PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1898-99.

ANNUAL BUSINESS MEETING.

Legislative Council Chamber, Halifax, 14th March, 1898.

The PRESIDENT, MR. A. MCKAY, in the chair.

The PRESIDENT addressed the Institute, as follows:—

GENTLEMEN,—It is an educational axiom of the first importance that in presenting a new subject for study it should in some vital way be correlated with ideas already in the mind of the student.

Guided by this principle, I should at the beginning of another year's work of this Institute, review briefly the progress made during the past year. This was in many respects most unsatisfactory. Never before did we have so much difficulty in securing papers for our ordinary meetings. We had in all thirteen communications, of which eleven were papers, three read by title. Six of these papers gave the results of investigations, conducted chiefly by two Dalhousie students in a physico-chemical field, regarding the behavior of ions under certain conditions. There were two papers relating to Geology, one to Natural History, one to Ethnology, one to Botany. In addition, Mr. Twining exhibited a model of a Pivot-boat, and explained its working, and Dr. MacGregor gave an address on Laboratory Methods.

It may, however, be found that the sum total of scientific knowledge has been increased somewhat by those original researches which were conducted in Dalhousie College, and that the printed results may be utilized by other investigators. Dr. Bailey's very interesting papers on the structure and geologic formation of Digby Basin throw much light on some hitherto obscure problems of the geology of that region.

The teaching of science in our public schools would be greatly improved if the methods recommended by Dr. MacGregor, in his able address on Physical Laboratory Work, were generally adopted.

It is too soon yet to attempt any prediction regarding Mr. Twining's novel experiments in boat-sailing. They seem calculated to lead to a great improvement in the quality of speed by showing how friction and water displacement may be reduced to a minimum.

Dr. MacKay's phenological observations, assisted as he is by a large corps of observers all over the Dominion, may lead to some important generalizations regarding the relation of organized life to latitude and other climatic conditions.

I have referred to the difficulty of securing papers on scientific subjects for our ordinary meetings. This does not necessarily imply that our members are becoming less interested in science than formerly. It may and probably does mean that work in science like work in every other department of human life is becoming more specialized. Our earlier scientists worked in comparatively new fields. It was then an easy matter to find plants or animals not previously known in our country and with the aid of good text books to describe and identify them. The first explorers in a rich gold mine find it easy to make fortunes. Those who come later require much greater skill and patience. It did not require much scientific knowledge forty years ago to enable a man to acquire some reputation in the field of science. The possibilities in this respect made it more attractive as an outlet for the expenditure of those surplus energies which are nowadays required for the severer business competition of a more congested state of society.

Then, a little enthusiasm, a vasculum, an insect net and a pocket-glass comprised all the outfit necessary to enable a man to write valuable papers and to give him a good standing in our Institute. Now he requires a thorough scientific training, costly scientific apparatus, and years of patient toil to be able to add a single new or valuable idea to our scientific knowledge. It is not, therefore, difficult to understand that scientific pursuits as a recreation are every year becoming less attractive and are being left to those who make of them the business of life.

While, in some departments of natural science, such as natural history, elementary electricity, and geology, the charm of novelty, ease of acquisition, and admiration for showy experiments no longer attract our older members, they should not lose their potency with the students of our high schools and academies.

The older members should, however, have some compensation in those departments of science, a practical knowledge of which is every day opening up mines of national wealth; for our love of money is supposed to grow with our advancing years and we should be willing to make great sacrifices for what tends so greatly to enrich our country.

During the past year we admitted two new members; but on the other hand, we lost by death three of our most prominent men, concerning whom you will permit me to say a few words.

JOHN SOMERS, M. D., died on the 13th of March. He was born in Newfoundland, came to Halifax in early infancy and received a fairly good education.

In conducting a drug store he acquired a taste for the study of medicine. One year before the close of the American civil war he was graduated from Bellevue in time to spend a year in active service as an army surgeon. He then returned to Halifax where he remained in the practice of his profession until his death.

He took an active part in the establishment of the Halifax Medical College in which he lectured for many years as Professor of Physiology and Examiner in Medicine. He was an active and useful member of society. In 1879 and 1880 he was a member of the Halifax School Board. He also served for some time as Chairman of the Public Charities Board.

In January, 1875, he was elected member of this Institute, and one year after, he read his first paper on his favorite subject, Botany. Of his 18 published papers, 14 related to Botany, 3 to Zoology, and 1 to the use of the Microscope. He had three papers in course of preparation when he died. He was an authority on the Mosses and Fungi of Nova Scotia and an accomplished microscopist. From a busy professional life he managed to snatch enough time to become fairly proficient in many departments of science. He was an omnivorous reader, had a good memory and well-trained powers of observation, so that whatever subject might be under discussion at our meetings he was always able to add something of value and interest. He was always ready to assist those engaged in scientific study. I first met him at one of our Field Meetings at Grand Lake 24 years ago. I shall never forget the delightful day which I spent with him in botanizing.

JULES MARCOU, who had been one of our corresponding members since 1891, died at Cambridge on the 17th of April. He was born at Salins, France, in 1824. He studied at the College of St. Louis, Paris, but failing health led him to make an excursion to Switzerland, where he soon acquired an intense love for the study of Geology. At the age of 21 he assisted Jules Thurman in his work on the Geology of the Jura Mountains. Here he met Louis Agassiz, with whom two years later he explored the Eastern United States and Canada. In 1850 he embodied these reserches in a geological map of the United States and the British Provinces of North America. For five years he was Professor of Geology at Zurich. In 1861 we find him associated with Louis Agassiz founding the Museum of Zoology at Cambridge, U. S. A. In 1867 he was decorated with the Cross of the Legion of Honor. He was a member of many scientific societies and published many valuable papers, maps and books. In common with our own Dr. Honeyman, he took special interest in the study of the Huronian, Cambrian, and Primordial Silurian rocks, and assisted the Doctor in the identification of some of the more obscure Nova Scotian fossils of these systems. He was a strong advocate of the Taconic system, since pronounced by Dana to be identical with the Lower Silurian system. It was, upon the proposal of Dr. Honeyman who labored in the same field, that he became one of our corresponding members.

REV. JOHN AMBROSE, D. C. L., who died at Sackville, on September 12th, may be regarded as one of the founders of this Institute. Before it was organized he promised his hearty support—a promise which we shall see was faithfully kept. He was indeed proposed as a member of the first Council, but probably owing to the fact that he resided at that time at Margaret's Bay he was unable to act.

He was born in St. John of Irish parents, received his common school education at Truro, and was graduated from King's College, Windsor—receiving the degree of B. A. in 1852, M. A. in 1856, and D. C. L. in 1888.

For over 44 years he labored successfully and acceptably as a clergyman; $2\frac{1}{2}$ years at Liverpool, 3 years at New Dublin, 13 years at Margaret's Bay, 23 years at Digby and 3 years at Herring Cove, and for $2\frac{1}{2}$ years more he enjoyed at his country farm at Sackville the respite from labor which he needed and which he had so well earned.

In addition to the performance of extensive parish duties as a clergyman, he took a prominent part in other church work. He edited a religious monthly called *Church Work*, and also the *Halifax Church Chronicle*. He was a Governor of King's College—strongly opposing its union with Dalhousie. In Digby he led a successful crusade against the iniquitous system of " Farming out the Poor." He lectured in England for the Society for the Propagation of the Gospel and the Society for the Promotion of Christian Knowledge.

Amidst all these labors he found time to make science a recreation. In January, 1864, he communicated his first paper to the Institute. It was followed by a series of papers, all relating to the birds and fishes of St. Margaret's Bay—a spot which should be as well known to our Zoologists as Arisaig is to our Geologists. His paper on the Stormy Pĕtrel was republished more than once.

In October, 1863, he was elected Associate Member,—retaining that position until 1881. Again in 1890 he was elected Corresponding Member.

Dr. Ambrose was a remarkably fine specimen of a man,—physically, mentally and morally—a man to whom the leaders in any public movement for the public good could appeal with the certainty of receiving sympathy and support.

While glancing over the records I made a few notes concerning matters which struck my attention in our early history and which may interest some of you.

On the last day of the year 1862 the late J. Matthew Jones presided at a meeting held in the hall of the Halifax Medical College There were present, T. Belt, S. Gray, Dr. Gilpin, Wm. Gossip, R. G. Haliburton, Capt. Lyttleton, H. Poole, Capt. Hardy, J. R. Willis and P. C. Hill. Of this company, so far as I know, all but one have passed away.

The object of the meeting was to organize an Institute of Natural Science for Nova Scotia. This Institute grew out of another organization which had done pioneer work in science. It may be said to have been a development from the Halifax Mechanics' Institute, which, under the inspiration of men like the late Andrew MacKinlay, did very much to awaken the general public to an interest in the discoveries of of science, which at that time were coming on like a November meteoric shower.

At the first meeting the officers of the older organization resigned, and the officers of the Institute of Natural Science were elected—Mr. P. C. Hill being President. At this meeting a Constitution and Bye-Laws were adopted. Among the resolutions which passed was the following: *Resolved*, That at the next monthly meeting each member be entitled to bring a friend.

Now every member is not only entitled to bring a friend to the meetings but he is urged to do so, and to bring not one friend only but as many friends as he pleases, provided he can sufficiently interest them in the work of the Institute.

At the meeting in February, the Right Honorable the Earl of Mulgrave, Patron of the Institute was present, and after listening to the papers and discussions he expressed himself much pleased, and promised to do what he could to advance the work.

In the early meetings of our Institute so great was the general interest in scientific work that there seemed to be always a sufficient supply of scientific papers ready to be read when required. Every meeting was closed by an announcement of the titles of the papers to be read at the next. This timely announcement of the subject gave members an abundance of time to prepare to take an intelligent part in the discussions which followed every paper.

But in these busy days in which our lot has fallen we are thankful if we can announce the programme a few days in advance, and sometimes papers are read by title because they are not ready. Could not the Secretaries and President by taking thought beforehand bring about the happy state of things in this respect, that formerly existed? It is worth the attempt.

In March, 1864, we find the first announcement of the receipt of Reports of sister societies. The small beginning of our present large and valuable library consisted of three volumes, namely, the second Report of the Scientific Survey of the State of Maine, the Report of the Natural History Society of Newcastle-upon-Tyne, and the first number of our own Transactions.

Now that our library has grown to such dimensions, we should prepare a catalogue complete to date. Copies of it should be sent to our academies and to all other institutions of learning in the Maritime Provinces and to all persons whom we might wish to persuade to become members. To young students having time and inclination for nature studies, such a catalogue would be suggestive and helpful in selecting those fields of work which have been most neglected in Nova Scotia. In the appendix to this catalogue there might be a list of the scientific books belonging to the City Public Library and to Dalhousie College, and also a yearly supplement of publications received by the Institute.

The year 1864 is also marked by the decision to have a series of Field Meetings in the summer season. The first excursion was to St. Margaret's Bay in June to investigate some Indian remains in that vicinity. These meetings were continued in 1865. They were very interesting and profitable. After visiting a locality and studying its natural history the members would assemble at some point for dinner, discussion, and the reading of papers relating to the day's work.

At a conversazione in the Horticultural Gardens on the 6th of July, there were about 200 persons present. The President delivered an address on the advantages which the Institute, if properly supported and encouraged, might be expected to confer upon the country. He afterwards gave a very interesting description of the butterflies and moths of Nova Scotia. Dr. Gilpin described the manner of taking and smoking Digby Herring. Mr. Gossip read a paper on the geological formation of Halifax. Dr. Lawson discoursed on Botany, while all the company enjoyed a repast of cakes, strawberries and cream, lemonade and ices. Thus, in the early days of this Society was the love of science fostered. The resumption of some of these old practices, which have unfortunately fallen into abeyance, would not be a retrograde movement. If we would study Nature honestly and effectively we must meet her face to face. She does not woo by proxy, by text-books, illustrations or recitations. With this principle in view then let me draw up an imaginary programme for next summer's Field Meetings.

Accompanied by friends we meet in the Public Gardens at 8.30 a. m. on the third Saturday in June, every one provided with substantial lunches. After an hour spent with Superintendent Power and Drs. MacKay and Lindsay investigating ferns and learning the scientific names of the trees and shrubs we take the street car to Point Pleasant. Here we examine the beautiful synclinal on the shore, and collect specimens of littoral fauna and flora. We then cross the Ferry to Purcell's Cove and have lunch, followed by short addresses relating to the scientific peculiarities of our immediate environment. After some botanizing we return visiting the gas works which we inspect carefully with a view to a better comprehension of a lecture by Prof. E. MacKay, giving a scientific account of the manufacture of gas from coal, dealing particularly with the by-products, showing their chemical relations and uses.

On the third Saturday in July we would make a similar expedition to Waverly Gold Mines—crossing to Dartmouth in the steamer "Chebucto," and to our destination by train. At Waverly we would examine the gold mine and the rich lacustrine flora.

In August, for one fare we purchase a return ticket to Campbellton, N. B., to spend two days with some of the most enthusiastic scientists of the Maritime Provinces—those Professors, Principals, and other teachers who are willing to devote two weeks of their holiday season to mutual instruction and enjoyment in the forest, field and laboratory. I refer to the Summer School of Science, which will then hold its 13th annual session. The President, Mr. Geo. U. Hay, has invited the Natural History Society of New Brunswick and also this Institute to co-operate with the Summer School in a grand gathering of the representative scientific men of the Maritime Provinces. The place of meeting would be a delight to the lover of romantic scenery, while affording to the botanist and geologist exceptional facilities for field work. The occasion might be utilized for the discussion of some of the larger questions regarding scientific education that are pressing upon us. Joint resolutions from our three scientific societies would have great weight with our governments, and might lead to the extension of our technical science schools, now so miserably inadequate, or to important modification in the methods adopted to further education in general science.

Before closing, it might be expected that as a member of a Scientific Institute and teacher, I should say a few words as to the place which science occupies in our educational system, as to the place it should occupy, and also concerning the best means to be used to secure for it that place.

As to the place which it does occupy. It is found in the prescribed course of study in the form of lessons on Nature for the eight grades of the common school course, with the addition of a few specialized lessons on the simplest principles of Physics and Chemistry for Grades VII. and VIII.

In this work the teacher and pupils are required to study things and not books, to perform experiments in order to learn how substances act under varying conditions and to draw their own conclusions. Is this done? It may be fairly well done in five per cent. of the schools, with very varying degrees of success in 60 per cent., and scarcely attempted in the remainder.

The majority of teachers would do better work if they could, but they have never seen it done: they cannot learn how from books; and they have not the pecuniary or moral support that comes from a general intellectual appreciation of the material, intellectual and moral benefits resulting from scientific training.

In the curriculum for our Academies and High Schools it is taken for granted that Botany and Physics are studied for about 90 minutes a week throughout the year. Chemistry and Mineralogy about the same time in the second year, and Physiology and more advanced Physics each about two hours a week for the third year. There are very few schools, however, in which so much time is devoted to Science. The Provincial Examinations show that experimental work is almost wholly neglected. The mental confusion and crudity of conception apparent in a large proportion of the answers received would tend to show that much of the science teaching is simply a mechanical memorizing of the text-book.

In the fourth year of the High School, science is optional. In the year 1897, 23 candidates received Grade "A Classical" and only three took Grade "A Scientific." Candidates who are trained in schools where the facilities for the teaching of science are poor and where the teachers are themselves not interested in science, are not likely to select the science subjects for their Grade "A" examination. Of the 37 Academic teachers reported as holding Grade "A" there are but two of them who hold the "A Scientific" and this, notwithstanding the fact that the enthusiasm of the Superintendent of Education for scientific subjects might be supposed to influence the teachers and students in the ranks below him.

The large proportion of "Classical A's" may also be partly accounted for by the fact that a considerable number of candidates are college students, and classics still dominates the Nova Scotia colleges. For matriculation leading to the degree of B. A. the student is supposed to have studied Latin for three years, but nothing is required in Natural Science.

More or less successful attempts are being made in some of the colleges to teach science. But divided and scattered as they are—five degree conferring institutions in a small province of scarcely half a million inhabitants, with no preparatory schools capable of giving a proper preliminary science training, it is small wonder that they take little interest in the teaching of new subjects which require expensive apparatus and hard work.

I should have said that there is one preparatory school, Pictou Academy, which still retains the preëminence in science-teaching which it reached when Dr. McKay, as Principal, filled its halls with students drawn from all parts of the province.

From what I have said it will be evident that taking the schools as a whole there is but little of science-teaching, and that little is poorly done.

2. What place should science occupy in the schools?

Our Nova Scotia educationists say that it is entitled to twelve per cent. of the time devoted to the compulsory subjects, or on an average, to ten per cent. of the whole time. In Germany the gymnasia (or classical schools) through all the grades devote seven per cent. of their time to science, and a considerable amount of time besides to physical geography. In the real-gymnasium and real-schulen, science is the leading subject. We all have some idea of what the German colleges and universities are doing for theoretical science.

As might be expected in these circumstances technical education has received an enormous development. In the small kingdom of Saxony, considerably less than one-third the size of Nova Scotia, there are 111 technical institutes. Prussia has 200 such schools and 12,000 pupils. Hesse with a population of 1,000,000 has 83 schools of design, 43 for manufacturing industries and many others for artisans of various trades. How many such schools has Nova Scotia?

It might here be asked: which was cause and which, effect,—the science-teaching of the gymnasia or the technical schools? The fact that so long ago as 1837 there was nearly as much science prescribed for the gymnasia as at present, would suggest an answer.

England, slow in adopting reforms, has at last been awakened to a sense of the danger in which she stands of losing her industrial supremacy unless she gives heed to the wise teachings of her great prophet, Herbert Spencer, who years ago said: "Paraphrasing an eastern fable, we may say that in the family of knowledges, science is the household drudge, who in obscurity hides unrecognized perfections. To her has been committed all the work ; by her skill, intelligence and devotion, have all conveniences and gratifications been obtained ; and while ceaselessly ministering to the rest, she has been kept in the background, that her haughty sisters may flaunt their fripperies in the eyes of the world. The parallel holds yet further. For we are fast coming to the dénouement, when the position will be changed, and while these haughty sisters sink into merited neglect, science, proclaimed as highest alike in worth and beauty will reign supreme."

The Duke of Devonshire has introduced a bill into the House of Lords which is practically a bill for the establishment of science schools. In Scotland, Sir Henry Craik's latest educational circular aims at the encouragement of Science and Art in combination with a sound scheme of general education. The course of instruction extends over three years as follows :

1. Experimental Science.—Not less than four hours a week, of which two hours must be experimental. In the third year at least three hours of practical work will be required.

2. Drawing.—At least two hours a week.

3. Mathematics, including Geometry, Mensuration, Arithmetic and Algebra.—At least four hours a week.

4. History and English Literature.—About five hours a week.

5. Geography.—About two hours a week.

6. Manual Training.—At least three hours a week.

7. One Modern Language.

8. Various other subjects of Practical Interest such as Bookkeeping, Phonography, &c.

It will be seen at once that the course very much resembles our imperative course, except in that it gives one-sixth of the time to science while we give only one-eight.

Coming to America we find that the recommendations of the Committee of Ten, of the Committee of Fifteen and of the Committee on Science Teaching in Schools to the American Society of Naturalists, all agree in recommending a course of study substantially like ours,—like our ideal course, but not like the actual course.

A consideration of these facts leads us at once to conclude that our prescribed course of study fairly well represents the best ideals of the most advanced educationists. That it is frequently criticised arises from the fact that there are in any community very few persons possessed of sufficient knowledge of the science and history of education and at the same time of the requirements of modern civilization to enable them to judge intelligently, and further, from the fact that but few of our teachers are possessed of the necessary professional qualifications to adapt themselves and their work to the various conditions and circumstances.

To quote from Dr. Rice: "That the mass of our teachers are incompetent for any very high quality of science-teaching is a truth as unquestionable as melancholy." But it is not the fault of the teachers that they are not prepared for their work. Out of 2,485 teachers we have 1,750 who receive less than $200 a year, out of which they have to pay for board and clothing, buy educational books and magazines, and purchase the apparatus and materials for science experiments in their schools. With such miserably inadequate salaries, insecure tenure of office, and no pensions, it is no wonder that the brightest young men and women look upon teaching as but a stepping stone to other positions that offer more substantial rewards with the promise of greater permanency.

All complaints against our course of study will cease when the complainants are capable of appreciating the worth of good teaching and are willing to give the moral and pecuniary support that will call forth the best talent and training. As the country advances in population, wealth and civilization the course of study will need to be modified, but to foreshadow the coming changes at present would be unwise.

3. What means must be used to secure for science the place which it should have in the actual work of the schools and colleges?

(*a.*) Make it an imperative subject in the College Matriculation Examination for B. A.

The colleges, more than any other agency, determine the character of the education given in the schools below them. They train those who become teachers of teachers. Legislators look to them for direction in educational matters. The High Schools and Academies work slavishly to produce the kind of students upon whom they are most likely to set their seal of highest approval. They have in every learned body throughout the land an ever increasing constituency moulded by their teaching and adopting their ideals. If there is a general lack of interest in science, or if it is badly taught, the colleges are largely responsible. If they would abandon the fetich of "culture-worship" and study the conditions of modern society they would add greatly to the inestimable benefits which they now confer upon the community.

Until the colleges take this step in advance, science will not be well taught in the schools, the colleges will not have students capable of doing the best science work; for if they neglect science until they reach their college course and give "so many years of exclusive attention to other subjects, their powers of observation and of imagination of physical phenomena are well-nigh atrophied; and the loving interest in nature, innate in every normal child, instead of being systematically developed is well-nigh extinguished."

The college can determine not only the subjects to which the academies shall in reality devote their attention; but, by the nature of their examinations, they can determine the character of the teaching. If the matriculation examination calls for experimental work it will be supplied. If the colleges neglect to exercise their power in this respect wisely they will lose it. Rival institutions unduly emphasizing the neglected work will divide with them their present constituencies. This is the experience of Germany, England, and the United States.

The growing wealth of the country and the keenness of competition in the learned professions are indications that the time has come when the colleges can safely require science for the entrance examination. Harvard has made it optional and the London University has made it imperative.

(*b*) The present Grade "A" work in the Academies should be discontinued and its place should be taken by a more thorough practical Science course for Grade "B". The "A" work cannot be properly done in the academies. It is essentially college work and should be kept where it belongs. Merely to state that Gage's Principles of Physics, Storer and Lindsay's Elementary Chemistry, Bessey's Essentials of Botany, Dawson's Hand-Book of Zoology, Colton's Practical Zoology, Sir William Dawson's Canadian Geology, Young's Elements of Astronomy, James's Psychology, and the Ontario Manual of Hygiene, together with twelve other subjects are all to be mastered in our poorly equipped academies in one or even in two years is to condemn absolutely the present arrangement with regard to Grade "A". It is but a survival from a lower stage of our educational development, and the sooner it is allowed to become atrophied by disuse the better.

If Academic and High School positions are worth on an average only ten years' tenure we will require but six new Grade A's each year,—say ten to give them the benefits of healthy competition, and let them have a thorough college training or its equivalent.

(*c*) The professional training of academic teachers and of the Principals of the larger schools should be part of a college course. Elsewhere at some length I gave my opinions on this subject. At present I will do no more than quote from an American educationist a few sentences which express the opinions of the most of our educationists and of our college graduates. "The environment of learning and culture are essential to the best training for the practice of the learned profession. * * * Existing normal schools, which have more than justified their establishment for the professional training of elementary teachers should continue to do their appropriate work. However much modified, they will not be well adapted to meet the wants of higher teachers."

Their professional training should be a post-graduate course at least in part. If our larger colleges cannot provide pedagogical training for the few Grade " A " teachers that we need we will have in the meantime no difficulty in obtaining it abroad ; but wherever it is obtained let it be as thorough as the post-graduate training required in the other professions.

(*d*) Examinations in science, whether by the colleges or by the Educational Departments, should be so modified as to take into account the pupil's laboratory work throughout the term and his present ability to perform and interpret experiments, and also to examine and classify mineral, plant and animal specimens.

A certified copy of his Note-Book of experiments should be taken as evidence of his work. In order to have some reasonable certainty that this work was honestly reported it would be necessary for some qualified person to inspect the laboratories and see the students at work twice every year. A written examination does not adequately test a student's science acquirements. If the Provincial Grade " A " scientific examinations are to be continued they should be conducted at the Normal School, and every candidate should have to do a certain amount of laboratory work in the presence of the examiner.

Such are a few of the suggestions which I have to offer for the advance of science in Nova Scotia. I feel confident that if adopted they will hasten the time when our reputation for science will not be confined to a few great names, but that all the people will reap the benefit in the opening up of new centres of those industries and manufactories for which the province is so well adapted.

The TREASURER presented the accounts for the year, 1897–8, which had been audited and were certified as correct. The following is an analytical statement of the expenditure :—

PROCEEDINGS AND TRANSACTIONS :—			
Printing and binding Vol. IX., Part 3	$158 00		
Less received for authors' separate copies	2 50		
		$155 50	
Distributing Vol. IX., Part 3		29 32	
			$184 82
Printing portion of Vol. IX., Part 4		$61 60	
Portrait and Plate, do		14 22	
			75 82
LIBRARY:			
Removal to Dalhousie College		$17 65	
Fittings		56 41	
Purchase of U. S. Government Reports		13 15	
Binding		75 00	
Miscellaneous expenses		8 20	
			170 41
Insurance (Library and Stock of Transactions)			16 75
Miscellaneous Printing, including Post Cards			25 00
Postage			5 67
P. O. Box			4 00
Advertising			4 00
Repairing and removing Blackboards			1 80
Typewriting			75
			$489 02

The Treasurer's Report was approved.

The Report on the Library was presented by the LIBRARIAN and CORRESPONDING SECRETARY. The Library had been increasing during the past year at a greater rate than ever before. The Institute had sent its Transactions for the first time to the following :—

Director-General de Correos y Telegraphos, Buenos Ayres.
Asociacion de Ingenieros Industriales, Barcelona.
State Library of Massachusetts, Boston.
St. Anne's College, Church Point, Digby Co., N. S.
Case School of Applied Science, Cleveland, Ohio.

High School, Dartmouth, N. S.
Scottish Meteorological Society, Edinburgh.
Institut Meteorologique Central, Helsingfors.
Cornell University (Geological Department), Ithaca, N. Y.
Royal Meteorological Society, London.
Institution of Electrical Engineers, London.
Kansas University, Lawrence, Ka.
Australasian Institute of Mining Engineers, Melbourne.
Kew Observatory, Richmond, G. B.
Royal Asiatic Society (Straits Branch), Singapore.
Public Library, St. Louis, Mo.
Anthropological Society of Australia, Sydney, N. S. W.
Catholic University of America, Washington, D. C.

Publications had been received for the first time during the past year from the following:

Société Belge de Geologie, Paleontologie et Hydrologie, Bruxelles.
Volta Bureau, Washington, D. C., U. S. A.
Australian Institute of Mining Engineers, Melbourne.
Carnegie Institute, Pittsburg, U. S. A.
Asociation de Ingenieros Industriales, Barcelona.
McGill University, Montreal.
Observatorio Meteorologico y Vulcanologico, Colima, Mexico.
Nederlandsche Dierkundige Vereenigung, Helder.
Institution of Civil Engineers of Ireland, Dublin.
Department of Mines, Wellington, New Zealand.
Engineers' Club of St. Louis, St. Louis, Mo., U. S. A.
Sydney Observatory, Sydney, N. S. W.
La Reale Academia de Ciencias y Artes, Barcelona.
Institution of Electrical Engineers, London.
Pasadena Academy of Sciences, Pasadena, Cal.
Wyoming Historical and Geological Society, Wilkesbarre, Pa.
Botanical Survey of India, Calcutta.

The Transactions were being sent out annually to 752 Societies, Museums, Libraries and Government Scientific Departments. Exchanges were being received from 440 Scientific Institutions. A considerable proportion of the 312 recipients of the Transactions from which exchanges had not yet been received were Libraries and Museums which did not issue publications of their own. A smaller proportion consisted of societies with which exchange relations had not yet been effected.

The cost of distributing the above 752 copies of our Transactions to institutions in all parts of the world had been $29.32, the possibility of securing so widespread a distribution at so small a cost being due to the courtesy of the Secretary of the Smithsonian Institution, Washington, in extending to the Institute the privileges of the Institution's Bureau of International Exchanges.

During the year, 113 volumes, for the most part English publications, had been put into the binder's hands. Including these, the Library now contained 1,326 volumes bound in cloth or leather, besides 67 volumes in boards with paper or cloth backs, in all 1,393 bound volumes. It contained besides, 271 volumes of sufficiently large size for separate binding, but at present simply stitched together in paper covers, as received, and a large number of volumes, at least 1,000 in Parts. The labour of looking into the completeness of these volumes in separate Parts, getting them completed when necessary, preparing them for the binder, and so on, is very great, and consequently in the case of many publications had not yet been undertaken. The Institute, as soon as funds will permit, should give the Librarian a paid assistant to do such work.

The Library had now been completely removed to the room at Dalhousie College, courteously offered free of rent by the Governors of that college. It had also been arranged in such a way that a visitor would have no difficulty in finding any work which the Library contained. The books are arranged under countries, labels and placards indicating the cases in which the publications of the various countries are to be found. In the division occupied by each country they are arranged under the cities which are the seats of the societies, museums, &c., from which they come, the cities being in alphabetical order. In the case of all publications in English, the shelves devoted to the various cities are indicated by labels giving the name of the city and the name of the society or other publishing body. The same system of labelling is to be extended to the publications in foreign languages at an early date. In any case in which the publications received from a society are too bulky for the shelf on which they would otherwise be placed, they are placed on the lowest shelf of the same division of shelving and the fact is indicated by a label on the shelf on which they would first be looked for, containing the name of the city and society and an arrow-head pointed downwards. It is hoped that with this system of arrangement members may find themselves able to get such books as they may desire without difficulty even in the absence of the Librarian.

The work connected with the arranging of the Library in its present quarters calls to mind the similar work which was done at the time when the Institute first really began energetically to build up its Library. The Proceedings contain no reference to the services rendered at that time by the late Mr. Denton, but though late, it is not too late to record the Institute's appreciation of them now.

The Library being in a room off the College Library will be found open by members daily, except on Saturdays and Sundays, from 10—1 and 3—5 o'clock. On Saturdays and in vacation, access to it may be obtained by members on application to the Janitor. Members resident in the country can ascertain whether such works as they may desire to see are in the Library, and have these which are, forwarded to them, by applying to the Corresponding Secretary. A printed catalogue would facilitate the use of the Library by members and should be undertaken as soon as the requisite funds are in hand.

The thanks of the Institute were presented to MR. BOWMAN for his services as Librarian, to the HON. ROBERT BOAK, President of the Legislative Council, for granting the use of the Council Chamber, to the CITY COUNCIL for the use of the City Council Chamber, and to the SECRETARY OF THE SMITHSONIAN INSTITUTION for his courtesy in continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

Resolutions of regret were passed on the announcement of the deaths of PROFESSOR GEBELIN of the Society of Commercial Geography of Bordeaux, and of DR. EDWARD ALBERT BIELZ of the Society of Natural Science at Hermannstadt ; and on the announcement of the resignation of PROFESSOR ALEXANDER AGASSIZ, Director of the Museum of Comparative Zoology, Cambridge, U. S. A.

The following officers were elected for the ensuing year (1898-99):—

President—ALEXANDER MCKAY, ESQ.

Vice-Presidents—A. H. MACKAY, ESQ., LL. D., F. R. S. C., and F. W. W. DOANE, ESQ., C. E.

Treasurer—W. C. SILVER, ESQ.

Corresponding Secretary—PROFESSOR J. G. MACGREGOR, D. SC.

Recording Secretary—HARRY PIERS, ESQ.

Librarian—MAYNARD BOWMAN, ESQ., B. A.

Councillors without Office—EDWIN GILPIN, JR., ESQ., LL.D., F. R. S. C.; MARTIN MURPHY, ESQ., D. SC., C. E.; WILLIAM MCKERRON, ESQ.; RODERICK MCCOLL, ESQ., C. E.; S. A. MORTON, ESQ., M. A.; WATSON L. BISHOP, ESQ.; P. O'HEARN, ESQ.

Auditors—G. W. T. IRVING, ESQ.; H. W. JOHNSTON, ESQ., C. E.

First Ordinary Meeting.

Legislative Council Chamber, Halifax, 14th November, 1898.

The President in the Chair.

A paper by Professor J. Davidson, Phil. D., of the University of New Brunswick, " On Statistics of Consumption and Expenditure in Canada," was read by Professor W. C. Murray. (See Transactions, p. 1).

The subject was discussed by Drs. MacKay and MacGregor, and Mr. Doane.

Second Ordinary Meeting.

Legislative Council Chamber, Halifax, 12th December, 1898.

The President in the Chair.

It was announced that Professor J. Davidson, Phil. D., University of New Brunswick, Fredericton, and Rev. Brother J. Peter, St. Joseph's Collegiate Institute, Buffalo, N. Y., had been elected Corresponding Members of the Institute; and that Andrew Halliday, Esq., M. D., Shubenacadie, N. S., and Arthur M. Edwards, Esq., M. D., F. L. S., Newark, N. J., had been elected Associate Members.

A paper by Dr. A. M. Edwards, entitled: "Infusorial Earths of the World, and the Iceberg Period," was read by Dr. A. H. MacKay.

Dr. A. H. MacKay gave an address on the subject of "The Diatomaceae of Nova Scotia." His treatment of the subject was a popular one, a number of microscopes with prepared slides being arranged for the convenience of their examination by those present. He called attention to the fact that these minute algae were characterized by the power of secreting silica from the waters in which they lived and building it up into the most beautifully formed and sculptured cell walls of transparent rock crystal; that they were so abundant in all of our fresh water lakes, which are not seriously disturbed by the turbulent earth laden waters of spring freshets, as to form layers many feet in depth in their bottoms of the dead silicious cells, the mass being sometimes so pure as to look like the whitest flour when dried; that this material was of commercial value in the manufacture of dynamite, of water-glass, tooth powders, scouring material of great fineness, firebrick, etc. He noted that these deposits in lakes on different sides of the same watershed were characterized by the presence in more or less abundance of some peculiar species. He was endeavoring to obtain sections of some of these deposits so as to be able to compare the variation of or succession in the species since the first deposits were laid on the barren beds of the lakes carved out in the glacial period. Over a hundred different species had already been observed in our fresh water deposits, many of them identical with those found in similar deposits in the Eastern hemisphere. Among them were found the silicious spicules of several species of freshwater sponges, which appear to be also more or less abundant in all our freshwater deposits. The following species of diatoms have been already identified in these deposits :

Cocconeis pediculus, *Ehr.* C. placentula, *Ehr.* Gomphonema acuminatum, *Ehr.* G. a, *var.* coronatum, *Ktz,* G. a. *var.* laticeps, *Ehr.* G. cristatum, *Ralfs.* G. gracile, *var.* naviculoides, *Grun.* G. abbreviatum, *Ag.* G. capitatum, *Ehr.* G. intricatum, *Ktz.* G. cistula, *Hemper.* Epithemia turgida, *Ehr.* E. gibba, *Ehr.* E. g. *var.* parallela, *Grun.* E. argus, *Ehr.* Himantidium arcus, *Ehr.* H. a. *var.* majus, *W. Sm.* H. a. *var.* tenellum, *Grun.* H, formica, *Ehr.* H. pectinale, *Ktz.* H. p. *var.* ventricosum, *Grun.* H. p. *var.* minus, *Ktz.* H. p. *var.* undulatum, *Ralfs.* H. soleirolii, *Ktz.* H. bidens, *W. Sm.* H. b. *var.* diodon, *Ehr.* H. praeruptum *var.* inflatum, Grun. H. polydon, Brun. H. polydentulum, *Brun.* Amphora ovalis, *Ktz.* A. affinis, *Ktz.* Cymbella gastroides, *Ktz.* C. cuspidata, *Ktz.* C. ehrenbergii, *Ktz.* C. lanceolata, Ehr. C. delicta, *A. Sch.* C. cistula, *Hemper.* C. heterophylla, *Ralfs.* C. tumida, *Ktz.* N. ambigua, *Ehr.* N. appendiculata, *Ktz.* N. affinis, *var.* amphirhyncus, *Ehr.* N. firma, *Grun.* N. Hitchcockii, *Ehr.* N. legumen, *Ehr.* N. dicephala, *Ktz.* N. radiosa, *Ktz.* N. scutellum, *O'Meara.* Pinnularia oblonga, *Rab.* P. viridis, *Rab.* P. v. *var.* hemiptera, *Rab.* P. perigrina, *Ehr.* P. nobilis, *Ehr.* P. major, *Rab.* P. dactylus, *Ktz.* P. gibba, *Ehr.* P. divergens, *W. Sm.* P. interrupta, *W. Sm.* P. mesolepta, *Ehr.* P. nodosa, *Ehr.* Stauroneis phoenicenteron, *Ehr.* St. gracilis, *W. Sm.* St. anceps, *Ehr.* St. fulmen, *Breb.* St. punctata, *Ktz.* St. stauropheria, *Ehr.* Surirella robusta, *Ehr.* S. splendida, *Ehr.* S. biseriata, *Breb.* S. bifrons, *Ktz.* S. turgida, *W. Sm.* S. linearis, *var.* constricta, *W. Sm.* S. slevicensis, *Grun.* S. elegans, *Ehr.* S. tenera, *Grey.* S. cardinalis, *Kitton.*

Nitschia amphioxys, *Ehr.* N. elongata, *Grun.* N. spectabilis, *Ralfs.* N. sigmoidea, *Nitzsch.* Stenopterobia anceps, *Breb.* Fragillaria construens, *Grun.* F. c. *var.* binodis, *Grun.* F. capucina, *Desm.* F. undata, *W. Sm.* Synedra ulna, *Ehr.* Meridion circulare, *Ag.* Tabellaria floculosa, *Roth.* T. fenestra, *Lyngb.* Cyclotella operculata, *Ag.* C. comta *var.* affinis, *Grun.* Melosira distans, *Ehr.* M. arenaria, *Moor* M. orichalcea, *Meriens.* M granulata, *Ehr.* M. crenulata *var.* valida *Grun.*

A vote of thanks was tendered Dr. MacKay for his address.

Third Ordinary Meeting.

Legislative Council Chamber, Halifax, 9th January, 1899.

The First Vice-President, Dr. MacKay, in the chair.

Lee Russell, Esq., B. Sc., of the Normal School, Truro, read a paper on "School-room Air," as follows :

One of the great problems of modern mechanics is to increase the efficiency of machines, to get the greatest amount of work done with a given expenditure of energy. Every possible device is used to lessen friction, to minimize waste, and to apply more advantageously the force employed. Rails in place of the uneven ground, rolling, instead of sliding, friction, are familiar examples of the gains made in the single direction of lessening friction, and many more might be instanced. These are purely physical instances, but the illustration may be carried further. Intellectual processes are as subject to waste and loss. Interruption, noise, disease, poisons, are the causes of loss in mental operations, as are dust, friction, inertia, and radiation, in those of a physical nature. Such considerations as these first led me to investigate some of the causes of decrease of efficiency in school.

It appears to me plain, that as the school year advances, there is a decrease in mental power in both teachers and pupils. By this is meant, that for a given result, more energy must be expended toward the close of the year than at the beginning.

This is not susceptible of exact proof, except by long and carefully conducted experiments, but from observations made upon the students at the Normal School at Truro I believe such to be the case.

It is well known that the exhalations from the bodies of animals have a poisonous effect if breathed, even tho much diluted with air. The classic researches of Pettenkofer, Brown-Séquard, d'Arsonval, Lehman, Merkel, Parkes, and others, have proved the presence of an organic poison in air which has been breathed by man or other animals. Its exact constitution is not known, but the effects of "Pettenkofer's man-poison" are apparent in every school-room. They are, headache, drowsiness, slight fever, and a general retardation of all reactions to stimuli. Partial loss of the power of inhibition is also noticeable. Less apparent, but more important, are the general weakening of vitality and the greater susceptibility to disease which follow prolonged breathing of impure air.

These effects are more easily seen in the weak and anaemic than in vigorous persons. It was the observation of the less vigorous students at Truro which first led me to suspect that the air in the Normal School might be one cause, at least, of the decrease in power which I had noticed. We have, as do all schools, pupils who, when at their best, are just able to keep up with the class, who are, mentally or physically, near the *fatigue-point*. A slight interference with their normal activity throws them off their balance, and they must drop behind. Not infrequently pupils come to us enfeebled by excessive study in preparation for examinations. Under favorable conditions they might do well, but if subjected to further strain they may break down. With these two classes of students, poisoning by impure air may make the difference between success and failure. At all times, and with all classes, it causes a determinable decrease in the amount of work, mental or physical, which is done with a given expenditure of energy. Especially where the system of public education is most highly developed and most strenuously applied, the evil effects of this poison have been most apparent.

In testing the air in the Normal School, the method and apparatus of Prof. Hch. Wolpert of Nuremburg was adopted. The chemical basis of this method is the fact that an alkaline solution of sodium carbonate becomes neutral by the absorption of carbon dioxid. If the alkaline solution be colored red by phenol phthalein, when the solution becomes neutral the color disappears. Thus, with a given amount of sodium carbonate, the decolorization of the liquid shows that a certain amount of carbon dioxid has been absorbed. If this carbon dioxid come from a measured quantity of air, the proportion of carbon dioxid in the air is easily calculated. Carbon dioxid is a constituent of all air, but it has been shown that in re-breathed air it increases in direct proportion to the other, more poisonous, but less easily detected, impurities. We shall therefore make no error if we use the amount of carbon dioxid as an indicator of the amount of the organic poisons.

The apparatus is so arranged as to admit into a glass cylinder which contains a measured amount of the standard solution, the air to be tested. When enough has been admitted to neutralize the solution, the proportion of carbon dioxid may be read off from a scale etched on the glass.

It should be stated that as checks upon the experiments, samples of air were tested by other methods, the results agreeing very closely with those obtained by the Wolpert method. This is not as exact as systematic chemical analysis, but it is sufficiently so for the purpose.

The instrument is graduated for 0°C and 760mm. of mercury pressure. As the air tested was always at a temperature of from 15°C to 20°C, and as the average pressure at Truro is 761mm., there should be about 7% added to the actual observations to correct them for temperature and pressure. I give below a table showing a set of observations which were made in the Chemical Laboratory at the Provincial Normal School. They are corrected for temperature and pressure, and the conditions in the room at the time of the various tests are given as accurately as possible.

TESTS OF THE AIR IN THE CHEMICAL LABORATORY, PROVINCIAL NORMAL SCHOOL, TRURO, NOVA SCOTIA.

Date.	Time.	Condition of the Laboratory.	CO_2 (parts in 10,000.)
Mar.	A. M.		
7	9.00	Empty	6.42
14	9.00	"	4.28
15	9.00	"	3.21
21	9.00	"	4.28
22	9.00	"	16.05
24	9.00	"	6.42
17	9.45	34 students—40 m.—high wind	9.63
22	9.45	32 " " windows open	16.05
8	10.00	" " 1 h..........	20.33
15	10.00	" " " windows open	9.63
22	10.00	" " " windows and doors open	16.05
8	10.40	" " 1 h., 40 m., windows and doors open....	23.54
9	10.40	" " "	21.40
15	10.40	" " " windows open	10.70
17	10.40	" " 1 h..........	16.05
9	12 m.	" " " windows open..........	20.33
16	12 m.	" " " "	17.12
21	12 m.	" " 1 h., 15 m., Blow-pipe lamps in use......	48.15
23	12 m.	" " " windows open..........	17.12
	P. M.		
7	5.00	Empty	16.05
10	5.00	"	20.33
26	5.00	"	42.80
27	5.00	Laboratory used for blow-pipe work in mineralogy for 1 h., 45 m., by 20 students	65.00

The observations made in the Laboratory were chosen for presentation because they present,

1. A mean between the worst and best rooms in the building.
2. A greater variety of conditions than any other room.
3. A large air space per pupil—9 cu.m., or 318 cubic feet.
4. Less interference from other rooms, and from interruption during the test.

The month of March was chosen because at that time the laboratory work consists of lectures and blow-pipe analysis, where few chemical re-agents are used and those mostly in the "dry" state. With one exception, March 21, no blow-pipe work was done till after 3 o'clock in the afternoon. Moreover, March presents many warm days when it is possible to have windows open, while in the winter the insufficiency of our heating apparatus is such as to make this impossible. It has been my endeavor to present a case considerably better than the worst which obtains in our school.

As will be seen, a great variety of conditions is presented. The use of the room is intermittent, and when in use, its ventilation depends wholly upon the temperature of the outside air. The heating apparatus is so inadequate that upon a cold day with all windows closed the temperature cannot be brought above 62° F. Hence it is only during comparatively warm weather that the windows can be opened at all.

The laboratory gives an air space of nine cubic meters to each of thirty-four students, due allowance being made for the desks and cases.

All authorities admit that air containing more than six parts of carbon dioxid in ten thousand is injurious, but for various reasons it is generally agreed that Pettenkofer's standard of ten parts of carbon dioxid may be used as the outside limit for ordinary school-room air. For kindergartens it is thought that the air should never become more impure than is indicated by the presence of four parts of carbon dioxid in ten thousand. It will be seen that only at the beginning of school does the air in the laboratory come within Pettenkofer's standard.

From all observations made in all the rooms in the Normal School, and in the corridors, the times of making the tests being from 9 a. m. to 5 p. m., and the conditions as various as exist in any school building, and the dates from March 6 to June 1st. I find the following averages for the amount of carbon dioxid in ten thousand parts of air:

At 9.00 a. m.	8.30
" 9.40 "	9.63
" 10.00 "	20.33
" 11.00 "	16.05
" 12.00 m.	23.54
" 3.15 p. m.	18.19
" 5.00 "	29.96

The decrease in impurity from ten to eleven o'clock is due to the recess taken by the model school at that time. The great increase after 3.15 is more difficult to account for, but it seems to me satisfactorily explained by these considerations. 1st. During school hours the warm air breathed out rises, so that even the heavy carbon dioxid is carried upward. When the whole air cools the carbon dioxid is found near the floor. 2nd. After school, much blow-pipe work was going on in the laboratory, raising the impurity in that room, and the library was usually crowded. The average of many five o'clock tests in the latter room gives forty-five parts of carbon dioxid in ten thousand of air.

A consideration of these figures will make it evident that we are severely handicapped in our work at the Normal School, and that pupils and teachers are, in a greater or less degree, poisoned by the air in the school building.

This is in no way a peculiarity of the Normal School. With the exception of some modern ventilated buildings in Halifax, and in a few of the towns, all schools are just as bad. I have found most country schools which I have visited with just as impure air as that at Truro.

The amount of air space per pupil in the various rooms in the Normal School is much greater than that in most schools. Six cubic meters per pupil is considered ample, and in no room at Truro, except the library, have we less than seven.

The obvious remedy here is to provide some means of changing the air. With the present heating it is impossible to do this by means of windows, even if there were no danger from drafts by such a mode of ventilation.

The really important problem to be solved is the ventilation of the country schools. Here are the greatest numbers, at ages when injury is very dangerous, since it may effect the whole future life of the pupil. That we may do the "greatest good to the largest number" by ventilating the country school houses is evident. The obstacle in our way here is the complete ignorance of the people of the principles of ventilation. This is perfectly excusable, since it is only within comparatively few years that the subject has been studied at all. A "campaign of education" is feasible, but is expensive. The Inspectors are the proper persons to bring the matter before the teachers and the trustees. The Department of Education can also do much by securing plans of suitable buildings and requiring all new school houses to be built upon one of these plans. They may be of various sizes and prices so as to suit the needs of poor or of wealthy sections. Thus, in time, every school-house in the Province would be provided with pure air, and the cost be saved many times over by the increased efficiency of both teachers and pupils. Until something is done by the central authority in some such compulsory manner as I have indicated, I fear there will be no change.

As for the Normal School, the only remedy for the state of affairs existing there is to provide the building with suitable heating and ventilation.

The paper was discussed by the Chairman, MESSRS. O'HEARN, McKERRON, DOANE, BLACKADAR, HOPSON, BAUSCH and PROFESSOR E. MACKAY.

A vote of thanks was presented to MR. RUSSELL.

FOURTH ORDINARY MEETING.

City Hall, Halifax, 13th March, 1899.

The PRESIDENT in the chair.

EDWIN GILPIN, JR., ESQ., LL. D., F. R. S. C., read a paper, entitled, "New Mineral Discoveries in Nova Scotia." (See Transactions, p. 79.)

A. P. REID, ESQ., M. D., exhibited and explained a model of a Sanatorium for Consumptives.

A vote of thanks was presented to DR. REID for his communication.

FIFTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 17th, April, 1899.

The PRESIDENT in the chair.

It was announced that at the last meeting of the Council, HERBERT E. GATES, ESQ., Architect, Dartmouth, and WILLIAM A. MACDONALD, ESQ., Halifax, had been elected ordinary members.

PROFESSOR J. G. MACGREGOR, D. SC., read a paper entitled, "On finding the ionization of complex solutions of given concentration, and the converse problem. (See Transactions, p. 67).

A paper entitled, "Phenological Observations, Canada, 1898," was read by A. H. MACKAY, ESQ., LL. D., F. R. S. C. (See Transactions, p. 91.)

Sixth Ordinary Meeting.

Legislative Council Chamber, Halifax, 8th May, 1899.

The President in the chair.

A circular from the Royal Society of Canada, relative to the appointment of a delegate to the forthcoming meeting, was read and referred to the Council for action.

Prof. J. G. MacGregor communicated a "Note on the variation with tension, of the elastic properties of vulcanised india-rubber," being an account of some experiments made in his Laboratory at Dalhousie College, by Mr. W. A. Macdonald.

The experiments had been intended originally to deal with rigidity only, but it had been found possible to apply some of the observations to the determination of Young's Modulus as well.

The composition of the specimen of india-rubber used was not known. It was in the form of a cylindrical cord and was fairly soft in texture and grey in color, a freshly cut surface having a mottled appearance. It had been obtained from Messrs. Thornton & Co., Edinburgh, and was both very true and very uniform in its circular cross section.

The method employed for determining the rigidity under tension was the method of oscillation. It was necessary therefore to fix the upper end firmly and to attach a weight-holder firmly to the lower end. As the problem had been assigned to Mr. Macdonald as a class exercise merely, and no appropriate gear for the attachment of the ends was immediately available, he had to be contented with a makeshift method. He drew the ends of the cord through pieces of glass tubing, previously coated internally with soft sealing wax, of considerably smaller diameter than the cord, and then gently heated the tubes until the wax melted. The tube at the upper end was fixed to a bracket, that at the lower end carried a cork disc which served as a weight-holder. To reduce the error due to lack of uniformity in the diameter of the cord near the ends, produced by the pressure of the tubes, the cord selected for use was a long one. Except in so far as the heating may have changed the physical properties of the cord near the lower end, the arrangement was satisfactory enough for the comparatively small extensions for which it was intended. But for the greater extensions, to which the earlier results made it appear desirable to proceed, it was not suitable. For under considerable stress the wax near the ends of the glass tubes gave way, and the space thus left in the ends of the tubes had to be packed to make it certain that the portion of the cord actually subjected to tension and torsion was the portion outside the tubes. The observations under the greater stresses are thus considerably less trustworthy than the others.

The weights used were square plates of sheet lead with an edge of four inches, having a small circular portion cut from the centre, and a slit from the centre to the edge to admit of their being placed on the holder. Their moment of inertia could therefore readily be calculated. The length of the cord was measured by means of a beam compass, reading to .01 inch, and its diameter by a micrometer gauge reading to .001 inch. The time of oscillation was determined by means of a stop-watch reading to 0.2 second. The observations given below were in all cases means of several individual observations,—the length and radius of five, and the times of oscillation, of ten. No special effort was made to keep the cord at constant temperature; but the temperature of the laboratory varied but little.

The course of the observations was determined by Mr. Macdonald's available time rather than by the fitness of things. He kept the cord stretched slightly throughout the whole series by 482 grm., and from time to time he would apply additional weights, make the requisite observations, and then remove such additional weights, the observations requiring perhaps a couple of hours. The dates of the observations are given in the table below. Unfortunately the length of the cord under its permanent stress was not in all cases, and its diameter was in no case, determined immediately before the application of the additional weights, such observations not being necessary for the purpose originally in hand.

The following table gives the results of the observations and the calculated values of the rigidity. The observations have been reduced to C. G. S. units, and the rigidities expressed in absolute units of that system. The rigidities were calculated from the formula:

$$n = \frac{8 \pi l I}{r^4 t^2},$$

where n is the rigidity, l the length, and r the radius, of the cord, I the moment of inertia of the lead plates, and t the time of a complete oscillation. In finding the moment of inertia the weight-holder of cork and glass was neglected, as also the small circular apertures in the lead plates. The volume of the cord is given in the table also.

Date.	Temperature, (°C.)	Length, (cm.)	Radius, (cm.)	Weight appended (grm.)	Time of oscilla. (sec.)	Volume of cord, (c. c.)	Rigidity, (abs. C, G. S. units). 10⁶×
				First Series.			
Mar. 16	15.6	90.68	.....	482	......	......	......
21	18.1	90.98	0.356	482	10 80	36.03	10.18
21	.....	96.60	.343	735	16.00	35.69	8.68
22	17.5	91.24	......	482	......	......	......
22	17.6	103.99	.335	981	20.04	36.73	8.69
23	18.7	91.51	......	482	......	......	......
23	18.9	113.92	.323	1222	25.32	37.25	8.67
28	18.6	92.35	......	482	......	......	......
28	18.6	123.21	.307	1467	29.76	36.57	9.89
Apr. 4	18.8	137.41	.293	1714	35.88	37.16	10.68
5	19.3	138.38	.293	1714	36.36	37.42	10.48
6	17.7	150.37	.279	1956	40.80	36.88	12.54
				Second Series.			
Apr. 13	17.0	95.65	.345	482	12.22	35.86	9.38
13	17.4	102.16	.337	735	18.44	36.36	7.44
13	17.5	110.31	.324	981	23.80	36.35	7.51
13	18.0	121.13	.312	1222	29.26	37.15	7.85
20	......	130.97	.301	1467	33.64	37.28	8.95
20	......	141.83	.290	1714	38.48	37.36	10.10
20	.....	151.99	.282	1956	42.30	37.96	11.37

The first series of observations showed that the rigidity, as determined, at first diminished with tension, then reached a minimum value, and finally increased, as the cord was more and more stretched,—an interesting result if it should be substantiated. Hence a second series of observations was made with the same cord and the same arrangements as the first. This series had to be made somewhat hurriedly, as will be seen by the dates of the individual experiments, but the experiments were made with the same care as those of the first series. It will be seen from the above table that (1) the treatment to which the cord had been subjected in the first series had diminished its rigidity, the values being smaller throughout than in the first series, and (2) that the initial diminution of rigidity with increase of tension, its final increment with tension, and the occurrence of a minimum point are as marked in the second series as in the first.

To find out if the occurrence of the minimum point was due to the defective character of the attachments at the ends of the cord, Mr. Macdonald made a number of observations with new modes of attachment. These consisted of brass tubes in one end of which three longitudinal cuts had been made, the ends of the three strips thus formed being bent inwards and provided with teeth. The ends of the cord having been passed into these tubes, the strips were firmly bound to the cord by means of wire. Unfortunately Mr. Macdonald had not sufficient time to make more than rough observations with the new arrangement. Such observations as he was able to make seemed to show that the minimum point had disappeared. Whether its disappearance was due to the more satisfactory attachments, the passing away of the heating effect or the fatigue of the cord, Mr. Macdonald hopes to determine by further experiments.

The above values of the rigidity agree fairly well with Mallock's[1] determinations, Mallock having found that the rigidity of what he calls "soft grey" india-rubber, determined dynamically, ranged from 5.52 to 8.76, if expressed as in the above table, and that for "hard grey" rubber it ranged from 10.77 to 13.94. Mr. Macdonald's rubber could not be designated as either soft or hard; and his values are intermediate between Mallock's for the soft and the hard specimens.

The volume of the cord underwent very little change during either the first or the second series. In both series, however, there is an unmistakeable though small increase of volume with stretching; but whether it was due to the stretching or to the series of oscillations to which the cord had been subjected does not of course appear.

[1] Proc. R. S. Lond., 46, 233, 1889.

Mr. Macdonald did not intend at the outset, to make any determinations of Young's Modulus; but his observations may be used for two purposes, viz., to determine (1) how the value of this modulus for a cord under a constant original stress varies with the magnitude of the increment of stress to which it is subjected, and (2) how the value of the modulus for a cord under different original stresses, and elongated by approximately equal increments of stress, varies with the magnitude of the original stress. In the determinations given below, Young's Modulus has been taken to be the increment of tensile stress divided by the corresponding increment of length per unit of the length immediately before the stress was increased.

(1) The observations requisite for the first purpose were made only in a few cases; and even in those cases in calculating the increment of tensile stress, it is necessary to assume (the requisite measurements not having been made) that the radius of the cord would not appreciably vary with the small variations of length under the permanent load—an assumption which is doubtless permissible. The following table gives the results :—

Original Stress (grms. per sq. cm.)	Additional Stress (grms. per sq. cm.)	Elongation per unit length.	Young's Modulus, (abs. C. G. S. units). $10^6 \times$
1354	789	.0618	12.53
1354	1574	.1397	11.05
1354	2529	.2449	9.73
1354	3424	.3342	10.05

These determinations would thus seem to show that for the smaller additional stresses to which the cord was subjected, the value of Young's Modulus diminished as the additional stress increased, that for the larger additional stresses, it increased with the additional stress, and that there was a certain additional stress for which Young's Modulus had a minimum value,—this additional stress being of such a magnitude as to produce an elongation of about 0.25. This result is in agreement, qualitatively, with Mallock's observations, which showed that Young's Modulus, statically determined, "diminishes with the extension until the stretched length is about 3/2 times the natural length." As Mallock's rubber no doubt differed in degree of vulcanisation from Mr. Macdonald's, and as he used a different initial stress, it is not surprising that the elongations giving a minimum value for Young's Modulus should be 0.25 in the one case and 0.5 in the other.

Mallock's mean value of Young's Modulus, when expressed in absolute C. G. S. units, was 8.56×10^6 for soft grey india-rubber, and 34.16×10^6 for hard grey rubber. As in the case of the rigidity, Mr. Macdonald's values are intermediate, being nearer Mallock's values for the soft than for the hard specimen.

(2) The following table contains the determinations made for the second purpose mentioned above.

Original Stress (grms. per sq. cm.)	Additional Stress (grms. per sq. cm.)	Elongation per unit length.	Young's Modulus, (abs. C. G. S. units). $10^6 \times$
	FIRST SERIES.		
1354	789	.0618	12.53
2143	785	.0765	10.06
2928	855	.0955	8.78
3783	995	.0816	11.97
4778	1072	.1152	9.13
5850	1161	.0943	12.08
	SECOND SERIES.		
1397	784	.0681	11.30
2181	847	.0798	10.42
3028	889	.0981	8.89
3917	957	.0812	11.55
4874	1036	.0829	12.26
5910	1026	.0716	14.05

It will be seen that in both series of observations the values of the modulus are large at the outset, diminish in value as the original stress is increased, reach a minimum value and thereafter increase with the original stress. The irregularity of the fourth and fifth determinations in the first series, is obviously due to the unusually long intervals of time which, as the first table, p. xxx, shows, intervened between the two pairs of observations on which they are based. The variation of Young's Modulus with initial stress, the additional stress being roughly constant, would thus appear to be similar to that which was shown above to hold with respect to additional stress when initial stress is constant.

It should be noted, with respect to all the above determinations of Young's Modulus that the values found apply to the state of the cord immediately after the application of the additional stress, and in addition that the cord was subjected to torsion after each observation of length.

Mr. Macdonald hopes to be able to continue the above investigation at a later date.

The paper was discussed by DR. MURPHY.

JAMES BARNES, ESQ., B A., Dalhousie College, read a paper "On the Conductivity, Specific Gravity, and Surface Tension of Aqueous Solutions containing Potassium Chloride and Sulphate." (See Transactions, p. 49.)

HARRY PIERS, ESQ, read a paper entitled, "Observations on a Fish new to the Fauna of Nova Scotia." (See Transactions, p. 110.)

CHARLES F. LINDSAY, ESQ., read a paper "On the presence of Acid Sulphates in Solutions containing Copper Sulphate and Sulphuric Acid."

The paper was discussed by PROFESSORS E. MACKAY and MACGREGOR, and DR. A. H. MACKAY.

A vote of thanks was presented to MESSRS. MACDONALD, BARNES and LINDSAY for their communications.

The following paper was read by title: "Notes on Nova Scotian Zoology: No. 5," by HARRY PIERS, ESQ.

The Council was authorized to receive as read by title, any papers that might be offered too late for this meeting.

HARRY PIERS,
Recording Secretary.