was easier felt than defined. One distinction between the two came to be universally accepted, namely, that only inorganic compounds could be built up in the laboratory from their elements. Organic compounds, on the other hand, could only be formed in organisms, under the influence of vital force.

This belief received a shock in 1828 when Wöhler, a distinguished German chemist, accidentally discovered that ammonium cyanate, commonly classed as an inorganic compound, could be readily converted into urea, a typical organic substance. It is not easy for us now to realize how startling this discovery seemed to the chemists of that time. If a modern chemist were to discover that living cells could be developed from ammonium salts, the discovery would scarcely produce a greater sensation. Wöhler's discovery showed that the synthesis of organic compounds was possible in the laboratory and that therefore the mysterious influence called vital force was not a necessary factor in their formation. Why, then, would it not be possible to make, starch, sugar, the fats, even muscular fibre from their elementary constituents? And so this first organic synthesis opened up to the vision of chemists a vista of possibilities hitherto undreamt of and pointed the way to an illimitable field for investigation and discovery.

It was long, however, before the next organic synthesis was effected. This was the synthesis of acetic acid, the acid of vinegar, and was carried out by Kolbe in 1845. Two relatively simple organic compounds had thus been synthesized in somewhat less than twenty years. This was slow progress. And in learning why advance had not been more rapid we shall learn something of the nature of the problem presented by organic synthesis.

Let us suppose that a clever workman who had never seen a watch finds one some day and, observing its usefulness, wishes to construct one for himself. Let us further suppose that he is permitted to experiment with the watch and to observe its exterior but that he cannot open it and that, therefore, the internal mechanism is invisible to him. Having learned everything possible from observation, his next step would be to make an hypothesis about the structure of the watch that would satisfactorily explain its observed behaviour. Then, having purchased the necessary parts from a dealer, he would proceed to put them together in accordance with his hypothesis. If the latter were well-founded the result would be a watch, the counterpart of that studied.

Now the problem which our amateur watch-maker had to solve is crudely analogous to the much more complex problem which confronts the chemist who attempts to synthesize an organic compound. First he has to determine the composition of the given compound; then to observe its behaviour under various conditions; then to make an hypothesis about its structure that satisfactorily explains the observed behaviour; finally, he has to cause the proper kinds of matter to unite in such a way as to give a compound of the assumed structure. If the assumed structure were correct, the result will now be the desired compound.

In the time of Wöhler, to determine the composition of a substance was in general much the easiest part of this problem; for methods of analysis had already been perfected. It was only necessary to obtain a pure specimen of the substance to be analyzed. This, indeed, sometimes was, and still is, a very difficult task. But as a rule, the nature and proportions of the constituents of a compound could be accurately ascertained without great difficulty.

It was far otherwise with the structure. Dalton's atomic hypothesis was already nearly quarter of a century old when Wöhler synthesized urea. According to this hypthesis when a compound of, say, carbon, hydrogen and oxygen is formed, the smallest particle of the compound capable of existing is some sort of little group or association of definite numbers of atoms of carbon, hydrogen and oxygen; and any given portion of the compound, say a pound of it, is simply an exceedingly large number of such little groups, massed together. These little groups of atoms are now called molecules. This picture of what we may call the invisible mechanism of matter may or may not be a true one; but the true mechanism, whatever it is, produces exactly the same visible effects as would result from the atomic hypthesis. This hypthesis, therefore, as far as it goes, serves the same practical purposes as a knowledge of the actual constitution of matter. It will be noticed, however, that it only provides us with a skeleton mechanism, leaving details to be filled in; and chemists soon felt the need of supplementing it with additional hyptheses. Wöhler's discovery, already cited, furnishes an illustration of facts which made this need apparent. Ammonium cyanate and urea have exactly the same composition, which is expressed in terms of the atomic hypothesis by the formula CH_4N_2O; that is, in every smallest particle or molecule we may suppose that one atom of carbon is associated with four of hydrogen, two of nitrogen and one of oxygen. It cannot be that these different atoms are associated in haphazard fashion, like so many different coloured marbles thrown into a bag. On the contrary, there must be one definite arrangement of them that gives ammonium cyanate and another that gives urea. So much is evident; but how is the arrangement in each case to be determined? And until the arrangement of atoms in the molecule of a given compound is known, or whatever it is that corresponds to this in the true mechanism of matter, how is the synthesis of the compound to be anything more than a lucky chance?

It is now clear why progress in the synthesis of organic compounds had been slow. The problem of constitution had first to be solved or at least some working hypothesis had to be formulated which would be a sufficient approximation to the truth to serve practical purposes. The history of Chemistry from 1820 to 1860 is characterized by successive attempts to attain this end. Berzelius' electro-chemical theory, the radical theory, the substitution theory, the newer type theory, and finally the theory of valence, mark notable steps in the progress. Each successive theory explained a wider range of facts than its predecessor, and gave place in turn to a theory capable of interpreting a yet wider range. We are here concerned only with the last-named, the theory of valence. This theory attributes to each atom a strictly limited capacity for combining with other atoms, as measured by the number of atoms with which it can combine. Accordingly, an atom cannot combine with or, figuratively speaking, become linked to, an indefinitely large number of other atoms, but only with a small number, the atoms of different elements having different capacities in this respect. For example, an atom of hydrogen, or of chlorine can never combine directly with more than one other atom and these elements are therefore called univalent. The capacity of an oxygen atom for combination is exhausted by combining with two atoms of hydrogen or any other univalent element; and hence oxygen is called bivalent. An atom of carbon can combine with a maximum of four hydrogen or four chlorine or two oxygen atoms, that is, carbon is tetravalent. With the aid of this hypothesis it was now possible to interpret experimental results by the formulation of relationships between the atoms of a molecule. An example will make this clear. The composition of alcohol is expressed by the formula C_2H_6O. Now one-sixth of the hydrogen and all the oxygen are removable from alcohol, and re-appear together again in one of the reaction products. These experimental results can be interpreted by attributing to one of the hydrogen atoms a different relation to the compound from that of the other five, and by supposing that this hydrogen atom is directly combined with the oxygen atom. But as hydrogen is univalent and oxygen bivalent, these relations would have to be expressed by the formula C_2H_5-O-H. Interpreting in similar fashion other reactions of alcohol, and assuming the tetravalence of carbon, we finally arrive at the formula CH_3-CH_2-O-H which expresses relationships between the atoms. Now formulae of this kind—known as structural or constitutional formulae—not only suggest new properties, but also methods of synthesis. For example, the above formula suggests a method of making alcohol from the hydrocarbon, ethane. The latter is a gaseous compound whose structure is represented by the formula CH_3-CH_3 By the action of bromine upon it we obtain bromethane, CH_3-CH_2-Br, a pleasant smelling, volatile liquid. Acting on this with a suitable metallic hydroxide should replace the bromine by an oxygen and hydrogen atom and hence should yield alcohol if our constitutional formula is correct,—

$$CH_3\text{-}CH_2\text{-}Br + MOH = CH_3\text{-}CH_2\text{-}OH + MBr.$$

This result has been experimentally verified.

In the constitutional formula of alcohol just given, the assumption is made that one atom of carbon can combine with another. An extension of this assumption explains the remarkable compound-forming capacity of carbon already mentioned. By supposing that one atom of carbon can combine with another, one of these with a third, this in turn with a fourth, and so on, we should obtain a structure analogous to a chain, of which carbon atoms are the links. No other element seems to have any appreciable power of forming such atomic chains, and on the other hand there appears to be practically no limit to the number of carbon atoms that can enter into the carbon chain. Hence the multiplicity and complexity of carbon compounds, and the variety and difficulty of the problems presented by the synthesis of them.

We owe the theory of valency to the labours of Frankland, Couper, and Kekulé. With its development, progress in the formulation of the constitution of carbon compounds became exceedingly rapid; and no less rapid was the advance of organic synthesis, for the determination of the constitution of a compound usually implied that either immediately, or at all events in no long time, methods would be devised for the synthesis of it. In this way, one by one, many of the organic compounds found in Nature were artificially prepared. But numerous as these preparations were they formed but a small fraction of the stream of carbon compounds entirely new to the world which now began to pour from chemical laboratories. The stream became a flood when a few years later, Kekulé, in a memoir regarded as the most brilliant piece of reasoning in the literature of organic chemistry, showed how the theory of valency could be applied to explain the peculiarities of a class of substances known as the aromatic compounds, which until then had presented a hopeless jumble of unintelligible reactions. This explanation constitutes what is called the benzene theory. Its effect in stimulating activity in organic chemistry, and more especially in organic synthesis was immediate and unexampled. The aniline colur industry, which it found small and helpless, forthwith became great and powerful. Even now, although forty-five years have passed since the benzene theory was published, its fertility remains undiminished. To quote from Professor Japp: "Kekulé's work stands pre-eminent "as an example of the power of ideas. A formula, consisting of "a few chemical symbols jotted down on paper and joined together "by lines, has . . . supplied work and inspiration for scien- "tific organic chemists during an entire generation, and affords "guidance to the most complex industry the world has yet seen."

It remains to cite a few examples of the achievements of organic synthesis. I shall have to pass by the almost innumerable essences, perfumes, colurs, anaesthetics, antispetics, and substances of therapeutic value, which we owe to this branch of Chemistry: and I can only linger long enough to merely mention the synthesis of camphor, and of the natural alkaloids, nicotine, atropine, conine, and cocaine, to mention some of the better known. But I shall venture to dwell a few moments on what has been accomplished in the synthesis of three important groups of substances produced in living organisms: (1) the sugars, (2) the proteins and (3) the vegetable dyes. As I have undertaken to avoid technicalities, the merest glance at these different fields must suffice.

The sugars, as is well known, form a very important natural group of substances closely related to starch, cellulose and the gums. The best known sugars belong to either one of two groups. Cane, malt and milk sugar, all having the composition expressed by the formula $C_{12}H_{22}O_{11}$ are called disaccharoses. Glucose or grape sugar and fructose or fruit sugar, having the formula $C_6H_{12}O_6$ are monosaccharoses. Until a little over twenty years ago, in spite of the importance of the sugars, little was known of their chemistry. This was not because they had not been studied but because of the hopeless character of the problem they presented.

It is to the work of Kiliani and especially to that of Emil Fischer that Chemistry is indebted for the solution of these problems. In 1866 Kiliani succeeded in determining the constitution of both glucose and fructose; and within the following four years Fischer not only synthesized both glucose and fructose, but also a large number of other related sugars previously unknown, and succeeded in completely clearing up the Chemistry of the whole group of saccharoses. Fischer's brilliant work was made possible by his discovery of a means of effecting what had baffled earlier chemists, the isolation of a sugar in pure condition from a mixture. The key to this problem he found in the reagent, phenylhydrazine, which he discovered would convert a sugar into an easily purified, easily identified, insoluble compound. But it requires a magician to wield a magician's wand: and phenylhydrazine in the hands of any less gifted worker would not have accomplished what it did in the hands of Emil Fischer. When after a few years work he finished his investigation of the monosaccharoses, that chapter of Chemistry was left practically complete.

The syntheses in the group of disaccharoses have been much less numerous. The most notable has been that of cane sugar, and with a passing reference to the way in which this has been accomplished we shall leave the sugar group.

When cane sugar undergoes inversion it takes up the elements of water and yields equal quantities of glucose and fructose. This and other reactions indicate that cane sugar is some sort of compound of glucose and fructose with water eliminated. The glory of first succeeding in producing such a compound is due to Marchlewski, who obtained cane sugar by the reaction of aceto-chloroglucose on potassium fructosate in 1899.

When we turn to the protein group we have to deal with the most complex substances known to Chemistry. At the same time their relation to the living organism makes them physiologically the most important of all substances.

The difficulty of research in this branch of organic chemistry are enormous. Many members of the group are non-crystalline substances, and hence excessively difficult, or impossible, to obtain in pure condition. Again they are, as a rule, very sensitive to changes of temperature and to the action of reagents, which of course greatly increases the difficulty of unravelling the nature of reactions. Finally they are substance of prodigious complexity—egg albumen having a molecular weight not less than 12 or 15,000.—that is to say, there must be several hundred atoms of carbon in the molecule. In spite of these difficulties, however, much progress has been made in the chemistry of the proteins in recent years; and the chief progress has been due to the application of synthetic methods. The magician under whose direction these methods have been carried out is Emil Fischer. Let us glance at the results.

When the huge protein molecule is broken up by the action of chemical reagents, such as acids and alkalies, the fragments consist of substances which can be analyzed and identified. They are found to belong for the most part to a class of substances known as amino-acids, of which amino-acetic acid (glycocoll) is a simple example:

$$CH_2NH_2CO_2H.$$

Now the manner of breaking up of the protein molecule is of such a kind that it is practically certain the parts represent veritable fragments or are closely related to veritable fragments of the original molecule. The work of Emil Fischer and his students has been devoted to piecing together these fragments in the way in which it seems most probable they ought to be combined. To show the nature of this piercing together let us begin with amino-acetic acid. It contains a group NH_2CH_2CO, which Fischer calls glycyl. Now this may be made to combine with amino-acetic-acid so as to yield the following:

glycyl,-glycine, $NH_2CH_2CO\text{-}NHCH_2CO_2H$.

In the same way we obtain:

diglycyl-glycine, $NH_2CH_2CO\text{-}NHCH_2CO\text{-}NHCH_2CO_2H$.

And this chain may be lengthened indefinitely. Now by substituting in a similar way other amino-acid groups as leucyl, $C_4H_9\text{-}CH(NH_2)CO$, other similar compounds are obtained. These compounds are named by Fischer the polypeptides. One of these has been synthesized which contains eighteen amino-acid groups like the above joined together, giving the enormous molecular weight of 1213—truly a masterpiece of synthetic skill. Now a remarkable fact is that these polypeptides have properties which are quite different from those of the amino-acids of which they are made up and approach closely the properties of proteins. They give, for example, some of the characteristic reactions of the proteins, and when they are fed to animals the products are the same as in the case of albumens. These results indicate that the advances now being made so rapidly are in the right direction and that the goal of the strenuous efforts being made, the synthesis of a veritable protein, is not beyond the power of organic chemistry.

In turning now to the group of vegetable dyes we leave pure science behind and deal with science in partnership with commerce and industry. For unlike the monosaccharoses and polypeptides with which we have been dealing, alizarin and synthetic indigo are articles of commerce which have competed with, and displaced, the vegetable dyes madder and indigo. Alizarin was the first but indigo is the greatest achievement of synthetic chemistry in this field. Many syntheses of it have been long known, the first having been effected in 1870. The problem of the commercial synthesis of indigo, however, involved other factors besides the purely scientific ones; and its solution is a magnificent tribute not only to the synthetic skill and the perseverance, but also to the business sagacity, of those workers who for twenty years never faltered in their determination to reach the desired goal.

The first attempts to place the synthesis of indigo on a commercial basis started from toluene, one of the constituents of coal tar, as raw material. From this substance there are numerous paths leading to indigo. Some of these perpetually lured the investigator on with the hope, so often elusive, that means could be devised of reducing the cost of production to such an extent as to make the route a commercial one. One of these routes led to indigo through a substance called authranilic acid. Then forthwith the dominant factor in the problem became the production of this acid at a sufficiently reduced cost. A method of making it from napthalene instead of from toluene was discovered, and this discovery was the turning-point of the struggle. "At one stroke" says one of the investigators[1] "the commercial manu-

[1] H. Brunk, Chem News (1902), 89, 212.

"facture of indigo was placed on a solid basis. From that moment "I had the firm conviction that the method on which we were "engaged would bring us to the desired end." The reason of this confidence lay in the fact that napthalene as raw material had the great advantage over toluene of being very much cheaper and more abundant; so much so that nearly 30,000 tons of napthalene annually were being converted into lamp black, or left unisolated, for lack of more profitable use.

Success, however, was not yet won. Besides the solution of numerous minor difficulties, it involved the devising of a cheaper method of producing concentrated sulphuric acid; and thus it has happened that it is to the struggle for synthetic indigo we owe the introduction of the contact process of manufacturing sulphuric acid which has already revolutionized this, the greatest of chemical industries.

It is now nearly a decade since the goal so long striven for was at length gained, and synthetic indigo was able to compete successfully both in quality and cost with the natural product. In 1901 the whole of the indigo imported into Great Britain was the product of the indigo plant. In 1908 synthetic indigo to the value of $670,000 was imported, or about one half of the total importation. It requires no prophet to foretell the conclusion of the story: the industry of indigo production will pass from the banks of the Ganges to those of the Rhine. And the moral is equally plain. It is the country that is most successful in making science not merely the occasional adviser of the industries, but their ally and confidant, that will be victor in the contest for industrial supremacy.

The Treasurer, M. Bowman, presented his annual report, showing that the receipts for the year 1909-10 were $849.19, the expenditures $609.45, and the balance in current account on 31st October, 1910, was $236.74; while the permanent endowment fund is $859.81, and the reserve fund, $190.68. The report having been audited, was received and adopted.

The Librarian's report was presented by H. Piers, showing that 1754 books and pamphlets had been received by the Institute through its exchange-list during the year 1909; and 1456 had been received during the first ten months of the present year (1910), viz., January to October, inclusive. The total number of books and pamphlets received by the Provincial Science Library (with which those of the Institute are incorporated) during the year 1909, was 2204. The total number in the Science Library on 31st December, 1909, was 38,988. Of these, 30,587 belong to the Institute, and 8,401 to the Science Library proper. That is, about 78 per cent. are the property of the former, and about 22 per cent. belong to the latter. 431 books were borrowed, besides the many that were consulted in the library. No binding was done during the year, there being no grant available for the purpose. From 13th May to 17th June, 1910, the whole Science Library was moved from No. 201 Hollis Street, where it had been located since its foundation in 1900, to the large new stack-room provided for it in the Nova Scotia Technical College, Spring Garden Road, and since then it had been entirely checked over, book by book, and rearranged.—The report was adopted.

The following were elected officers for the ensuing year (1910-11):

President,—WATSON L. BISHOP, *ex-officio* F. R. M. S.

1st Vice-President,—DONALD M. FERGUSSON.

2nd Vice-President,—PHILIP A. FREEMAN.

Treasurer,—MAYNARD BOWMAN, B. A.

Corresponding Secretary,—ALEXANDER H. MACKAY, LL. D., F. R. S. C.

Recording Secretary and Librarian,—HARRY PIERS.

Councillors without office,—ALEXANDER MCKAY; PROFESSOR FREDERIC H. SEXTON, B. SC.; FRANCIS W. W. DOANE, C. E.; A. L. MCCALLUM, B. SC.; PARKER R. COLPITT; GEORGE R. BANCROFT, B. A.; and PROFESSOR EBENEZER MACKAY, PH. D.

On motion, a vote of thanks was presented to the retiring President, DR. E. MACKAY, for the unusually able and satisfactory manner in which he had filled the chair during his three years term of office, the limit of time allowed by the by-laws.

FIRST ORDINARY MEETING.

Civil Engineering Lecture Room, N. S. Technical College, Halifax; 13th May, 1911.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

A paper by WALTER HENRY PREST, of Bedford, N. S., entitled, "A Suggestion for Anthropological Work in Nova Scotia," was read by DR. A. H. MACKAY. (See Transactions, p. 35.) The subject was discussed by DR. MACKAY, H. PIERS, Dr. E. MACKAY, G. W. T. IRVING, and the author. The consideration of what, if any, exploratory work might be undertaken, along the line suggested by the paper, was referred to the council. (For the results of such work, see W. H. Prest's "Report on Cave Examination in Hants County, N. S.", in Transactions, vol. xiii, pt. 2, p. 87.)

SECOND ORDINARY MEETING.

Reading Room, N. S. Technical College, Halifax; 31st May, 1911.

THE PRESIDENT, WATSON L. BISHOP, in the chair.

It was announced that the following had been duly elected ordinary members by the council: C. B. NICKERSON, M. A., demonstrator in chemistry; CLARENCE D. HOWE, B. SC., professor of civil engineering; HOWARD L. BRONSON, professor of physics; D. S. MACINTOSH, B. SC., lecturer on geology; and HAROLD S. DAVIS, B. A.; all of Dalhousie University, Halifax.

On motion of H. PIERS and A. L. MCCALLUM, it was resolved that the Nova Scotian Institute of Science learns with deep regret of the death of its corresponding member, DR. ROBERT WHEELOCK ELLS, F. R. S. C., and desires to express its high appreciation of him and of the very valuable work he had done for Canadian geology, particularly in the Maritime Provinces.

The following papers were read by title:

1. "Recent Meteorological Notes."—By F. W. W. DOANE, city engineer, Halifax. (See Transactions, p. 53.)

2. "Monthly Mean Temperatures, Halifax, N. S., and Plymouth, G. B., compared."—By HENRY S. POOLE, D. Sc., F. R. S. C. (See Transactions, p. 52.)

3. "Mineral Occurrences in Granite at New Ross, Lunenburg county, N. S."—By A. L. MCCALLUM, B. Sc., Halifax.

4. "On the Effect of Gravity on the Concentration of a Solute."—By HAROLD S. DAVIS, B. A., Dalhousie University, Halifax. (See Transactions, p. 291.)

5. "Rare Fishes in Nova Scotia."—By HARRY PIERS, curator of the Provincial Museum, Halifax.

HARRY PIERS,
Recording Secretary.