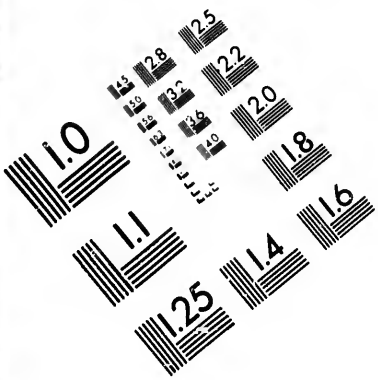

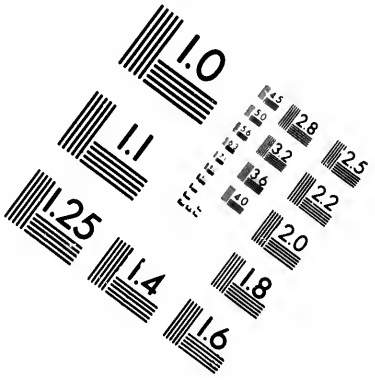

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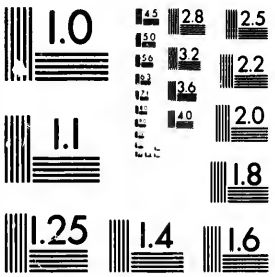

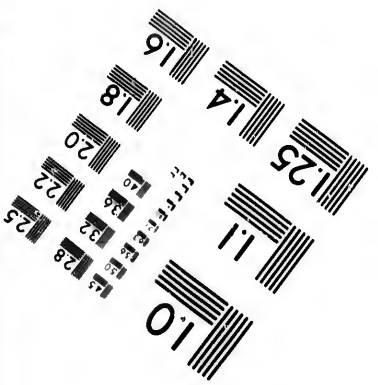

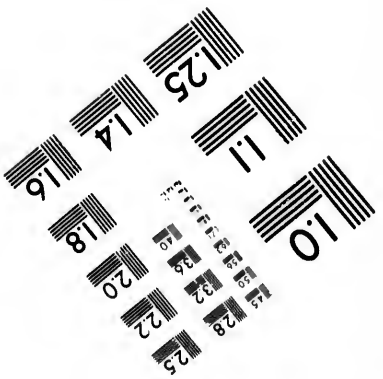

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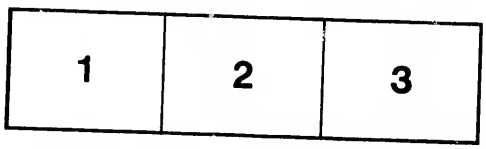

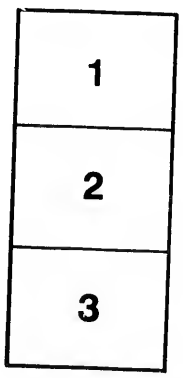

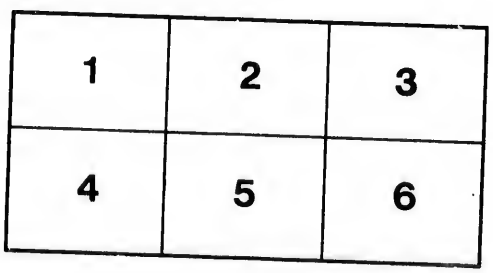

SCIENCE EDUCATION ABROAD.

A LECTURE

BY

J. W. DAWSON, LL.D., F.R.S., &c.,

Principal and Vice-Chancellor of McGill University,

MONTREAL.

(Being the Annual University Lecture of the Session 1870–7, delivered in the William Molson Hall, Nov. 18, 1870.)

[MONTREAL GAZETTE REPORT.]

MONTREAL:

GAZETTE STEAM PRINTING HOUSE 181 ST. JAMES STREET.

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SCIENCE EDUCATION ABROAD.

Every one who reads must know that in our time no subject is more extensively agitated and debated than that of the present lecture. In every civilized country it has become a question of first-rate importance, not only for educators but for business men and statesmen, how the largest amount of success can be attained in the practical application of science to the arts of life. Everywhere, as a means to this end, it is felt to be necessary to provide the widest extent of science education for the mass of the people, and the highest perfection of such education for those who are to take leading places as original investigators or as directors of business undertakings.

From the time when I first had the honour of addressing a Canadian audience, until this day, I have not ceased, in season and out of season, to urge this subject on the attention of the friends of education here, as one of the pressing wants of this country; and within the few past years, feeling that we were falling farther and farther behind other countries, I have made some special efforts to collect additional information as to the state of science education abroad, and to bring this to bear on the public mind here, as opportunity offered.

In my recent visit to Great Britain I had this object specially in view; and found it to be one much before the minds of all educated men, and prominent in conversation and discussion whenever education was referred to. The results of recent industrial exhibitions had painfully impressed the minds of Englishmen with their actual and growing inferiority in important arts and manufactures to better educated nations. Great efforts were being made to erect new schools of science and to introduce science teaching more effectually into other institutions. The usual expedient in England in all doubtful and urgent matters of national importance, the appointment of a Royal Commission of Inquiry, had been resorted to; while the Commission already engaged in the improvement of the endowed schools had taken high ground on the question of science education. All this was very interesting to me, and I availed myself fully of the many opportunities which offered to visit schools of practical science, and to learn the views of those most concerned in their management; and who, in the true spirit of the brotherhood of Science, were ready to place all means of information at my disposal. What I learned I would now desire in some measure to lay before this audience, with practical deductions bearing on our own condition. While however, most desirous to convey to your minds the impressions made upon my own, I feel that the subject is too vast to be discussed in an hour, and that I can present but a mere skeleton, unless I confine myself to notices of a few of those institutions which appear to be most instructive with reference to ourselves. I shall therefore, first, shortly define what I understand in this paper by science education, shall then notice a few science schools in England and elsewhere, and shall conclude with some practical applications of the subject.

WHAT IS SCIENCE EDUCATION.

In speaking of science then, I would restrict your attention to the physical sciences, or those which relate to what we call material things. In this great group of sciences we may recognize three subdivisions, distinguished by the modes in which they are pursued, though shading into each other. (1) Mathemetical sciences, or those in which the methods chiefly pursued are those of mathemetical reasoning and calculations, as, for instance, astronomy; (2) Experimental sciences, of which chemistry and several departments of natural philosophy may be taken as examples; (3) Observational sciences, such as zoology, botany, and geology. Each of these classes of subjects must be treated according to its own methods; and unless so treated is useless whether as a means of training or for practical application. The learning, for example, of any of the natural sciences by "getting up" a text book, without actual examples and work, is not of the nature of science education; and much of

the undervaluing of science studies as a means of education, on the part of practical teachers, is due to their want of acquaintance with this first truth. Natural history or experimental science taught merely from books, is only an indifferent form of verbal training, and it is no wonder that those who know it only in this way should form a very low estimate of its educational value. To be usefully taught, the pupil must be familiar with the actual objects of study, and must understand experimentally the modes of attaining to results with regard to them. He will then receive a real and valuable kind of education, the benefits of which may be summed up as follows:—(1) The student is taught to observe, compare, and reason for himself, and this in a practical manner, not so easily attainable in other subjects, and tending to give an accuracy of method and quickness of perception and of forming conclusions most valuable in actual life. (2) Much knowledge of a useful and interesting character is acquired; and the student, while learning the uses and properties of common things, may rise to large and enlightened conceptions of the works of God, and the natural laws under which man exists. (3) Men are trained to pursue original investigations, and thus to enlarge the boundaries of science. (4) The means are afforded to utilize natural resources and improve arts and manufactures. With regard to the extent and nature of such science education, it appears to be the result of experience in all the more advanced countries; (1) That there should be special practical schools to train investigators and practical science workers in the departments most important to the welfare of the community. (2) That science study should form some part of a liberal education. (3) That the elements of some of the natural or physical sciences should be taught in all the common schools. (4) That means should be employed to train competent teachers of science. This being what I understand by science education, with reference to its nature, results and methods, let us glance at some of the efforts put forth on its behalf, more especially in the mother country.

THE ROYAL SCHOOL OF MINES.

In London the principal institution for science education, supported directly by the Government, is the Royal School of Mines, Jermyn street, with which is associated the Royal College of Chemistry in Oxford street.

The Royal School of Mines is an outgrowth of the Geological Survey of Great Britain, whose building it shares and whose officers are its chief directors and instructors. This association gives it great advantages, in securing the influence and management of the distinguished head of the Survey, Sir R. I. Murchison, and the services of such eminent practical geologists and naturalists as Ramsay, Huxley, Etheridge and Smyth, as professors, in giving the students access to large and admirable collections in Geology and an extensive scientific library, and in placing the young men under the immediate superintendence of those who have the best opportunities for opening up to them the paths of usefulness and success. The very atmosphere of such an institution savours of practical science, its appliances for work and study are of the most inviting description, and it has several prizes and scholarships for its more deserving students, and gives the title of "associate" to those who pass its final examinations. Notwithstanding these advantages, though it has many occasional or partial students, the number of regular students has been much smaller than could be desired. This may in part be accounted for by its situation in a city not directly interested in mining, and remote from the great manufacturing districts; in part, perhaps, by the want of appreciation of the advantages of science training on the part of the English public. It is certain, however, that the School of Mines, though its instructing officers are second to none in the world, is inferior to the great science schools of America and the continent of Europe in its academical organization, in the completeness of its course, more especially in the direction of literary and mathematical culture, and in the standard of attainment required for entrance. Were it improved in these respects, and enabled to offer a larger number of direct prizes to students, its usefulness might be greatly increased.

Still, with these limitations, the success of the school has been great. It has trained a succession of competent men for geological surveys in the United Kingdom and the colonies. Among others, the present head of the Geological Survey of Canada is one of its graduates. It has also sent forth a number of trained men into mines and manufactures, who have been very successful, not only in introducing new inventions and improvements, but in realizing fortunes for themselves; and it is stated that the demand for these men is much greater than the supply. The course of study in the school of mines extends over three years, and in the senior year the students are allowed options, by vir-

tue of which they may devote themselves specially to chemistry, mining or geology.

The Royal College of Chemistry is a distinct institution, situated in a different part of the town, which is a cause of some inconvenience to the students of the School of Mines, who have to attend its lectures and classes in practical chemistry. It was established originally by a private subscription, but has been adopted by Government. Under the able management of Prof. Frankland, it is a useful institution, and always crowded with pupils. It has, however, accommodation for only 42 practical students, and this by no means of the airy and sumptuous character to be found in the laboratories of the continent of Europe and the United States. Crowded among the shops of a noisy business street, it has no room for extension, and its teachers and students have to submit to many inconveniences which might readily be obviated were it removed to a more suitable locality, and provided with a laboratory fitted up with modern improvements. It must, however, be admitted that the utmost possible use has been made of its too limited accommodation.

THE DEPARTMENT OF SCIENCE AND ART.

The Royal School of Mines, as well as the Royal College of Science, Dublin, and the Edinburgh Museum of Science and Art, are under the direction of the Government Department of Science and Art; but its largest sphere of operations is in the great South Kensington Museum, and the schools connected with it throughout the country. In its last report these schools and classes are stated at 525 in all, with an aggregate of 24,865 pupils. This represents much science teaching; all, however, of an elementary character, and of small amount relatively to the great population of Britain and Ireland. Much of the teaching is necessarily done by teachers of a very humble grade of scientific attainment; but the most effectual means are taken to ascertain that it is faithfully done, and to give it opportunities for improvement. The principle adopted is that of giving money aids to teachers, building grants, grants for apparatus, &c., scholarships and exhibitions, medals and prizes to pupils. All of these are awarded on the results of rigid examination, conducted by papers sent from London and reported on by examiners, among whom are some of the first scientific men in the country. The aids to teachers are at the rate of £2 per annum for each first-class pupil, and £1 for each second-class pupil; and the teacher, in order to receive aid, if not a University graduate, must have obtained at least a second class in the advanced grade of these examinations. Of the aids given to pupils a number are in the form of exhibitions in aid of attendance on higher science schools, and in the case of the higher Government schools the fees are remitted in favor of students taking these exhibitions. It would be difficult to imagine a system likely to do more good, and all that is wanted is that it should be further extended and that more thorough means should be adopted for training the teachers.

SOUTH KENSINGTON MUSEUM.

The most conspicuous part of the establishment at South Kensington is its museum, embracing a vast collection of objects illustrative of industrial products, art and manufactures, and one of the most popular and useful places of instruction by the eye in London. It is proposed to remove to the extensive buildings at South Kensington the vast Natural History collections of the British Museum, and also the collections of the Geological Survey, so as to promote science study as well as that of art. Art education on an extensive scale is conducted at South Kensington itself, as well as in a multitude of affiliated art schools. More especially, young persons are trained as teachers, and with reference to practical applications to decorative art of every description. As illustrations of these, I was shown large collections of patterns for wall papers, table cloths, pottery, and coloured and engraved glass, prepared by the pupils for competition for prizes offered by manufacturers; while in a gallery of the museum, assistants were busy in arranging a vast collection of drawings and paintings sent in from affiliated schools for competition. In the Art training school I saw hundreds of pupils engaged in all kinds of work from the elements of drawing to studies in painting and modelling from life. In addition to the study in the schools, the students, of whom there are between eight and nine hundred, have access to the Galleries of Art in the Museum, and to an Art Library of 25,000 volumes and a collection of 55,000 engravings and photographs. Last year 107 schools were conducted under the "Department" with 20 000 pupils; and in addition to these, elementary drawing was taught in 1,094 schools to 120,928 children. Though art is distinct from science, I think it proper, when speaking of South Kensington, to refer to its work in art as well as in science. Not only is science the handmaid of art, but art

is also the handmaid of science, and both must flourish or decay together. More especially the study of art in its application to the wants of ordinary life, cannot fail to be auxiliary to the advancement of science. It is a matter of profound regret that the Boards of Art organized in this country more than ten years ago, have been permitted to languish, and have not been enabled to establish here institutes on the plan of those of the Department of Science and Art in England.

THE LONDON UNIVERSITY.

University College, London, has no organized science school, but it trains men for the Bachelor of Science examination of the London University. This is a general science examination, implying the training necessary for matriculation, and subsequent studies in Physics, Chemistry, Animal Physiology, Geology, Logic, and Moral Philosophy. Bachelors of Science of two years standing can go up for an examination for the degree of Doctor of Science. These science degrees of the University of London do not lead directly to practical work, and this is an important defect in the system, but they are, no doubt, very important as stimuli to the general preparatory training required by every man of science. The Bachelor of Science degree as offered by the University of London, has also undoubtedly tended to raise science to its proper status in connection with the higher education. but it is not as yet largely taken. At the graduation in May last, at which I was present, there were only eleven Bachelors in Science and seventy Bachelors in Arts. This arises in part from the want of prestige and antiquity in the degree itself, and in part from its having to compete with the honours in science which may be taken in courses in arts, and with the special science schools.

The Birkbeck laboratory of University College accommodates 24 practical students; and I was pleased with the ingenious arrangement of its theatre, by means of which 98 students can be employed simultaneously in making experiments with tests, under the direction of Professor Williamson and his assistants. This is only one among many indications which I observed of the tendency to give to examinations and instructions in science a practical character, an evidence that its true nature is being more and more appreciated.

THE ROYAL INSTITUTION.

It would be wrong to leave London without referring to the remarkable and unique establishment known as the Royal Institution, founded in 1799, at the suggestion of Count Rumford, and celebrated throughout the world as the theatre of the labours of Davy, Faraday and Tyndall, while in London itself it is known and valued as an agreeable and popular exponent of science by means of its lectures and discourses. The Royal Institution has a good building in Albemarle street, containing its theatre, laboratories, library, and reading room. Its function is two-fold. First, it sustains as its professors eminent scientific men, and provides them with the means for prosecuting original research; secondly, it provides, by its afternoon and evening lectures, the means of presenting to the more refined and educated classes, information as to the latest results of scientific discovery, from the lips of the actual discoverers themselves. Its lecture-room is always filled with a cultivated and attentive audience, who have the advantage of learning orally and at first hand what others must gather from reading, or from secondary sources.

The Royal Institution thus occupies a middle place between the general public and those Scientific Societies, like the Royal, Geological and Linnean, whose objects are strictly scientific or special, and whose meetings are consequently almost entirely composed of scientific men. At the same time it promotes original research in a manner peculiar to itself, and in the highest degree successful. It undoubtedly exerts a most important influence in keeping those who move in the higher strata of society in London abreast of the science of the day, and thus in procuring moral as well as material support for scientific researches; more especially for those which, not being of direct educational or practical utility, are liable to be neglected even by the more intelligent portion of a community, engrossed in the accumulation of wealth or in the still more laborious pursuit of spending it.

OWEN'S COLLEGE, MANCHESTER.

In the great manufacturing community of Manchester, academical education rears its head in an institution of no mean repute in the matter of science education. Owens College is, like our own McGill, based on the liberality of a wealthy merchant, whose name it bears, supplemented by numerous additional benefactions. Among these I find a sum of £10,000, subscribed by 118 merchants and others, for a chemical laboratory and a library; a sum of £9,472 subscribed by the prin-

cipal engineers of Manchester and neighboring towns, for the foundation of a chair of civil and mechanical engineering, and a fund of £200 per annum to augment the endowment of the professorship of chemistry. These noble benefactions remind us of the liberality of some of our Montreal merchants and professional men, and should act as a stimulus to others.

I am indebted to Principal Greenwood and Professor Williamson for enabling me to learn the nature and results of the science teaching at Owens College, which in many essential respects more nearly resembles some of our Canadian colleges than any other institution which I saw in England. The department of general literature and science, or, as we should say, the course in arts, extends over three years, and, like our own, includes a certain amount of modern languages, and physical, natural, and mental science. The department of theoretical and applied science, or science course proper, also extends over three years. The first is identical with the first in arts. The second and third are occupied entirely with science subjects, along with the French or German language. The students in this department are prepared for the bachelor of science examination at London. This course is said to be suited to prepare "for the higher departments of manufacturing art, and for pursuits and professions purely scientific." It is also said to be "adapted for such as are hereafter to be engaged in commercial pursuits"—a remarkable testimony to the ideas of education on the part of business men at Manchester, who in this respect come up more nearly than any others in England and her colonies, to the standard of the New England cities. The Principal informed me that there were last session 100 students taking this science course. The third department in Owens College is that of civil and mechanical engineering, in which students are prepared for the examinations in engineering in the Indian Public Works Department, and also for entering on the higher branches of the engineering profession. The course extends over three years. It had only twenty students last year.

Another and most interesting feature of Owens College, suited to its position in a great manufacturing town, is the provision made for evening classes. These include the subjects of the general course, and also a pharmaceutical course intended to prepare chemists and druggists for the examinations under the Pharmacy Act. Most of the students in these classes are what we would call partial students; but some study for the Degree of B. A. of London University. The intention of the college is to accommodate those whose business engagements prevent them from attending lectures in the day time; and the number of students last year was no less than 400. This is a remarkable indication of the avidity for learning on the part of the young business men of Manchester, who enter on this somewhat severe course of study as an employment for their evenings, and after the toils of the day. It is further to be considered that many of these young men have to walk or drive considerable distances in order to attend these classes; but in all the cities of England distance is much less regarded than it is in this country. Prof. Roscoe delivers a separate course of lectures on chemistry to women, which, I was informed, had been successful, though I did not note the number of students. The authorities of the college have under consideration the establishment of a regular academical course for women, which will be largely of a scientific character.

Owens College has its class rooms at present in an old building adapted to its use; but an elegant new building is now in process of erection at a cost of £90,000, and a sum of £130,000 is said to have been raised as a building fund. The foundation stone of this building was publicly laid in September last. It is to be observed that Mr. Owens wisely prohibited any portion of his endowment fund being expended in buildings, and that the Government of Great Britain has given no aid to Owens College, so that this large sum is a product of private munificence, chiefly in the town of Manchester.

SCIENCE TEACHING AT CAMBRIDGE.

The two great English Universities of Oxford and Cambridge are obviously not content to lie under the aspersion some time ago cast on them by an eminent scientist that their "atmosphere" is unfavourable to scientific study. Both are making rapid strides in this direction.

At Cambridge, under the kind guidance of Prof. Stokes, himself one of the most eminent of living physicists, and of the patriarchal Sedgwick, and his able assistant Seeley, I saw the improvements which in late years have been made in the means of study in natural and physical science, and which tend, with other changes, to give greater effect to the regulations in favour of the natural science tripos. Still more recent movements in this direction are the appointment of a university professor of pure physiology, and

the movement in aid of a university professorship and demonstratorship of experimental physics, towards the buildings and apparatus necessary for which, the Chancellor, the Duke of Devonshire, has offered a contribution of £6,300.

WHAT OXFORD IS DOING.

Oxford has, however, taken the lead of its sister University in this matter, and I shall therefore notice more in detail what I had the pleasure of seeing there in the way of provision for practical science teaching.

The new museum, now of world-wide reputation, is not merely a museum in the more modern sense of the term, but a series of scientific laboratories and class rooms, attached to a magnificent library and museum. The museum proper had been largely increased and improved in its collections since my last visit in 1865, and its great central glass-roofed court, more than 100 feet square, with its surrounding galleries, is now well filled with specimens in Geology and Zoology. On the south and west sides, the museum is encompassed with class rooms and laboratories in geology, chemistry, and physical science. On the north side are the laboratories and class rooms in physiology. Prof. Phillips was absent, owing to an attack of illness, and in his department I saw only assistants engaged in laboriously piecing together the huge bones of the Cetiosaurus, a gigantic reptile with thigh bones more than five feet in length, of which a magnificent skeleton has recently been discovered in a quarry not far from Oxford. I had, however, the pleasure of seeing the students at work in the laboratory of practical chemistry, under Prof. Brodie, and of examining the admirable arrangements of Prof. Rolleston for practical work in physiology. Among other things which I saw in the physiological laboratory, were excellent dissections of mollusks and worms made by students as a part of their examinations in the honour course of Natural science.

Though the museum contains rooms for experimental physics, the University has greatly enlarged its means of instruction in this department, by the erection in the vicinity of the museum of a physical laboratory, which I believe will cost about £40,000, and which, in the perfection and completeness of its arrangements, will surpass all similar workshops of science, not only in England, but in the world. Prof. Clifton, who himself showed me the building, and explained its plan, has endeavoured to make this laboratory in itself a model of practical science, considered as the art of doing everything in the best way, by applying in the most perfect manner every known improvement and many original inventions of his own, to secure convenience and accuracy of working. The building has a central hall for apparatus, and for certain experiments requiring large space; a class room, which is a model of acoustic perfection and mechanical arrangement; and a number of work-rooms, in which all the most delicate kinds of operations in weighing and measuring can be carried on with the best apparatus and with every precaution against error. This laboratory was to be opened in the present autumn, and I was informed by Prof. Clifton that he expected to begin with about 30 practical students. The object of the laboratory is two-fold—(1) to train observers and experimentors more thoroughly than heretofore; (2) to undertake original physical researches with more perfect appliances than those now available.

The Oxford new Museum, with the neighboring Physical Laboratory, thus constitutes in itself a great educational institution in physical science, managed by some of the ablest instructors and original investigators of the day, and providing for studies in experimental physics, chemistry, mineralogy, geology, physiology, and zoology; botany being otherwise provided for in connection with the Botanic Garden. It has seven large class rooms and a multitude of working rooms and laboratories, with the scientific department of the Radcliffe Library. These appliances are as yet large in comparison with the number of students who use them; but the number of students is increasing, and this apparently not at the expense of the literary courses of study. It is to be observed, moreover, that the aim of the Oxford Science school is high. Its object is not so much to train practical workers in science as applied to the arts, as to give the education necessary to enable those who receive it to take their places as original investigators in the advancement of theoretical science, and in connection with this to bring out the true value of physical science as a means of securing the highest mental culture. Viewed with reference to these ends, Oxford is undoubtedly an excellent Science school; and a University which offers its highest honours, in courses, in which practical chemistry and physics, and dissections of invertebrate animals, constitute important parts, cannot be regarded as unfavourable to the cultiva-

tion of science. It must be admitted however that these improvements have been effected only after severe contests between the advocates of modern science and the conservative element in the University, contests in which my valued friend, Dr. Acland, well known to many of us here, has borne an influential part.

MOVEMENT IN EDINBURGH.

Edinburgh has as yet no organized Science school, and has undoubtedly been falling behind the English schools in its reputation for training in natural science. This is, however, a relative rather than an actual decadence, and there is a very strong desire on the part of many of the friends of the University to restore its ancient reputation in this respect. In evidence of this we have the recent endowment of the Baxter Chair of Engineering, and the still more recent offer of Sir Roderick I. Murchison to give £6,000 as the endowment of a Chair of Geology, which I am informed the Government is likely to supplement with a like sum. The Department of Science and Art has also attached to the University a museum on the plan of that of South Kensington, under Prof. Archer; but no lectures are delivered in connection with it. No Institution in Great Britain has a better field for science education than Edinburgh, and it possesses many excellent teachers, but their action is to some extent paralyzed by want of facility for mutual co-operation, and by the want of some professorships necessary to complete the course of study. In the meantime, there are excellent practical classes in chemistry, experimental physics and botany, and there is an academical course for a science degree. In this course the candidate is required to have the degree of B.A., M.A., M.B., or M.D., or to hold certificates of having passed the examinations in two of the departments of the University course, or to have matriculated in the University of London. Otherwise he must pass a preliminary examination. He must then pass a general examination in mathematics, physics, chemistry, zoology, and botany; but may omit this examination if an M.A. who has taken honours in natural science, or an M.B. or M.D. who has taken honours in natural history, and has passed the examinations in physics, higher mathematics, and logic. There is then a final examination, in which the student may select one of three branches in which to pass, viz.: (1) Mathematical science (2) physical and experimental science; (3) natural science. On passing this examination he is entitled to the Degree of Bachelor of Science; and at the end of twelve months may come up for the degree of Doctor of Science, in the examination for which he must show profound knowledge of a special scientific subject. The number of candidates for these degrees is not as yet large, but is increasing. They might obviously be rendered much more valuable and attractive by connection with special science courses, leading to application to the arts or to definite branches of original research.

It may be well to mention here that the Principal of Edinburgh University, in his inaugural address, has suggested the omission of Greek from the University course for M.A., to make room for science culture, and that the chairman of the Endowed Schools Commission has, as already mentioned, put this idea in a practical shape before the English Universities, in an official letter to the Vice-Chancellors, in which he intimates the design of the Commissioners to establish schools in which Latin alone shall be taught, in addition to science and modern languages and literature, and invites them to open their examinations for degrees and honours to the pupils of such schools. While it is to be doubted whether any such change is required here, where classics have not been so exclusively insisted on in the schools as in England, the arguments adduced by Lord Lyttleton in his circular are well deserving of study, as indicating the strong feeling among parents and educated persons in England that science education for their children is a matter of absolute necessity, and that, if it cannot otherwise be obtained, some portion even of their cherished literary culture must be sacrified to a want, on the supply of which even national existence may depend.

SCIENCE TEACHING IN THE UNITED STATES.

We might now turn to the efforts which have been made in the United States, where, owing to the more general diffusion of elementary education, the value attached to the applications of science to the arts of life, and the liberality of private benefactors and of the State and general Governments, much more has been done than in England, and where such schools as the Lawrence and Sheffield Schools, the Boston Institute of Technology, and the Cornell University, challenge comparison with any in the world. I shall, however, refer to only one of these, which I had the pleasure of visiting rather

more than a year ago, and which, in my judgment, has been one of the most successful.

SHEFFIELD SCIENTIFIC SCHOOL.

The Sheffield Scientific School is a modern outgrowth of the old University of Yale College; and originated in 1847 in the organization of the "Department of Philosophy and Arts," under Professors Silliman and Norton, representing respectively the subjects of Applied Chemistry and Agriculture. The scheme seems to have been devised by the elder Silliman, and to have had its birth in his private efforts in previous years to give practical instruction to special students. This department was maintained with moderate success for several years; but at length in 1860 Mr. Sheffield, a wealthy citizen of New Haven, came forward to its aid with a handsome gift of a building and apparatus valued at over $50,000 and a fund of $50,000 more to endow Professorships of Engineering, Metallurgy, and Chemistry. This enlightened benefaction at once placed the school on a respectable footing, and in 1863 it was further enlarged by the application to its use of the share of the State of Connecticut in the large grants of land made by Congress in that year for purposes of scientific education, grants which have borne similar good fruit in many other States. The Sheffield School will also be a large sharer in the benefits which the University will derive from the great Museum founded by Mr. Peabody, and endowed by him with the sum of $150,000. The present extremely valuable collections of Yale College are stored in rooms of quite inadequate dimensions, and are being rapidly augmented and improved. Prof. Marsh and Prof. Verrill alone have vast stores of fossils, corals and other specimens in basements and cellars; and when the whole shall be arranged in Mr. Peabody's Museum, Yale College will be inferior to few Academic institutions in the world in regard to its facilities for teaching the science of nature through the eye. A special collection in the Sheffield School, very valuable and well worthy of study, is that of economic geology. It is admirably arranged, and gives at one view an idea of nearly all the mineral resources of the United States from the Atlantic border to the Pacific.

The building of the Sheffield School is well suited to its purpose, though it is an old medical school adapted to its present use: and the scope of the institution is wide, including six distinct courses, any of which may be followed by the student. These are: 1st Chemistry and Mineralogy; 2nd, Engineering and Mechanics; 3rd, Mining and Metallurgy; 4th, Agriculture; 5th, Natural History and Geology; 6th, A Select Scientific and Literary Course. The class rooms and laboratories struck me as remarkably ingenious and neat in all their arrangements, and combining in a great degree all possible conveniences, while the uncomfortable arrangements too often seen in academic rooms had evidently here been replaced by the exercise of some engineering and mechanical skill and contrivance; and by a combination of lecture room and cabinet the means of illustration had been rendered extremely accessible. In token that the Sheffield School is not altogether a school of mines looking down into the bowels of the earth, its liberal founder has presented it with an Equatorial Telescope, made by Clark, with an object glass having an aperture of nine inches. It is placed in a tower constructed for it; and with a meridian circle and other instruments, enables students to learn all the work of a regular observatory, as well as the operations of astronomical geodesy. Any one interested in the training of the young men of Canada can scarcely avoid a feeling of envy in visiting such an institution as this, furnished with so many facilities for enabling the active mind of youth to grasp all that is of practical utility or provocative of high and noble thought in the heaven above and in the earth beneath. At this moment a Canadian Sheffield, judiciously aiding any University having an adequate and permanent basis, would do more to promote the trade and manufactures of this country and its scientific reputation, than can be done by any other agency.

The faculty of the Sheffield School includes twenty-three names, and its roll of students numbers one hundred and forty. It is scarcely necessary to say that several of the professors at Yale are active and successful original workers, and that the place is not only an effective scientific school, sending out each year a large corps of trained men into the higher practical pursuits connected with science, but also an important centre of discovery and original investigation, further materials for which are being constantly accumulated. More especially in geology, mineralogy, palæontology, zoology, and chemistry, are such men as Dana, Silliman, Marsh, Brush, and Verrill adding to the stock of knowledge for the whole world, as well as training their students. And this is one of the results in all cases of a well appointed and efficient school of science.

An additional endowment of about $50,000 has been collected during the past year for this excellent school, which in its provisions for scientific, in connection with academical education, is second to none in the possession of the English race.

One most important feature of the Sheffield School is that it combines all that is valuable in a science degree with the special training of a practical science course. Students who have the necessary literary acquirements may thus obtain the degrees of Bachelor and Doctor of Philosophy along with their special scientific training as civil or mining engineers, assayers, &c., while others can secure the practical advantages without the degree. In a recent article in the Yale College *Courant*, Prof. Dana explains the details of this system and its advantages and economies. He maintains that "the modification in American colleges, which is demanded by the vast development of the sciences of nature within the past century, and also by the contemporary progress of linguistic and other sciences, is accomplished by the Yale scheme through a method which does not sacrifice in any degree classical education, and which at the same time combines thorough literary culture with the widest range and highest development of scientific education."

GERMANY AND SWITZERLAND.

But though much is being done in England and the United States, science and technical education are carried to a still higher point in Germany and in Switzerland, which perhaps excel all other countries in this respect. In the former country, while every one is educated, general education is made to lead to technical education in a great variety of schools, suited to persons in all conditions of life, and culminating in the great technical Universities, a kind of institution as yet unknown in the English-speaking world, unless Cornell University can be regarded as a step in this direction. In Germany there are now no less than six technical Universities, and a large number of technical colleges or higher schools to train students for these Universities, or for directly entering into employments in arts and manufactures.

TECHNICAL UNIVERSITIES.

Mr. Scott Russell, in his work on Technical Education, takes the Polytechnicon, or Technical University of Switzerland, as an example of the most perfect organization of this kind; and I may abridge from his notes the following facts as to its scope and organization. Its courses of study are arranged under 145 subjects, divided among 31 professors, 10 assistant professors, and 16 private teachers and lecturers. They consist entirely of science, applications of science to the arts, and modern languages, literature and history. Among the few subjects not included under these heads are the Swiss federal constitution and rights, and the Biblical History of Creation, a subject scarcely thought of in the English world, even in the education of theological students. The students are either regular or "free," the latter taking selected courses; but of 762 students only 173 are free or occasional. In the regular programme of study the 145 subjects above referred to are divided into eight groups: (1) Preparatory subjects necessary for those who come imperfectly prepared; (2) subjects relating to architecture and building; (3) civil engineering; (4) mechanical engineering; (5) practical chemistry; (6) agriculture and forestry; (7) subjects necessary for scientific workers, professors and teachers; (8) a general course of philosophy, statesmanship, literature, art, and political economy. In aid of these courses of study the University possesses an astronomical observatory, arranged for teaching observers; a chemical and mechanical laboratory, for experiments in new inventions, &c.; a chemical laboratory, for ordinary practical teaching, which Mr. Scott Russell calls a palace of science in comparison with similar places in England; collections of drawings, models and machines; a collection of architectural models and sculpture; collections in zoology, geology, and antiquities; and a botanical garden. To the foundation of the University the Federal Government of Switzerland contributed £20,000, and the canton of Zurich £136,000. Its annual expense is very moderate, being only £13,459 sterling. From such institutions in Germany and Switzerland annually proceed numbers of educated young men who are prepared to advance every branch of art by the applications of science, who are distancing England in so many manufactures, and who are now contributing so largely to the wonderful success of the German armies. It is well for us to remember that the Technical University of Zurich ministers to the wants of a population of only two millions and a half, or considerably less than that of Canada, and that even the little state of Wurtemberg, with a population of less than two millions, has its Technical University at Stuttgardt, with no fewer than 57 professors and teachers. It is further to

be observed that these Universities are but the higher pinnacles of a complete system of technical education, descending from them to the humblest schools of practical science, for the children of labourers. It is scarcely necessary to add that they do not detract from or interfere with the great general Universities of Germany, in which scholarship and philosophy have reached so high a pitch of development.

A recent English writer thus eulogizes the Prussian system :—

"The Prussians, whatever their other qualities, are emphatically a scientific people, and to that predominating characteristic first and foremost are their recent military triumphs due. We do not mean that because they are great chemists, astronomers, and physicists, therefore are they necessarily great soldiers : so narrow a proposition would hardly be tenable. What we mean is that the spirit of science possesses the entire nation, and shows itself, not only by the encouragement given throughout Germany to physical research, but above all by the scientific method conspicuous in all their arrangements. What does the word Science, used in its wider sense, imply? Simply the employment of means adequate to the attainment of a desired end. Whether that end be the constitution of a government, the organization of an army or navy, the spread of learning, or the repression of crime, if the means adopted have attained the object, then science has been at work. The method is the same, to whatever purpose applied. The same method is necessary to raise, organize, and equip a battalion, as to perform a chemical experiment. It is this great truth that the Germans, above all other nations, if not alone amongst nations, have thoroughly realized and applied. In all the vast combinations and enterprises with which they have astounded the world, no one has been able to point to a single deficiency in any one essential element. Every post has been adequately filled and every want provided for ; from the monarch, the statesman, and the strategist, to the lowest grade in the army. This is the method of science, literally the same method which teaches the chemist to prepare his retort, his furnace, and his re-agents, before commencing his experiment."

WANT OF SCIENCE TEACHING IN CANADA.

Let us now turn to our own country, and study its means and appliances for the pursuit of practical science. The task is an easy one, for with the exception of two or three small and poorly supported agricultural schools, this Dominion does not possess a school of practical science. With mining resources second to those of no country in the world, we have not a school where a young Canadian can thoroughly learn mining or metallurgy ; and, as a consequence, our mines are undeveloped or go to waste under ruinous and unskilful experiments. With immense public works, and constant surveys of new territories, we have not a school fitted to train a competent civil engineer or surveyor. Attempting a great variety of manufactures, we have not schools wherein young men and young women can learn mechanical engineering, practical chemistry, or the art of design, or we are very feebly beginning such schools. We have scarcely begun to train scientific agriculturists or agricultural analysts. Our means for giving the necessary education to original scientific workers in any department, or of training teachers of science are very defective. Hitherto we have been obliged to limit ourselves to the provision of general academical courses of study, and of the schools necessary for training men in medicine, law and theology. Other avenues of higher professional life are, to a great extent, shut against our young men, while we are importing from abroad the second-rate men of other countries to do work which our own men, if trained here, could do better. Let us enquire then what we are doing in aid of science education, more especially in this commercial and manufacturing metropolis of Canada, which we may surely venture to regard as at least a Canadian Manchester, and something more important than a Canadian Zurich.

WHAT IS BEING DONE IN MONTREAL.

(1) We have at least advanced so far as to regard physical science as a necessary part of a liberal education. In this University some part of natural or physical science is studied in each year of the College course, and we provide for honour studies in these subjects, which are at least sufficient to enable any one who has faithfully pursued them to enter on original research in some department of the natural productions and resources of the country, and to receive some considerable portion of the training which such studies can give. We have provided in our apparatus, museum, and observatory, the means of obtaining a practical acquaintance with several important departments of science. But in a general academical course of study too many other subjects re-

quire attention to allow science to take a leading place; and it is not the proper course of educational reform to endeavour to intrude science in the place of other subjects at least quite as necessary for general culture. We require to add to our general course of instruction special courses of practical science, presided over by their proper professors, and attended by their own technical students.

(2) The lower departments of science education are to some small extent provided for by the teaching of elementary science in the schools. This, imperfect though it is, is of value, and I attribute to the partial awakening of the thirst for scientific knowledge by the small amount of science teaching in the ordinary schools in the United States and in this country, much of that quickness of apprehension and ready adaptation to new conditions, and inventive ingenuity which we find in the more educated portions of the common people. The Provincial Board of Arts and Manufactures also deserves credit for the attempts which it has made, under many discouragements, to provide science and art classes for the children of artisans. Proposals are also before the Local Legislature for Schools of Agriculture. The Local Government has procured reports on this subject from the Principals of the Normal Schools, and has also sent a special agent to study and report on the Agricultural Schools of France and Belgium, which are well worthy of imitation. A still more important suggestion has been made to the Dominion Government by the Director of the Geological Survey for the erection of a School of Mining.

These arrangements and proposals are valuable as far as they extend; but they fall short of providing the full measure of the higher science education, whether with reference to the training of original investigators, or of the various kinds of professional men required for the development of the resources of the country. Let us enquire how this wider and higher science culture can be secured.

SUGGESTIONS FOR HIGHER SCIENCE TEACHING.

The higher technical and science education may be provided for in either of the following ways. (1.) We may have special schools of mining, engineering, &c., each pursuing its own course, and not connected with any general institution. The objections to this are, that it is not economical, that it cannot provide the necessary literary and general training, that the pupils of such schools are very likely to be of various degrees of excellence and very partially trained. Such objections are applicable to schools like the Royal School of Mines in London, and I think they would prove fatal to the influence of such schools in this country. (2.) We might imitate the German technical universities. This would be the most thorough course possible; and were the means forthcoming, I cannot conceive of any greater educational benefit to this country than the institution of such an University. But it may be long before we shall find in our Legislatures, general and local, the wisdom and patriotism which actuated those of Switzerland in establishing the Zurich School; and we may have to wait quite as long for the appearance of a Canadian Cornell to give and to stimulate legislative liberality by his giving. (3.) The last, and, it appears to me, the only practicable course at present, is to ask for endowments similar to those of Lawrence and Sheffield, and thus to establish special courses of Science in connection with academical institutions, on the plan so well carried out in Owens College, Manchester, and in the Sheffield School of Yale. This has proved the course most successful in the United States and in the Mother Country, and I have no doubt will prove so here. It is to be observed in this connection that I would not propose merely the institution of a Science degree. We have in this University the means to do this now, but I doubt its expediency, more especially as our honour course in Mathematical and Natural Science is equivalent to that for such a degree and something more, and can be as readily and easily pursued. Nor would I follow the advice above referred to as given by the Principal of Edinburgh University and the Chairman of the Endowed Schools Commission, to curtail the classical part of the ordinary course in favor of science studies. Such an arrangement would, I have little doubt, injure the literary part of the academical course more than it would benefit science. I would prefer a regular and definite science school, with a course extending over three or four years—the first year to be identical with or similar to that of the ordinary course, or an equivalent examination to be exacted, at least, in modern literature and science; and the remaining years to be occupied with mathematical, physical and natural science, and modern languages, branching in the closing two years into special studies leading to particular scientific professions. The staff and appliances of such an institution would de-

pend on the extent of its range; and this, to ensure success, should not be small.

In this University large provision has been made in apparatus, collections and teaching power, for the foundation of a good science school; but to enable us in to undertake the task effectually would require, in addition to our present means:

1. The separation of our mathematical and physical chairs, or the employment of an assistant professor.

2. The division of our natural science chair into two, or the appointment of an assistant professor.

3. The endowment of a chair of civil engineering and surveying.

4. Professors, lecturers, or tutors in mining, assaying and metallurgy, practical chemistry, agriculture, and agricultural chemistry, and mechanical drawing.—Some of these departments might be taken up by persons otherwise em[illegible]ed, and not depending for their whole support on the University.

5. Some improvement of and additions to our present apparatus, and the addition of collections of models, machines, and objects relating to the arts.

This might involve an additional annual expenditure of say $8,000, a very trifling sum in comparison with the cost of similar institutions elsewhere. With this, and the fees of students, we might here establish an efficient School of Practical Science and Technology for the Dominion of Canada, which would at once raise the character and reputation of this city throughout the world, and confer incalculable benefits on education and the arts of life. Such an Institute is wanted to crown the educational fabric reared here by the liberality of Montreal merchants, with its highest success and the full measure of its utility. I would go further than this, and hold forth the hope of the full realization of the object in view, if an annual revenue of even half the sum above mentioned could be secured at once by private endowment. We could begin on an economical scale, and with the more important subjects only, and could, surely, with some reason expect the Government of the country to supplement such a private endowment with a like sum.

It may be asked, would students be forthcoming? I may with confidence answer the question in the affirmative. From the applications made to me on the part of young men for whom I can do little or nothing, I believe that one central well-appointed technical university in this Dominion, would be well sustained, in so far as the number of students is concerned; and that the extension of population, of mines, manufactures, railroads, and other works, would afford an ample outlet for all the men it could train, while the professional work of such men would itself tend to increase the demand.

It is certain, however, that if the Government of this country could be induced to sustain a system of elementary technical schools similar to those of the Department of Science and Art in England, or similar to those of Prussia, a double benefit would be secured, in so far as the higher science education is concerned, in finding occupation as teachers of science for some of the graduates, and in giving the necessary preliminary training to students. At the same time the effects of such schools would be of incalculable importance to the working classes of this country. Local benefactors might do something for such schools; but for a proper system the Legislature must intervene, and it can secure the end only by payment for results on the English system, under proper arrangements for examination and inspection.

CONCLUSION.

In conclusion, I may remind some of my audience and inform others, that the views advanced in this lecture, and which are now sweeping on in a resistless tide in every civilized country, are not new with me. When, in 1855, I entered with much diffidence on the arduous and then not very hopeful office which I now have the honour to occupy, I held views on this subject as advanced as those which I hold now, and saw quite as clearly as at this moment, the improvement and extension of science education to be the greatest educational movement of our time. I had then studied the Reports of the University Commissioners in England, and had read the admirable exposure of the evils of the existing systems made by Sir Charles Lyell. I was familiar with the details of the Prussian system. I had recently been engaged, with several leading educationists, under the presidency of Sir Edmund Head, in the organization of a scheme for the reform of the University of New Brunswick. I had just returned from conference with leading educational and scientific men in England and the United States. I was strongly impressed with the necessity of science education in this country, zealous for its introduction here, and hopeful that, if any kind of education would commend

itself to the good sense of a progressive, commercial community, this would.

Confessing in my inaugural address that I came among you "in the hope of promoting the study of the subjects to which I had devoted myself, and at the same time advancing the cause of education," I maintained that the spirit now abroad with regard to University reform "had for its object to make the carefully elaborated learning of all the great academical centres become more fully than it has yet been the principal moving power in the progress of practical science, of useful art and of popular education," and I specially indicated the institution of schools of civil and mining engineering and of scientific agriculture, as enterprises which should be at once entered upon.

When I look back on the hopes and struggles of those earlier years, though I entertain a feeling of profound thankfulness to God for the measure of success and prosperity which has attended this University, and though I am most grateful to its many benefactors, I cannot forget the disappointment of my own hopes. Much has been done for general education, and McGill College has grown to be a comparatively great and prosperous institution. But all that I have done toward this any one could have done. The one thing that I could have done, for which I was willing to sacrifice all that I would have gained as an original worker in Geology, and which would have been of more real importance, not only to Montreal, but to all this great country from Red River to Newfoundland, than all the rest, has not been done. I confess I often almost sink under the despairing feeling that it will not be done while I live; and that I may never have the opportunity of doing for this community the only great service that I believe myself competent to confer upon it.

Yet I know that much good preliminary work has been done, that material has been accumulated and tastes for science created; and I am reluctant to abandon the hope that I may yet see in Montreal a thoroughly equipped Institution, in which any young man, with the requisite ability and preliminary education, may learn the scientific facts and principles, and receive the training in scientific methods, necessary to qualify him for mining, metallurgy, assaying and engineering, agriculture, chemical manufactures, or other applications of science to art. Until this can be realized, I shall feel that the work of my life has been only very partially and imperfectly successful; and I shall know that this city has not taken the means to prepare itself fully for that greatness which its position and advantages mark out for it, but which it cannot attain, except as the educated metropolis of an educated country—educated not merely in general learning and literature, but in that science which is power, because it wields the might of those forces which are the material expressions of the power of the Almighty Worker.