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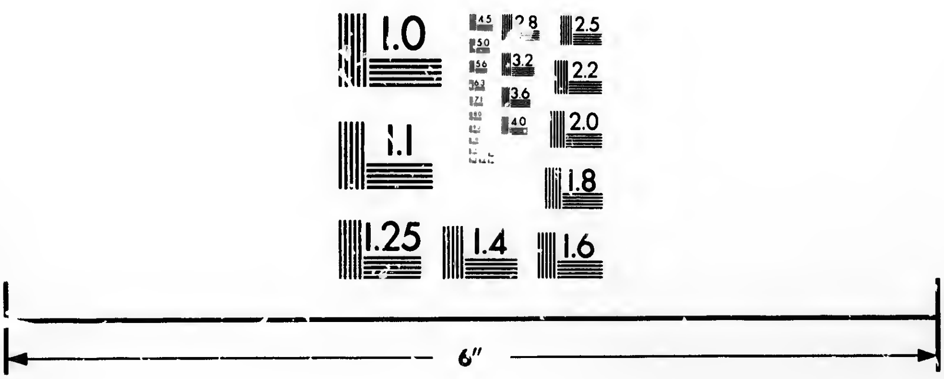

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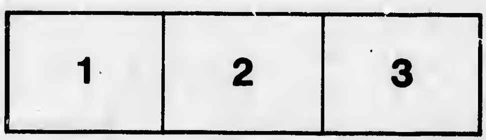
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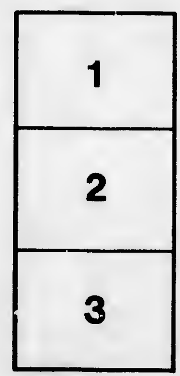
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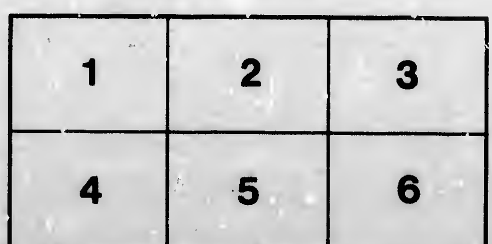
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REPORT OF AN INQUIRY

IN REGARD TO

SCHOOLS OF TECHNICAL SCIENCE

IN CERTAIN PORTIONS OF THE

UNITED STATES;

(CONTAINING ALSO BRIEF REFERENCES TO THE PROVISION FOR TEACHING PRACTICAL SCIENCE IN THE UNITED KINGDOM.)

BY

J. GEORGE HODGINS, LL.D.,

Barrister-at-Law, Deputy Superintendent of Education for the Province of Ontario;

AND

ALEX. T. MACHATTIE, M.D., F.C.S.,

Of London, Ontario.

SUBMITTED TO THE HONOURABLE JOHN CARLING, M.P.P., COMMISSIONER OF PUBLIC WORKS AND AGRICULTURE FOR THE PROVINCE OF ONTARIO, JAN., 1871.

Toronto:

PRINTED BY HUNTER, ROSE & CO., 86 AND 88 KING ST. WEST.

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REPORT

OF

DRS. HODGINS & MACHATTIE

ON

TECHNICAL EDUCATION, OR SCHOOLS OF INDUSTRIAL SCIENCE, IN CERTAIN PORTIONS OF THE UNITED STATES.

TORONTO, January, 1871.

To the Honourable John Carling, M.P.P., *Commissioner of Public Works and Agriculture, Province of Ontario.*

SIR,—The undersigned, having been deputed by your Department "to proceed to the United States, for the purpose of inspecting and reporting upon any Technical or Science Schools, or Colleges there established, as to their buildings, departments of study, and general appliances," beg leave to report as follows:—

2. Owing to the limited time at our disposal, we were compelled to confine our inquiries and observations to the following institutions devoted to technical education. They are however, among the most important ones in the United States, which give instruction in this special subject. They are as follows:—

1. THE LAWRENCE SCIENTIFIC SCHOOL.
   (*Connected with Harvard University, Cambridge, Mass.*)
2. THE SHEFFIELD SCIENTIFIC SCHOOL.
   (*Connected with Yale College, New Haven, Conn.*)
3. THE SCHOOL OF MINES.
   (*Connected with Columbia College, N. Y.*)
4. THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.
   (*City of Boston, Mass.*)
5. THE FREE INSTITUTE OF INDUSTRIAL SCIENCE.
   (*City of Worcester, Mass.*)
6. THE COLLEGE OF CHEMISTRY, PHYSICS, MECHANIC ARTS, &C.
   (*Connected with Cornell University, Ithaca, N. Y.*)
7. THE RENSSELAER POLYTECHNIC INSTITUTE.
   (*City of Troy, N. Y.*)
8. THE COOPER UNION OF SCIENCE AND ART.
   (*City of New York.*)*

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*Of the 337 other Colleges and collegiate institutes in the United States, 50 report a "Scientific Department," with an attendance of nearly 3,000 students. There are 175 other higher Educational Institutions in the United States, viz: 101 Theological Colleges; 52 Medical and Dental Colleges; and 23 Law Schools.

3. It is worthy of note that four of these important institutions exist in one State, that of New York, three in the State of Massachusetts, and one in Connecticut. These States form the great manufacturing and industrial centres of the union. The establishment, therefore, in them of these schools indicates a wise sagacity on the part of their founders.

4. Having been furnished by you with an official letter of authority to proceed with the inquiry, we decided to pursue it in a manner which would enable us to obtain, in the shortest possible time, the fullest information in regard to each institution visited. With this view, we agreed upon the following plan:—

(1.) Personally to inspect the institution, its lecture rooms, laboratories, &c.

(2.) To take a sketch, or note, of everything of interest bearing upon our inquiries, which we might observe in each institution, and to get information in regard to the systems of heating and ventilation.

(3.) To procure plans of buildings, and copies of the reports of institutions visited, or other documents of value, on the subject of Technical Education.

(4.) To obtain from the heads of the institutions visited, replies to a series of upwards of *sixty questions*, which we had previously drawn up for this puprose. The answers to these questions will not be given separately, but will be incorporated by us in this report.

5. We were received with great courtesy by the heads of the institutions visited, and by the professors; and every facility was freely afforded to us to obtain full and satisfactory information on the subjects of our inquiry.

6. Before attempting a brief discussion of the necessity and advantage of Schools of Technology, or Industrial Science, in this country, and pointing out the many facilities and appliances for imparting instruction in this subject in the United States, we deem it desirable as a preliminary, to condense in a brief form, several important financial items of information in regard to the institutions visited, as follows:

I. Cost of the Buildings, Fittings, and Apparatus.

(Note.—The figures are in most cases approximate.)

No.	Name of Institution.	Original Cost of Building.	Original cost of Fittings.	Original cost of Apparatus, &c.
1	Lawrence Scientific School, Harvard College	$30,000 (An old building.)	(uncertain)	(uncertain)
2	Sheffield Scientific School, Yale College	$100,000	(uncertain)	$15,000
3	Massachusetts Institution of Technology, Boston	$290,000	$10,000	$15,000
4	School of Mines, Columbia College, N.Y.	$80,000 (Temp. buildings only.)	(uncertain)	$25,000 Minerals $3,000 add'nl
5	Institute of Industrial Science, Worcester, Mass.	$67,000 (Workshop $30,000 ad.)	$5,000	$5,000
6	Rensselaer Polytechnic Institute, Troy, N.Y.	$40,000	$5,000	$8,000
7	College of Chemistry, Physic, &c., Cornell University, N.Y.	$300,000 (A proportion only.)	(uncertain)	$25,000
8	Cooper Union for Science and Art, N.Y.	$630,000	$6,000	$10,000

II. Revenue and Expenditure.

(1) Revenue.

(Note.—The figures are, in most cases, merely an approximation.)

No.	Name of Institution.	Fees from Students.	Other Sources.	Total.
		$	$	$
1	Lawrence Scientific School, Harvard College	6,500	13,500	20,000
2	Sheffield Scientific School, Yale College			
3	Massachusetts Institute of Technology, Boston	31,000	19,000	50,000
4	School of Mines, Columbia College, New York	12,000	68,000	80,000
5	Industrial Science Institute, Worcester, Mass	700	17,000	17,700
6	Rensselaer Polytechnic Institute, Troy, N. Y	23,000	None.	23,000
7	Cornell University, Ithaca, N. Y	22,500	37,500	60,000
8	Cooper Union, New York	Free.	43,000	43,000

(2) Expenditure.

(Note.—The figures are, in most cases, approximate.)

No.	Name of Institution.	Salaries.	Other Expenses.	Total.
		$	$	$
1	Lawrence Scientific School, Harvard College	13,500	3,500	17,000
2	Sheffield Scientific School, Yale College			30,000
3	Massachusetts Institute of Technology, Boston	44,500	5,500	50,000
4	School of Mines, Columbia College, New York	63,100	16,900	80,000
5	Industrial Science Institute, Worcester, Mass	13,400	3,600	17,000
6	Rensselaer Polytechnic Institute, Troy, N.Y	20,000	3,000	23,000
7	Cornell University, Ithaca, N. Y	50,000	10,000	60,000
8	Cooper Union, New York	6,200	33,800	40,000

III. Professors, Students' Fees, &c.

No.	Name of Institution.	Instructors.			Students. Min'm ages, 16 and 18	
		Professors.	Instructors.	Total.	Numb'rs	Fees per Annum.
1	Lawrence Scientific School, Harvard College	8	3	11	35	Chem. $200 Eng'eer 150
2	Sheffield Scientific School, Yale College	21	1	22	125	150
3	Massachusetts Institute of Technology, Boston	18	14	32	240	150
4	School of Mines, Columbia College, New York	8	12	20	150	200
5	Industrial Science School, Worcester, Mass	4	2	6	80	100
6	Rensselaer Polytechnic Institute, Troy, N. Y	9	2	11	150	200
7	Cornell University, Ithaca, N. Y	12		12	? 150	45 being raised.
8	Cooper Union, New York	3	21	24	1280	None.

Note.—The Professors and instructors were, as we invariably found, paid fixed salaries, without reference to the number of students in attendance, or the fees paid by them. These salaries varied, in the case of professors, from $2,500 to $5,000 per annum. Students were invariably required to pay for breakages, but not in all cases for chemicals used—the latter expense, however, is very trifling. In those institutions receiving an apportionment from the United States National Fund for the promotion in the several States, of Industrial and Scientific education, a condition was imposed by the State Legislature to provide tuition free for a limited number of Students.* Hence, at the Worcester Institute of Industrial Science, out of the eighty students in attendance, only seven of them paid an annual fee of $100, the other seventy-three were admitted free, either from the State, or from the City of Worcester. In no case were students boarded or lodged on the school premises. At Cornell University, a boarding hall was provided near the institution, more as a protection to students against high charges in the village of Ithaca. It is proposed, however, as soon as possible, to discontinue it.

IV. Course of Study.

7. The course of study in each of the institutions visited, varied according to the number of Professors and Instructors employed, and the extent of the accommodation provided. They all, however, embraced the subjects of Mathematics, Chemistry, Natural Philosophy, Drawing, Civil and Mechanical Engineering, and the Modern Languages. This latter branch of instruction was invariably provided for, as so many of the scientific text-books and works, which are required to be used or consulted, are written in French and German. In the great majority of cases, four years was the period allowed to complete the course—two years preliminary and two years professional; so that graduates of Colleges were only required to pursue the professional course of two years.

8. As an example of the best and most comprehensive course of study for a school of Industrial science, we give in the Appendix, a copy of that adopted by the Sheffield Scientific School at Yale College, and at the Massachusetts Institute of Technology, at Boston,—the latter being one of the latest and most complete institutions of the kind in the United States. (See page 25.)

V. Subjects to be taught in the Proposed Institution.

9. As to the subjects which should be taught in the proposed College of Technology, or School of Industrial Science for Ontario, we may state that the following are regarded as essential to the usefulness and efficiency of any institution of the kind proposed.

(1). *Pure and Applied Mathematics.*—This department should include Mathematics proper, Natural Philosophy, Civil, Military and Mechanical Engineering and Surveying. To render the teaching in this department efficient, the students should be required, among other things, and as part of their regular instruction, to visit with their professor, or his assistant, the larger engineering or manufacturing establishments. In vacation time, mining students should be taken, if possible, on excursions to convenient mining districts. The engineering students should be required to undertake practical surveys of a given section of country, for railway or other purposes.

(2.) *Architecture and Drawing.*—This department should embrace Free-hand, Architectural, Engineering and Topographical drawing, with plans, sections, etc.

(3.) *Pure and applied Chemistry.*—This important department, should include organic and inorganic chemistry; chemistry as applied to the industrial arts, and to Mining and Metallurgy.

(4.) *Natural Science.*—This department should include Geology, Mineralogy, Zoology and Botany, and their industrial applications.

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* This fund was created by an Act of Congress, passed in 1862, apportioning "to each State a quantity of public land, equal to 30,000 acres, for each Senator and Representative in Congress, according to the census of 1860." The object of the grant was to provide in each State of the Union, for "the endowment, support and maintenance of at least one College, where the leading object shall be, (without excluding other scientific and classical studies, and including military tactics), to teach such branches of learning, as are related to agriculture and mechanic arts, in such manner as the Legislatures of the States may respectively prescribe, *in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.*" The Act further provides that "a sum, not exceeding ten per centum upon the amount received by any State, may be expended for the purchase of lands for sites and experimental farms, whenever authorized by the respective Legislatures of the States."

Note.—In Massachusetts, the grant is annually divided among several institutions; in New York, the whole of it was given to Cornell University, and in Connecticut, to Yale College, for the benefit of Sheffield Scientific School.

(5). *Modern Languages.* The only two, which are essential to be taught in this department, are the French and German languages. The student being already familiar with English, would require the addition of the other two, as so large a proportion of the best works on scientific literature is written in French and German.

10. We think it necessary to advert in connection with this matter to a possible cause of failure in an institution of this kind, which should be avoided, namely, attempting too much at first. Whatever is undertaken should be done as thoroughly as is compatible with the means at the disposal of the Institution; but to establish at the outset a large educational staff, before any experience has been obtained of the kind of students, or the nature of the studies most in demand, is only calculated to weaken each individual department. We would recommend, therefore, for the sake of economy, that the number of teachers should at first be small; and that each teacher should instruct in all departments of his particular subject, until experience shows in what branches of study increased assistance may most profitably be employed. Although all the subjects taught in the various Technical Schools are important, some are more important than others. Wherever the financial condition admits of it, the tendency is to increase the number of subjects taught, and the number of teachers or professors, but some Institutions still suffer from having undertaken too many subjects with insufficient means.

11. The kind of instruction, and the method of giving it, should be as practical as possible. As a rule, students of special subjects are not considered desirable: as it is believed that a student, say of chemistry, will make a better chemist if he studies the other subjects included in a scientific education, although in doing so he necessarily devotes less time to chemistry. Young Institutions, however, are scarcely in a position to make these distinctions, though in most thoroughly established Technical Schools specialists are discouraged as much as possible without being excluded. Great prominence is given to the study of Modern Languages, because of the high value of the Scientific Literature of France and Germany.

Note.—Although the building should be constructed to provide for instruction in the five departments named, it might not be deemed desirable to introduce immediately the two latter important departments (of the Natural Sciences and Modern Languages.) The introduction of the three other departments is, however, vital to the success and usefulness of the institution. Provision might also be made for popular lectures and instruction in the evenings, at which Teachers, young men, mechanics and others employed during the day might attend. This we found to be an interesting feature in some of the institutions which we visited. At the Massachusetts Institute of Technology at Boston, Mr. Lowell, with his usual munificence, had provided at a cost to himself, of $3,000 per annum, an evening course of lectures, which had been attended by an average number of 500 persons —chiefly Teachers, and persons engaged in manufacturing establishments.

VI. Character and Cost of the Proposed Buildings.

12. We have had in all our enquiries especial reference to the character, cost and convenience of the proposed building for this Province. After a careful consideration of the whole subject,—looking at what has been done, and what has been deemed essential, elsewhere, and fully appreciating the wants and necessities of our own people,—we do not think that it would be desirable or expedient to erect a building capable of accommodating less than from 120 to 150 students, or providing for less than the five departments of instruction, which we have enumerated,—three of which to be established at once, and the other two subsequently.

13. Under the system which we recommend, the Professor of Mathematics should be prepared to instruct students of Architecture and Civil, Mechanical, and Mining Engineering, in those branches of pure and applied Mathematics, and Natural Philosophy which individually they require. The Professor of Chemistry must teach the elements of Chemistry and its applications to any particular Industrial pursuit: and the Professor of Drawing should also suit his instructions to the end each student has in view. Of the Natural Sciences, Geology, Botany and Zoology—prominence must be given to one or all

according to circumstances, and French and German taught to those who wish to avail themselves of the rich scientific literature of these languages.

14. By such a course of Instruction as is sketched out above, provision is made for the Professional Education of Architects, Civil, Mechanical and Mining Engineers, Chemists, Metallurgists and Teachers of Science: and according as the want for increased teaching facilities in any one of the branches is felt, that want can be supplied.

15. An Institution of the capacity indicated,—including a main building, and detached Laboratories, besides providing for heating, ventilation, fittings, furniture, apparatus, models of machinery, architectural and drawing models, chemicals, books for the professional library of the instructors, etc.—could we have no doubt be provided at a cost not exceeding $50,000.

16. For convenience we give the following approximate statement of the proposed capacity, cost, etc., of the projected institution:—

I. The Main Building.

(To accommodate from 120 to 150 students.)

1. The Principal's Room, or Office	
2. Waiting or Visitors' Room	
3. Entrance Hall and Coat Rooms	
4. Public, or General Lecture Hall	
5. Model Room for Machinery	
6. Physical Laboratory for Instruction in Natural Philosophy	
7. Geological and Mineralogical Collection Room	
8. Lecture Room for Mathematics, Engineering and Surveying,—for 60 Students	
9. Do. for Chemistry and Metallurgy,—for 120 Students	$25,000
10. Do. for Architecture and Drawing,—for 60 Students	
11. Do. for Geology, Mineralogy, Zoology, and Botany,—for 60 Students	
12. Do. for Modern Languages,—for 60 students	
13 to 17. Five Ante rooms for Professors' Studies and Libraries	
18, 19. Two Attic Rooms for Drawing	
20, 22. In basement—Workshops, General Store and Heating Apparatus	

II. Detached Building for Chemical Laboratories.

1. Quantitative Chemical Laboratory	
2. Qualitative Chemical Laboratory	
3. Assay and Metallurgy Room	
4. Balance Room	$5,000
5. Store Room for Chemicals	
6 Private Laboratory for Professor	

III. Steam Heating and Ventilation	5,000
IV. Fittings and Furniture for Rooms and Laboratories	6,000
V. Apparatus and Chemicals	4,000
VI. Mechanical Models	3,500
VII. Professional Library for three Professors	1,500
	$50,000

VII. Estimated Annual Expenditure.

This we can only estimate in general terms at from $12,000 to $15,000 per annum as follows :—

(1.) Salaries of three Professors and servants, etc.	from	$7,000	to	$8,000
(2.) Apparatus, Chemicals and Models	from	1,500	to	2,000
(3.) Fire, Water and Light	from	2,000	to	2,500
(4.) Repairs and Furnishing, etc.	from	800	to	1,000
(5.) Contingencies, Printing, etc.	from	800	to	1,000
		$12,100	to	$14,500

VIII. Construction of the Buildings.

17. We have obtained plans of the latest and best constructed of the Technical Schools which we visited, and have also taken notes of many details of construction and arrangement. These, with such verbal explanations as we shall be able from personal observation to give, can be placed at the disposal of the Architect, who may prepare the plans of the proposed building. As to its exterior, that will likely harmonize with the style of the Normal School Buildings, already erected on Victoria Square—where we understand the proposed building will be erected; but there are a few suggestions in regard to the interior arrangement of the building which we would respectfully beg to offer, as follows :—

(1.) The proposed building should be detached; and, in its size and construction, care should be taken to provide abundance of light in all of the rooms.

(2.) In order to promote a thorough system of ventilation, as many flues as possible should be inserted in the interior and exterior walls. They should, as it were, be honeycombed with flues. These wall flues should terminate in main flues, leading to the top of the building; or, if desirable, in the chimneys, proper precautions against fire being taken. The great defect complained of in every institution which we visited was its imperfect ventilation; and the nearest approach to a satisfactory solution of the vexed question of thorough ventilation was reached in those buildings which, in their construction, had been abundantly supplied with ventilating flues, with openings at the top and bottom of the rooms.

(3.) Closely connected with the ventilation is the heating of the buildings. The result of our inquiries in this direction showed that the best and most successful plan adopted was that which combined the main features of the hot-air and steam heating systems. The principal objection to the hot-air system is that the air is not merely heated, but made very dry. In most cases it is considerably altered in character by reason of its contact with the highly-heated (often red-hot) surface of the iron in the chambers of the furnace. The main objection to steam heating is that it merely warms the air in the room (which is often impure, or becomes so,) without providing for a supply of fresh air from without. In combining these two systems, the plan most in favour at present is, to construct a series of steam coils in a chamber sufficiently large, into which pure air from without is constantly introduced. This air, being heated by the coils, is forced, by means of fans or other mechanical appliances, through flues into the rooms to be heated, and there, having served its purpose, is, as it becomes impure, conveyed away by means of the ventilating flues. To supplement this system, it has been found most desirable to have a small auxiliary steam coil in each room, which may be turned on or off at the pleasure of the occupants.

(4.) Each of the lecture rooms should be provided with an ante-room to serve as a study, or otherwise, for the Professors; and in it should be placed a small library of professional books bearing on the particular subject taught in the lecture room.

(5.) The rooms for drawing should be placed in the attic, or upper story, of the building. The entire flat could be made available for the drawing classes by running a partition down the centre of the room, and lighting each division of the room, partly by means of a sky-light, and partly by means of a window near the ceiling,—forming a continuation of the sky-light at the top—the drawing tables being arranged so that the light should come from the left at an angle of about 45°.

(6.) Black-boards are an essential feature in a School of Technology. No lecture room is complete without them; but they are not so necessary in the rooms for drawing, as the work is chiefly done on drawing-boards, &c. The best black-boards which we saw were those constructed of slate.

(7.) The laboratory working tables for students should be constructed on the alcove system between the windows, and placed at the sides of the rooms, and not in the middle.

(8.) A room for models of machinery and other mechanical contrivances, as well as for architectural models, should be provided. This room should be large enough to permit of easy access to the models by the students, for the purpose of sketching and drawing them. Such a room, with a good collection of enlarged models of machinery would serve as a substitute for machine shops (without involving their expense), especially if it had also specimens of tools, lathes and other appliances of useful handicraft, etc.

(9.) As a counterpart to this room for models, there should be one for a collection of mineralogical and metallurgical specimens and models of crystallography. If these collections of models and specimens could be placed on the same floors as the respective lecture rooms devoted to mechanics, metallurgy, etc., and be connected with them, the convenience and completeness of the arrangement would contribute largely to lessen the labours of the Professor, while easy access to the models, &c., would promote the progress and efficiency of the classes.

(10.) At the sides of the lecture rooms, (at the end) and behind the platform, it would be a great convenience to construct (in most of the lecture rooms) glass cases, in which to arrange the apparatus, and keep it from dust when not in use. The neatness and economy of such an arrangement would amply repay the institution for the original cost of the cases, and would ensure the care and safety of the apparatus, a good deal of which being fragile in its nature and delicate in its construction, would suffer greatly from exposure or carelessness.

(11.) A large public Lecture or Examination Hall, with suitable convenience for a lecturer, is an essential feature in an Institution of this kind. In such a Hall popular evening lectures on practical scientific subjects might be given, at which persons engaged during the day might attend. Such a Hall would also be useful for examinations, or for any public exercises connected with the Institution.

(12.) Finally, plainness, combined with neatness and convenience, should characterize the entire building. No unnecessary ornament or decoration should be used; but every part of the building should have a practical adaptation to the purposes for which it is designed. On this and other points we have obtained detailed information, which may be of service when the plans are being prepared.

IX.—Admission to the American Institutions—Fees—Vacation.

18. The minimum age at which students are admitted to the several institutions we visited was from 16 to 18 years. In all cases they were required to pass a prescribed examination chiefly in Arithmetic, Algebra (to quadratic equations,) Geometry, English Grammar and Geography.

19. The fees payable annually by each student (when not a State beneficiary) varied from $100 to $200. $150 we found to be the usual fee. In Cornell University it was at first only $30; it has now been raised to $45 per annum, with a prospect of a still further rise. A first supply of apparatus and chemicals was usually given to each student; subsequent supplies had to be paid for at about cost prices, while breakages were at the risk of the student, who was required to pay for them.

20. The School Term in each of the Institutions, visited, generally extended from July or August to September or October, giving to the Students a vacation of about two months in summer, and an interval of two weeks, or more, at Christmas.

X.—Discipline in the American Institutions.

21. In regard to the question of daily discipline among the Students of the Institutions which we visited, the invariable reply was that it was of the simplest kind—that it involved no anxiety on the part of the authorities or professors. The young men were of that age and character which required little more than an appeal to their better feelings, their ambition and their honour. This, and the fact that their continuance in the Institution depended upon their daily application and their individual progress, had a sufficiently salutary effect upon them to ensure good conduct, and a desire to conform to the rules of the Institution.

XI.—Mode of Teaching, Examinations, etc.

22. In most of the Institutions visited, the mode of teaching was by conversational lecture, combined with a daily system of questioning on the lesson of the preceding day. The Students were required to take notes of a certain class of lectures; but, where practicable, blackboard exercises on the part of the whole class was invariably the chief feature of the daily exercise or "recitations" of students. This was followed by a brief explanation of the lessons for the next day. At the end of each month (in some Institutions), and invariably at the end of each half year in all of them, the students were subjected to a rigid written examination, followed, in many cases, by an oral one, designed to test more fully the personal knowledge of the subject on the part of each individual student. The result of the half yearly examination determined the status as well as the continuance in the Institution of the student, and thus a healthy stimulus was kept up throughout the whole course.

XII.—Admission of Females to these Institutions.

23. Although in most of the Institutions visited, no regulations have been adopted to prevent the admission of female students to the classes, yet practically they do exist,—for in none of them are there any such students. In three out of the eight Institutions visited, the authorities refuse to admit them; in the others they successfully discourage their attendance. To the popular Evening Classes and Lectures, however, at the Massachusetts School of Technology (Boston), the Institute of Industrial Science (Worcester, Mass.), and the Cooper Union (New York), [where numbers of females can come together] they are freely admitted. Those reported in attendance at the Massachusetts Institutions, during the time of our visit, were chiefly the school teachers, who were fitting themselves for employment as instructors in drawing and chemistry in the Public Schools of that State. These subjects (especially drawing), we understand, having been recently prescribed by the Legislative for introduction into these Schools.

XIII.—Management and Government of the proposed College.

24. Having given at some length, the statistical and other details of the various Schools and Colleges visited by us, it now remains to make some general observations founded on the information obtained during our inspection of these Institutions.

25. We are naturally led to consider, in the first place, whether or not Technical Schools in the United States have been an assured success. To this question we can give an almost unqualified answer in the affirmative; for although there are cases in which the result has been a partial or complete failure, this is invariably attributed by those who possess experience on the subject, to the organization and government of the School, and not to the character of the education given in it. We have had the strongest testimony as to the necessity of keeping institutions for Technical Education entirely apart from, and independent of, any other Literary or Scientific Schools or Colleges; and to this point we would most particularly draw attention, for we consider it one of the chief essentials to success.

26. On no point, we repeat, was the testimony at the institutions we visited more clear, distinct and uniform than that the proposed School of Technology should, in its teaching

and management and government, be kept entirely distinct from any other institution. To attach it as an appendage to any school or college for teaching purposes would be to ensure its ultimate failure. The more efficient the institution to which it might be attached for these purposes (paradoxical as it may appear) the more certain and speedy would be the failure of the school. Even at the two distinguished American Universities of Harvard and Yale, where scientific schools exist, their efficiency and success is just in proportion to their entire practical separation for teaching and other purposes from the other parts of the University.*

27. At Columbia College, too, the scientific part of that University (the school of mines) is situated quite at a different part of the city from the rest of the college; and it is chiefly taught and managed by a different set of professors, etc., from those connected with the college proper. The plan upon which Cornell University appears to have been projected may seem to conflict with the experience of the older universities on this point. But, while it is admitted that the conception and design of Cornell University were noble and munificent in themselves, yet it is regarded by sagacious men as an experiment at present,—the success of which time alone can demonstrate. Even in Cornell the separation in the teaching and management was more marked than we expected to find it; but until a larger teaching staff is provided, the union of professorships in different departments of the University must be regarded as a serious defect in its organization.

28. There are one or two facts connected with this subject which we think worthy of your consideration, and which will tend to illustrate our meaning more clearly:—

(1.) Schools of Technology are *sui generis*. Their chief speciality is, in the highest sense, "object teaching,"—or teaching by illustration and practice. They require much mental, but still more of manual effort and physical labour on the part of the students. The classes, and even the individual students, require more constant teaching oversight and professorial supervision than in Colleges or Universities. This being the case, it must be obvious that the Professor of a College, or of any other purely literary institution, is not so well adapted (either by his daily habits of professorial routine, or by the character and mode of his instruction—its literary purpose and objects—) for taking charge of classes in another institution of a totally different character, as a person specially qualified for the work. Of course we speak generally; for no doubt a person may be found now and then who combines in himself, even in an eminent degree, the double qualification of which we speak.

(2.) Again: a divided interest in two institutions is fatal to success in either or both. It is contrary to the nature of things that it should be otherwise. Personal associations, leanings, preferences, and interest, singly or combined, tend to sway the individual more or less strongly towards one or other institution with which he may be connected. The result must, in the end, be (as we have stated) fatal to success in either or both. Besides, in the joint management of institutions partaking somewhat of the same character, and yet dissimilar in their objects, interests clash and points of difference arise, often unpleasant in themselves, which must invariably prove fatal to the efficiency of one or other. Although, as we understand, it is the intention of the Government to erect the School of Technology in Victoria Square (on the Normal School plot) yet we would strongly recommend that it be not associated or connected with that institution in any way, but left entirely under the care, management and control of the Government itself.

29. Such being the purport of our inquiries and observations on this subject, we beg respectfully to submit the results of them to your consideration, with a view to their practical application.

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* A pamphlet issued at Yale, on the relations of the colleges to the University, states that "The Classical or Academic and the Scientific departments (ordinarily called Yale College, and the Sheffield School of Science) are distinct colleges for the undergraduate students of the University—distinct in teachers, scholars, buildings, apparatus, and special working libraries. * * * The ranges of studies in the two Colleges, the Academic and Scientific, are so diverse in character, that the interests of the students and of education are better subserved by two distinct faculties working separately, than by one single combined faculty." Another pamphlet says:—

"The instructors of the Sheffield School are appointed by the Yale College Corporation, but they constitute a body as distinct from the Academic faculty as the faculties of Law, Medicine and Theology."

XIV.—Question as to the Advisability of Machine Shops.

30. The only Institution which we visited to which a Machine Shop was attached was that at Worcester, Massachusetts. In one or two others a small work shop (with lathes, tools, &c.) was provided. The general feeling on the subject is, that they are expensive and of doubtful utility, and that, if introduced at all, it should be to a very limited extent, and not for the purpose of training skilled mechanics. At Worcester, where a good machine shop exists, it is to some extent made available for the younger students, who are treated as apprentices. But, even there the shop is deemed an experiment. As the work done in the shop is thorough and of a saleable description, it competes in the open market, and brings its full value. The labour being cheaper than in other machine shops, it would appear that such a shop might not only be self-supporting, but profitable. There is, however, one serious drawback to this, that the experienced workmen are compelled to devote much time to novices and apprentices; but as the primary object of the machine shop is, not to make money, but to teach—the want of profit can scarcely be regarded in the light of a failure.

31. As a substitute for machine shops in the other Institutions, tools, models, and drawings are freely provided. The students are also required, as a regular part of their class training (and with a view to familiarize them with the actual details of work), to make regular visits of inspection in the neighbourhood to machine shops, engines, mills, furnaces, chemical works, &c. And when practical (especially during the holidays), facilities or encouragements are given to the students to visit with a professor, mining districts, large engineering constructions, important buildings, &c.

Note.—Students in the Engineering and Surveying Departments are statedly assigned given sections of country, in which they are required to "locate" a line of railway, or to make a topographical survey of it, as the case may be.

XV.—Necessity for Models of Machinery, Lathes, Collections of Tools, &c.

32. As already intimated, a substitute for machine shops (in connection with the students' visits of inspection to manufactories, mills, &c.), a collection of enlarged models of engines, and machinery of various kinds, is absolutely necessary. These models should be of sufficient size and construction to enable the student easily to understand the details of their mechanism, to take them apart and reconstruct them, to make sketches, isometric, perspective and working drawings of them, with the necessary details of plans and sections, &c.

33. In addition to these enlarged models, small models, charts, diagrams, and photographs of works and machinery, &c., should be procured. Whenever practical original working plans and drawings, with the estimate (or copies), and specifications of engineering works, or machinery, which have been actually constructed, should also be obtained. The latter, in the hands of students, give a reality to their theoretical instruction, which is invaluable to them in the progress of their studies. After a study of such plans and drawings, a visit of inspection to the work or machinery itself will more deeply impress on the student's mind the minutiæ of its details, and familiarize him more with the intricacy, and yet simplicity, of its parts, than a week's laborious study of the theory of the construction of the same piece of machinery or work.

XVI.—Laboratories for Students—Metallurgy.

34. We have before briefly referred to the subject of Students' Laboratories, and the necessity of a mineralogical and metallurgical collection of models and specimens. We cannot too strongly press upon your notice the necessity of providing amply for this department of instruction in the proposed Institution. The students should have every facility for pursuing their practical studies in chemistry and metallurgy, in the laboratories which we have already named. In a country like ours, whose mining interests are yet in their infancy, and which must every year increase in magnitude, we should seek to

train skilled men, who, by their knowledge and ability, can so materially aid in the development of this most important department of national wealth and industry.

XVII.—Persons to be benefitted by the College of Technology.

35. To these suggestions on the appliances of Technical Education, it may be well to add some of the advantages which, in our opinion, are likely to result from founding a Technical School or College in Ontario. We should anticipate, from what we have seen elsewhere, and from the character of the rapidly increasing industries of Canada, great benefits, both to the students themselves and to the country generally. Graduates and students of a well conducted and efficient Technical School necessarily share in its reputation; and a diploma or certificate from a good school is usually a passport to remunerative employment. A glance at the record of the after history of the graduates of some of the Technical Schools in the United States is amply sufficient to establish this statement. At one which we visited, we were informed that the Principal was quite unable to supply the constant demand for students to fill professional situations of a high and lucrative character. That the students themselves are sensible of the value of the training, is almost always shown by after donations to the museum or scientific collections, and in some cases, where they have obtained pecuniary assistance in their studies, by afterwards contributing in money the amount of the fees which they had, while students, been unable to pay.

36. To the general community a School of Industrial Science is of great value as a central source of information to manufacturers and others on all new discoveries pertaining to their pursuits. From the Professors in such a school, advice and opinions on scientific questions can be had, and in well trained students is to be obtained the scientific and practical assistance required in most manufacturing establishments. The students themselves become teachers of science; and both they and their professors extend the limits of science by original investigation. Every civilized country is devoting increased attention to this kind of education, as the best means of keeping their industries abreast of the general and rapid progress in all the industrial arts and manufactures; and we, therefore, believe for this, and for the other reasons given above, that a Technical College for the Province of Ontario is not only likely to prove beneficial and successful, but is an obvious and growing necessity.

37. It may, nevertheless, be asked: what particular *classes* of our population are likely to be benefitted by the projected School of Technology? We have in part anticipated a reply to this question in what we have already stated. It may, however, be desirable briefly to enumerate the various professions and callings which it is designed practically to benefit by the proposed Institution. They may, (following the classification at the Yale Scientific School,) be grouped together as follows:—

(1.) *Civil Engineers.*—Those who have to do with the construction of roads and bridges, railways, acqueducts, reservoirs, drainage systems and public works in general.

(2.) *Mechanical Engineers.*—With reference to the superintendence of manufactories, workshops, machine shops; the invention and construction of machinery, the applications of steam, etc.

(3.) *Mining Engineers.*—With reference to the development of the mineral wealth of the country, the superintendence of mines.

(4.) *Metallurgists and Assayers.*—Those who have to do with the analysis of iron, lead, copper, gold and silver ores.

(5.) *Chemists.*—With reference to agriculture, manufactures, pharmacy and various commercial pursuits.

(6.) *Physicians and Sanitary Advisers.*—In certain preparatory studies in physics, chemistry, botany, etc.

(7.) *Men of Science.*—Either as professors, teachers, explorers, investigators, etc.

XVIII.—Value of Such Schools Elsewhere.

38. It is not necessary in this report to refer except briefly to the invaluable results which have flowed in Europe from the establishment of such schools. In England (without referring to the newer departments of science in the National Universities, and other valuable science education agencies) the Department of Science and Art, and its latest development (as a great school of observation) of the South Kensington Museum, have given an immense impetus to industrial education and instruction in practical science in all the large cities and towns of the three Kingdoms. In Prussia, Switzerland and other parts of the Continent of Europe, the progress in this direction has been of late years greater than in the Mother country. But the recent work by Scott Russell, Esq., shewing the present unsatisfactory state of technical science and instruction in Great Britain (as compared with its higher development in other parts of Europe), has stimulated scientific men in Britain; and there is no doubt that the next few years will witness a vast improvement in this respect.

39. During our recent visit to the United States we made particular inquiries into the value and results to the community of the establishment of Technical Schools in that country. The replies received from the authorities of those institutions which had been long enough in existence to render any appreciable service were most gratifying. They furnished us in most cases with details showing where and how their students and graduates were employed after they had left the institution concerned. Numbers of them were professors, assistant professors and instructors elsewhere; many were employed by the Federal and State Governments on explorations in the distant Territories and in surveys elsewhere; numbers more were employed on railways, in manufactories, in mining, assaying and in public works requiring the highest engineering skill. On this latter part, one fact was mentioned which practically illustrated the great value of such schools. The planning and construction of the great suspension bridge, which it is designed to throw across the East River, at New York, to connect that city with Brooklyn, have been confided solely to the engineering skill of the graduates of the Rensselaer Polytechnic Institute, at Troy, N. Y. The chief engineer of that extensive work (W. A. Roebling, Esq.) and all his assistants are from that one Institution; and they have, we understand, fully and satisfactorily solved the problem of the practicability of that great work. Of the other graduates of that and other Schools, we learned that they were employed in all the national undertakings requiring engineering skill. They are also employed as State Geologists, Surveyors-General of States, Engineers of Railways, Superintendents of Iron Works, Manufactories, etc. The development of American talent and ingenuity may be gathered from the fact that the number of patents for inventions issued by the Department at Washington each year is about 10,000!

XIX.—Necessity for a School of Technology for Ontario.

40. No one who has attentively studied the educational progress which we have made during the last ten years, or carefully watched the development of the material resources and manufacturing industries of this Province, but must have been painfully struck with the fact that, while we have liberally provided for the merely intellectual wants of our people, we have almost entirely neglected making any provision for training, and then turning to practical account that superior scientific and industrial skill among ourselves, which in other countries contribute so largely and effectively to develop their physical and industrial resources. We have hitherto been content to receive our supply of such skilled assistance from abroad; and we have left to European and American Institutions the duty of developing the Canadian talent and ability of such of our youths as have enterprise and means enough to go abroad to acquire that practical knowledge of the industrial arts, which we deny to them in their native land.

41. In this respect our American neighbours furnish a favourable contrast, and display their usual national sagacity. In their great industrial and manufacturing centres, they have established institutions devoted to industrial science and education. Nor have they been content with a meagre provision in this respect. In the small State of Massachusetts,

(with a population in 1870 of 1,457,000,) they have already established *three* such institutions as the Government now propose to establish in this Province. In the neighbouring State of New York, they have no less than four Schools of Technology (more or less extensive), one of which was established nearly fifty years ago. The result has been that in all their great civil, military, engineering and industrial and mining projects, they have been able at all times to command the best skill and talent among themselves; and that talent always receives a sufficient encouragement by being constantly employed either in the service of the State, or in the great railway, mining or industrial enterprises which are so largely developed and encouraged in the United States.

42. As to our own country, some may doubtingly ask: what need is there that we (a young country) should provide for instruction in the industrial and mechanical arts? To this we reply, that the almost unconscious development among ourselves of the manufacturing interests of the country has reached a magnitude and importance that it would be suicidal to those interests (in these days of keen competition with our American neighbours) and injurious to their proper development, not to provide without delay for the production among ourselves of a class of skilled machinists, manufacturers, engineers, chemists and others. No one can visit any of the industrial centres which have sprung up in different parts of the country and in our larger towns, without being struck with their value and importance, and the number and variety of the skilled labourers employed. Inquiry into the source of supply of this industrial class reveals the fact, that, from the youngest employe up to the foreman of the works, they are almost entirely indebted to England, Scotland, the United States and other countries for that supply.

43. If you pursue your inquiries further, and ask what provision is made in the schools of the town or other establishments in the county for instructing young lads in the elements of Mechanics, Chemistry and Natural Philosophy, and thus preparing them in some degree for supplying the natural demand created in these establishments? you will find that there has been little done of a practical nature in this direction; and that these subjects have been allowed to occupy a subordinate place in the course of study in the public schools. There are exceptions, of course, in some schools, but not to any great extent.* We are glad to find that this will be no longer the case; but that, influenced by a knowledge of the facts which we have stated, provision has been made in the New School Bill, for giving due prominence to these important subjects in all our high schools.

44. As a fitting sequel to this provision in the High Schools, for developing the taste and stimulating the desire of our youths to prepare themselves for industrial pursuits, is the proposal to establish a school of Technology. Such an institution will supply a great desideratum; and with the elementary training now proposed in our high schools, will enable us to provide within ourselves for the supply which the manufacturing establishments that have grown up in the country, so imperatively demand. A boy, who in his school career shows a mechanical turn, or scientific taste, will no longer have to seek its higher development outside of our own country, or, from want of means, leave it ungratified. He will now have provided, almost at his own door, an institution which will be admirably fitted to give the freest scope to his talent and genius in this particular direction.

45. Rising up above this mere local view of the question, other broader and more comprehensive ones force themselves upon our attention. Are we not conscious of the extraordinary scientific and industrial progress of the present day? Do we not hope for, and predict under God's providence, a great future for this country? Have we not in the assertion of our incipient nationality, entered the lists of industrial competition with the United States, and even with England and other countries? And do we not, therefore, require to make, without delay some provision for training that class of our young men, who must in the future take the leading part in that competition? The wonderful progress of the mechanic arts, is within the memory of most of us. The marvellous revolution, caused by the practical application of steam and telegraphy (those golden links of science),

* From the last report of the Chief Superintendent of Education for Ontario, we find that out of 6,500 pupils in the Grammar Schools, 1,681 were reported in classes of Physical Science, only 885 in drawing, and 429 in the elements of Mensuration and Surveying.

to locomotion, commerce, industry, and intercommunication, has so stimulated the inventive genius of man, that we now cease to be astonished at any new discovery; and only await each successive development of science still more wonderful than the last, to calmly discuss its merits each advantages. In this active race of competition, our Province (the leading onein the Dominion), cannot stand still. With all of our inventions, we have not yet been able to discover a royal road to learning; and our youth cannot, Minerva-like, spring fully armed into the arena of competitive science and skill. We must, therefore, provide liberally for their patient and practical instruction in every grade and department of knowledge, so that, with God's blessing, we shall not fall behind in the great race of national intelligence and progress.

XX. Recent important movements in Great Britain and Ireland in the direction of Technical Education.

46. We have, we trust, satisfactorily shown what is being done in the United States to promote Technical Education, and have sought to demonstrate the necessity for our own movement in this direction. We will now endeavour to show what steps have recently been taken in Britain the more efficiently to promote science education in the Mother country. From a recent Report of a Committee of the House of Commons (appointed after the results of the Paris Exhibition of 1867 had demonstrated the comparatively inferior position of England in certain developments of industry) "*to inquire into the Provisions for giving Instruction in Theoretical and Applied Science to the Industrial Classes*," dated 1868, we find that this whole subject was fully discussed. 8276 questions were proposed to and answered by representatives from the Government Departments of Education and Science, the Universities and Colleges, Mechanics' Institutes, Science Schools, and manufacturing centres of England and Scotland. (A separate commission was issued for Ireland, to which we shall presently refer.) From the report itself, founded upon this mass of evidence, we make a few extracts to which we would especially invite your attention. These extracts go to prove most conclusively that it is not from want of "practical experience and manipulative skill," which "are possessed in a pre eminent degree" by British artisans that comparative failure is owing, but to the absence of "scientific training" and thoroughness "elementary education" which latter is so universal among the working populations of Germany and Switzerland.

47. Speaking of the "*Relation of Industrial Education to Industrial Progress*," the Committee remark: "The industrial system of the present age is based on the substitution of mechanical for manual power. * * * The acquisition of scientific knowledge has been shown by the witnesses to be only one of the elements of an industrial education and of industrial progress. * * * The other indispensible element of industrial success is the acquisition of practical experience and manipulative skill. The evidence given before your Committee places beyond all doubt the fact that *these latter acquirements* are possessed in a pre-eminent degree by our manufacturing population of every grade, according to their several necessities. They are obtained in our factories, our forges, our workshops, our shipyards and our mines, which in their organization and appliances are the models which, with a few special exceptions, other nations have hitherto imitated and followed, but not surpassed."

48. In endeavouring therefore to account for the fact that the English manufacturers and artisans are surpassed by their Continental rivals, the Report goes on to discuss the whole question in the following striking language:—"Although the pressure of foreign competition, where it exists, is considered by some witnesses to be partly owing to the superior scientific attainments of foreign manufacturers, yet the general result of the evidence proves that it is to be attributed mainly to their artistic taste, to fashion, to lower wages, and to the absence of trade disputes abroad, and to the greater readiness with which handicraftsmen abroad, in some trades, adopt themselves to new requirements. * * * Only two witnesses from Birmingham, the one an eminent merchant, the other a manufacturing jeweller, and Mr. Gill, a woollen manufacturer, of Innerleithen, in Scotland, attribute the loss of certain trades to the superior skill, appliances and education of the German, Belgian and American manufacturers; and the great

steel works of Krupp, in Westphalia, have been named as the only instance of a factory which is said to possess an organization superior to that of any establishment in the same branch of industry in this country."

"At the same time, nearly every witness speaks of the extraordinary rapid progress of Continental nations in manufactures, and attributes that rapidity, not to the model workshops which are met with in some foreign countries, and are but an indifferent substitute for our own great factories, and for those which are rising up in every part of the continent; but, besides other causes, to the scientific training of the proprietors and managers in France, Switzerland, Belgium and Germany, and to the elementary instruction which is universal amongst the working population of Germany and Switzerland. There can be no doubt, from the evidence of Mr. Mundella, of Professor Fleeming Jenkin, Mr. Kitson, and others, and from the numerous reports of competent observers, that the facilities for acquiring a knowledge of theoretical and applied science are incomparably greater on the continent than in this country, and that such knowledge is based on an advanced state of secondary education.

"All the witneses concur in desiring similar advantages of education for this country, and are satisfied that nothing more is required, and that nothing less will suffice, in order that we may retain the position which we now hold in the van of all industrial nations. All are of opinion that it is of incalculable importance economically that our manufacturers and managers should be thoroughly instructed in the principles of their arts.

"They are convinced that a knowledge of the principles of science on the part of those who occupy the higher industrial ranks, and the possession of elementary instruction by those who hold subordinate positions, would tend to promote industrial progress by stimulating improvement, preventing costly and unphilosophical attempts at impossible inventions, diminishing waste, and obviating, in a great measure, ignorant opposition to salutary changes.

"Whilst all the witnesses concurred in believing that the economical necessity for general and scientific education is not yet fully realized by the country, some of them consider it essential that the Government should interfere much more actively than it has done hitherto, to promote the establishment of scientific schools and colleges in our great industrial centres."

49. As to the "conclusions" at which the members of the Committee arrived, we give them in their own words, as follows:—

"The evidence which has been given before your Committee, and in part summarized in the preceding pages, together with the information which is accessible to them in common with other members of the community, has convinced them:

"(1.) That with the view to enable the working class to benefit by scientific instruction, it is of the utmost importance that efficient elementary instruction should be within the reach of every child.

"(2.) That unless regular attendance of the children for a sufficient period can be obtained, little can be done in the way of their scientific instruction.

"(3.) That elementary instruction in drawing, in physical geography, and in the phe nomena of nature, should be given in elementary schools.

"(4.) That adult science classes, though of great use to artizans, to foremen, and to smaller manufacturers, cannot provide all the scientific instruction which those should who are responsible for the conduct of important industrial undertakings. That all necessities do not oblige them to leave school before the age of 14, should receive in-tion in the elements of science as part of their general education.

"(5.) That the re-organization of secondary instruction, and the introduction of a larger amount of scientific teaching into secondary schools, are urgently required, and ought to receive the immediate consideration of parliament and the country.

"(6.) That it is desirable that certain endowed schools should be selected in favourable situations, for the purpose of being reconstituted as science schools.

"(7.) That superior colleges of science, and schools for special scientific instruction requiring costly buildings and laboratories, cannot be supported by fees alone, without aid from one or more of the following sources, namely, the state, the localities, and endowments or other benefactions.

"(8.) That such colleges and special schools are most likely to be successful if established in centres of industry, because the choice of such centres tends to promote the combination of science with practice on the part both of the professors and of the pupils.

"(9.) That the provinces of England, especially the agricultural districts, have not received a sufficient proportion of the State grants for scientific education.

"(10.) (Local.)

"(11.) That some slight addition to the emoluments of science teachers would probably tend materially to promote the establishment and permanence of elementary science classes.

"(12.) (Local.)

"(13.) That the managers of training colleges for the teachers of elementary schools should give special attention to the instruction of those teachers in theoretical and applied science, where such instruction does not exist already.

"(14.) That teachers in elementary day schools should be paid on results for teaching science to the older scholars, in the same way as payment is now made for drawing in such schools. That the education of higher science teachers should be encouraged, by the granting of degrees in science at Oxford and Cambridge, as at other universities, and by the opening of a greater number of fellowships to distinction in natural science, as well as in literature, and mathematical and moral science."

50. From the same report, and from the evidence of Dr. Lyon Playfair, contained in that report, we learn that "in Scotland, where the superior primary instruction of the artizans removes one of the obstacles to their acquiring scientific instruction, the Watt Institution of Edinburgh, and the Andersonian University of Glasgow, have rendered good service, the former during nearly half a century, the latter for more than 20 years; they can boast amongst their scholars such names as those of Nasmyth, James Young, and many others."

51. Dr. Playfair says:—"The four Scotch universities for very many years have given much more science instruction than the Universities in England, and the effect of that has been that they have got a great hold of the population; there are more university students in proportion to the population in Scotland than there are in any other part of the world; there is one university student for every 866 of the Scotch population, while there is only one university student for every 5,445 of the population in England; and one university student to every 2,894 of the population in Ireland, so that it will be seen that we have got in Scotland much more hold of the people on account, I believe, mainly of our teaching subjects which relate to their future vocations in life. We have lately in Edinburgh established a professorship of engineering, and one also of Agriculture. We had an old foundation of agriculture, and we have now put it on an efficient footing. For the first time I believe, in the history of British colleges, we have established degrees in technical science equal in rank to that of masters of arts or doctor of medicine, or bachelor in law; our new degrees being applicable to agriculture, engineering and veterinary surgery."

52. From the "Report of a Commission on Science and Art in Ireland," dated in 1869, we learn that in that country a "College of Science" had been recently established The object of this college is to afford "a complete and thorough course of instruction in those branches of science which are more immediately connected with and applied to all descriptions of industry, including Agriculture, Mining and Manufactures; that it should in this way supplement the elementary scientific instruction already provided for by the Science Schools of the Department; and that it should assist in the training of teachers for these schools."

53. From the same Report we condense the following summary of the latest Regulaions (1869) of the Science and Art Department for the promotion of education in those ubjects in the United Kingdom:—

"The action of the Science and Art Department is to aid instruction in *science* in the following subjects :—1, practical, plane and solid geometry ; 2, machine construction and drawing ; 3, building construction, or naval architecture and drawing ; 4, elementary mathematics ; 5, higher mathematics ; 6, theoretical mechanics ; 7, applied mechanics : 8, acoustics, light and heat ; 9, magnetism and electricity ; 10, inorganic chemistry : 11, organic chemistry ; 12, geology ; 13, mineralogy ; 14, animal physiology ; 15, zoology ; 16, vegetable physiology and economic botany ; 17, systematic botany ; 18, mining ; 19, metallurgy ; 20, navigation ; 21, nautical astronomy ; 22, steam ; 23, physical geography. And in *Art* in :—(1) elementary drawing as an education of the power of observation, and (2) drawing, painting, modelling, and designing for manufacture and decoration.

As respects *Science*, the aid consists of—

(*a*) Public examinations, in which Queen's medals and Queen's prizes are awarded held at all places complying with certain conditions.

(*b.*) Payments on results to teachers, as tested by examination.

(*c.*) Scholarships and exhibitions.

(*d.*) Building grants.

(*e.*) Grants towards the purchase of apparatus, &c.

The *Examinations* are held in May by the local committees. The examination papers are prepared by the professional examiners in London, and are sent to the local secretary ; one evening is set apart for each subject, so that the examination in each subject is simultaneous.

"*Payments* are made to the teachers on the *results* of the May examination. Any person may qualify to earn payments on results—

(*a.*) By obtaining a first or second class in the advanced grade of the class examination ; or,

(*b.*) By taking honours.

	1867.				1868.			
	England.	Ireland.	Scotland.	Total.	England.	Ireland.	Scotland.	Total.
Number of Science Schools..	150	53	9	212	210	76	15	301
Number of persons under instruction	6,441	2,125	1,664	10,230	9,480	2,870	2,611	14,961
Number of persons examined	3,288	1,409	223	4,920	5,077	1,714	360	7,161
Number of papers worked ...	5,933	1,895	385	8,213	9,845	2,813	457	13,113
Amount paid to teachers.*...	£5,513	£2,017	£446	£7,976	£8,455	£3,269	£381	£12,105
Number of teachers qualified to earn payments engaged..............	138	50	12	200	206	75	12	293

"There are two forms of *scholarship* in connection with Elementary schools.

"1st. In the *Elementary School Scholarship*, £5 are granted to the managers of any elementary school for the support of a deserving pupil, selected by competition, if they undertake to support him for a year and subscribe £5 for that purpose. The payment of £5 by the Science and Art Department is conditional on the scholar passing in some branch of science at the May examination.

"2nd. *The Science and Art Scholarship* is of a more advanced character, and does not depend on any corresponding contribution on the part of the locality. A grant of £10 is made towards the maintenance, for one year, of the most deserving pupil or pupils in elementary schools who have passed certain examinations in science and in drawing.

"In both these cases the scholar must be from twelve to sixteen years of age, and one scholarship is allowed per 100 pupils in the school.

"The exhibitions are :—

* This is the amount up to the present time, all the claims not having yet been paid.

1st. *Local Exhibitions,* for advanced scientific instruction, to enable students to complete their education at some college or school where scientific instruction of an advanced character may be obtained. Grants of £25 per annum for one, two or three years are made for this purpose, when the locality raises a like sum by voluntary subscriptions. And if the student attend a State school, such as the Royal School of Mines in London, the Royal College of Chemistry in London, or Royal College of Science in Ireland, the fees are remitted. The exhibition must be awarded in competition.

"2nd. *Royal Exhibitions* of the value of £50 per annum, tenable for three years, to the Royal School of Mines, London, and the Royal College of Science, Dublin, are given in competition at the May examinations. Six are awarded each year—three to each institution. Free admissions are also given to all gold medallists.

"Besides these the *Whitworth Scholarships,* of the value of £100 per annum, tenable for two or three years, are also given in competition at the May examinations.

"A *grant* in aid of a *new building,* or for the adaptation of an existing building, for a school of science may be made at a rate not exceeding 2s. 6d. per square foot of internal area, up to a maximum of £500 for any one school, provided that the school—

"(*a.*) Be built under the Public Libraries Act;

"(*b.*) Be built in connection with a school of art, aided by a Department building grant;

And certain other conditions.

"A *grant,* towards the *purchase of apparatus, diagrams,* &c., of 50 per cent. of the cost of them, is made to science schools.

"As respects Art the aid is:—

"Firstly. Towards the teaching of *elementary drawing in schools for the poor.* This aid consists of payments to the managers of schools instructed by teachers certificated for drawing (*a*), of 1s., 2s. or 3s., on account of children who pass a very elementary, the 'first grade," examination; (*b*), of 5s. or 10s. on children or pupil teachers who pass the more advanced, or "second grade" examination; and (*c*), of prizes to successful children and pupil teachers.

"The "first grade" consists of free hand drawing in outline from flat examples, drawing from regular solids or objects of simple form, and of easy problems in practical geometry.

The second grade examination is of a higher standard than that of the first grade, but in the same subjects, with the addition of perspective and mechanical drawing. Examinations are held in May, in any elementary school, taught by a master, holding a certificate for drawing, or who has passed a second grade examination in any of the above three subjects of drawing.

"Secondly,—Towards art instruction in *night classes for artizans,* held in elementary schools, in literary, mechanics' or similar institutions. This aid consists of payments to the managers of 10 or 15 on account of artizans, or their children, above 12 years of age, satisfactorily taught drawing of the second or third grades, by certificated teachers; of prizes to successful students; and of payments towards the local expenses of examination.

The 'third grade' is represented by works embracing the whole course of instruction in night classes, or schools of art, such as drawing from examples, from casts or models, from nature, the antique, or the life; painting, flowers, landscape, or from life; designing or drawing for decorative purposes.

"Thirdly,—To *Schools of Art* being held in room entirely devoted to art instruction. This aid consists of similar payments to the managers to those awarded to night classes, and of the following additional payments:—

"20s. on account of every artizan satisfactorily instructed in art.

"£15, or £30 on account of art pupil-teachers.

"£5, or £10 on account of students trained for art teachers, or national art-scholars.

"£3, on account of free studentships to artizans, submitting advanced works.

"£10, on account of expenses of annual report and examination.

"Prizes are given to successful students, and the advanced studies of the schools of art are brought together in a *national competition*, when *gold, silver* and *bronze medals*, and other prizes, are awarded. All payments are contingent on the employment of certificated teachers.

"Elementary schools, night classes, and schools of art, are aided to the extent of 75 per cent. in the purchase of *examples*.

"*Grants* are made in aid of *building* schools of art.

"Fourthly,—By the maintenance of the *National Art Training School*, at South Kensington, in which highly qualified students from local schools of art, are admitted and trained as masters for schools of art, or as designers, or art-workmen. Such students receive allowances for their support of from 15s. to 40s. weekly.

"Fifthly,—Through the *National Museum of Decorative Art* and the *National Art Library*, which are made as far as possible, circulating collections for the benefit of local schools of art.

"Number of schools to which Grants were made in—

	England.	Ireland.	Scotland.
Schools of Art	80	5	9
Night Classes	59	2	2
Elementary Schools	500	29	59

PAYMENTS ON RESULTS OF ART EXAMINATIONS, 1867.

	England.			Ireland.			Scotland.		
	£	s.	d.	£	s.	d.	£	s.	d.
Schools of Art	4701	11	7	235	6	1	875	9	1½
Night Classes	358	12	10¾	53	5	0	35	6	9½
Elementary Schools	2650	18	0	136	10	0	293	14	0

54. Such are the encouragements, in the mother country, to scientific education. We forbear to enter into further details in regard to the condition and progress of industrial science in other parts of Europe. Germany, supreme in the art and appliances of war, is fast becoming the work-shop of Europe. Even in these other countries, where the physical labour is abundant, science in its application to the mechanic arts, is felt to be not so much a labour-saving as a labour-multiplying power. It is, therefore, to a new country, a substitution in part for immigration of a most valuable and substantial kind, and one which should be stimulated in every possible way. It is estimated that in the United States alone, steam and water applied to machinery, is equivalent to the power of *one hundred millions of men!* The results of labour, under such circumstances, becomes less dependent upon physical effort, than on the skill and ability of the workman in the use of tools and mechanical contrivances. The question of technical education, is therefore not an open and debatable one. It is a national necessity.

55. We trust that the information which we have collected and embodied in this Report, will put the Government in possession of all the facts which they desire to obtain in regard to Schools of Technology in the United States.

All of which is respectfully submitted to your consideration.

We have the honour to be,

Sir,

Your obedient, humble servants,

J. George Hodgins.

Alex. T. Machattie.

APPENDIX A.

COURSE OF STUDY IN THE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

BOSTON. 1870-71.

The Massachusetts Institute of Technology provides a four years' course of scientific and literary studies and practical exercises, embracing pure and applied mathematics, the physical and natural sciences with their applications, drawing, the English language, mental and political science, French and German. The course is so selected and arranged as to offer a liberal and practical education in preparation for active pursuits, as well as a thorough training for the professions of the Civil and Mechanical Engineer, Chemist, Metallurgist, Engineer of Mines, Architect, and Teacher of Science. All the studies and exercises of the first and second years are pursued by the whole school. At the beginning of the third year, each student selects one of the following special courses of study:—

1. A Course in Mechanical Engineering.
2. " " Civil and Topographical Engineering.
3. " " Chemistry.
4. " " Geology and Mining Engineering.
5. " " Building and Architecture.
6. " " Science and Literature.

CONDITIONS OF ADMISSION.

To be admitted to the first year's class the student must have attained the age of sixteen years, and must pass a satisfactory examination in arithmetic, so much of algebra as precedes equations of the second degree, plane geometry, English grammar and geography. In general, the training given at the best High Schools, Academies, and Classical Schools, will be a suitable preparation for the studies of this School.

In order to enter the second year's class, the student must be at least seventeen years of age, and must pass a satisfactory examination upon the first year's studies, besides passing the examination for admission to the first year's class; and a like rule applies to the case of students seeking admission into the classes of the succeeding years.

Graduates of Colleges will, in general, be presumed to have the requisite attainments for entering the third year as regular students, and may do so on satisfying the department they purpose to enter that they are prepared to pursue their studies to advantage.

A knowledge of the Latin language is not required for admission; but the study of Latin is strongly recommended to persons who propose to enter this School.

COURSE OF INSTRUCTION.

First Year.

Mathematics.—Algebra beginning with quadratic equations and including logarithms.

Solid Geometry. Mensuration. Plane Trigonometry. Applications of Trigonometry to Navigation.

Physics.—Sound. Heat.

Chemistry.—Experimental study of General Inorganic Chemistry.

English.—Composition. History and Structure of the Language.

French.—Grammar and Translation.

German.

Descriptive Geometry.—Problems of position relative to the Point, the Right Line and the Plane.

Mechanical Drawing.—Use of instruments, water-colors and India-ink. Graphical construction of problems in Geometry, Trigonometry and Descriptive Geometry.

Free-hand Drawing.—With chalk and crayons. Machinery. Ornamentation.

Second Year.

Mathematics.—Spherical Trigonometry. Analytic Geometry of two and three dimensions. First Principles of the Differential and Integral Calculus.

Descriptive Astronomy.—The Earth. The Sun. Time. Gravitation. The Moon. Planets. Comets. Nebulæ. Constellations.

Surveying.—Field Work. Plotting surveys. Computing areas. Plans.

Physics.—Light. Magnetism. Electricity.

Chemistry.—Qualitative Analysis. Organic Chemistry.

English.—Composition. Reading. History of the Language.

French.—Grammar and Translation.

German.

Descriptive Geometry.—Projections, Perspective, Shades and Shadows.

Mechanical Drawing.—Geometric, Perspective, and Isometric Drawing.

Free-hand Drawing.—Machinery. Ornamentation. Landscape.

Third Year.

I.—Course in Mechanical Engineering.

Machinery.—Cinematics. Principles of Mechanism. Measurement of the Dynamic Effect of Machines. Regulating Apparatus, as Brakes, Fly-Wheels, Governors, etc. Friction and Rigidity. Materials, Construction, and Strength of Machinery. Action of Cutting Tools.

Mathematics.—Differential and Integral Calculus. Analytic Mechanics.

Applied Mechanics.—Dynamics of Solids. Hydrostatics and Hydrodynamics. Thermodynamics.

Descriptive Geometry—Applications to Masonry, Carpentry, and Machinery.

Metallurgy.—Metallurgical Processes, Constructions and Implements.

Drawing.—Machinery.

Physics.—Laboratory Practice.

Geology.—Physiographic Geology. Lithology. Outline of Geological History. Dynamical Geology.

English.—Logic. Rhetoric. History of English Literature.

Constitutional History.—England and the United States.

French.—(Spanish may be substituted.)

German.—

II.—Course in Civil and Topographical Engineering.

Engineering.—Survey, Location, and Construction of Roads, Railways, and Canals. Measurement and Computation of Earthwork and Masonry. Supply and Distribution of

Water. Drainage. Hpdrographical Surveying. River and Harbor Improvements. Field Practice.

Topography.—As practised by the U. S. Coast Survey.

Mathematics.—Differential and Integral Calculus. Analytic Mechanics.

Applied Mechanics.—Stress. Stability, Strength, and Stiffness.

Spherical Astronomy.—Higher Geodesy. Latitude and Longitude.

Descriptive Geometry.—Applications to Masonry and Carpentry.

Drawing.—Plans, Profiles, Elevations, Sections, etc.

Physics.—Laboratory Practice.

Geology.—Physiographic Geology. Lithology. Outline of Geological History. Dynamical Geology,

English.—Logic. Rhetoric. History of English Literature.

Constitutional History.—England and the United States.

French.—(Spanish may be substituted.)

German.

III.—Course in Chemistry.

Industrial Chemistry.—Study of Chemical Manufactures. Glass, Pottery, Soda-ash Acids, Soap, Gas, etc. The Arts of Dyeing, Calico Printing, Tanning, Brewing, Distilling, etc.

Metallurgy.—Metallurgical Processes, Constructions, and Implements.

Assaying.—Wet and Dry Ways.

Descriptive and Determinative Mineralogy.—Use of the Blowpipe.

The foregoing studies are elective. Each student must select one or more of them. The following studies are required:—

Quantitative Chemical Analysis.—Laboratory Practice.

Drawing.—Chemical or Metallurgical Apparatus. Plans of Works.

Physics.—Laboratory Practice.

Geology.—Physiographic Geology. Lithology. Outline of Geological History. Dynamical Geology.

English.—Logic. Rhetoric. History of English Literature.

Constitutional History.—England and the United States.

French.—(Spanish may be substituted.)

German.

IV.—Course in Mining Engineering.

Engineering.—Survey and Construction of Roads and Railways, Measurement of Earthwork and Masonry. Hydraulics. Draining. Field Practice.

Descriptive and Determinative Mineralogy.—Use of the Blowpipe.

Assaying.—Wet and Dry Ways.

Quantitative Chemical Analysis.—Laboratory Practice.

Metallurgy.—Metallurgical Processes, Constructions, and Implements. Furnaces, Crucibles, Blowing Machines, Fuels, and Fluxes.

Mathematics.—Differential and Integral Calculus. Analytic Mechanics.

Applied Mechanics.—Stress. Stability, Strength, and Stiffnesss.

Drawing.—Sections and Maps. Mines. Metallurgical Apparatus.

Physics.—Laboratory Practice.

Geology. Physiographic Geology. Lithology. Outline of Geological History. Dynamical Geology.

English. Logic. Rhetoric. History of English Literature.

Geology.—Physiographic Geology. Lithology. Outline of Geological History. Dynamical Geology.

English.—Logic. Rhetoric. History of English Literature.

Constitutional History.—England and the United States.

French.—(Spanish may be substituted.)

German.

V.—Course in Building and Architecture.

Architectural Design.—The Elements of Design. The Principles of Composition. Exercises. The Study of Executed Works.

Construction.—Building Materials and Processes. The Study of Works in Progress.

Drawing.—Plans, Elevations, Sections, and Details. Ornament. Sketching from Buildings.

Mathematics.—Differential and Integral Calculus. Analytic Mechanics.

Applied Mechanics.—Stress. Stability, Strength, and Stiffness.

Descriptive Geometry.—Applications to Masonry and Carpentry.

Geology.—Physiographic Geology. Lithology. Outline of Geological History.

English.—Logic. Rhetoric. History of English Literature.

Constitutional History.—England and the United States.

French.—(Spanish may be substituted.)

German.

VI.—Course in Science and Literature.

Mathematics.—Differential and Integral Calculus. Analytic Mechanics.

Chemistry.—Quantitative Analysis. Pure and Applied Chemistry.

Physics.—Physical Research.

Architectural Design.—The Elements of Design. The Principles of Composition. Exercises. The Study of Executed Works.

The foregoing studies are elective. Each student must select one or more of them. He may in addition choose any of the special subjects of the other Professional Courses, such as Descriptive Geometry, Engineering, Spherical Astronomy, Metallurgy, or Mineralogy. The following studies are required :—

History,—Guizot—Histoire Generale de la Civilisation en Europe.

Drawing.—Subjects determined by each student's choice of studies.

Physics.—Laboratory Practice.

Geology.—Physiographic Geology. Lithology. Outline of Geological History. Dynamical Geology.

English.—Logic. Rhetoric. History of English Literature.

Constitutional History.—England and the United States.

French.—(Spanish may be substituted.)

German.

Fourth Year.

I.—Course in Mechanical Engineering.

Machines.—Strength and Proportions of the Parts of a Machine. Hand Machinery,—Cranes, Derricks, Pumps, Turn-tables, etc.

Motors.—Hydraulic Moters. Water-wheels. Water-Pressure Engines. Power and Strength of Boilers. Steam Engines,—Stationary, Locomotive, Marine. Air and Gas Engines.

Building Materials.—Stones, Bricks, Mortars and Cements.

Descriptive Geometry.—Applications to Masonry, Carpentry, and Machinery. Modelling.

Drawing.—Machines. Working Plans and Projects of Machinery, Mills, etc.

Political Economy.

Natural History.—Zoology, Physiology.

French.—(Italian may be substituted.)

German.

II.—Course in Civil and Topographical Engineering.

Engineering.—Structures of Wood,—Framing, Trusses, Girders, Arches, Roofs, Bridges. Structures of Stone,—Foundations, Retaining Walls, Arches, Bridges. Structures of Iron,—Foundations, Beams, Girders, Columns, Roofs, Bridges. Field Practice.

Physical Hydrography.—As practised by the U. S. Coast Survey.

Machinery and Motors.—Hand Machinery. Water-wheels. Boilers. Steam-en gines
Building Materials.—Stones, Bricks, Mortars, and Cements.
Descriptive Geometry.—Applications to Masonry and Carpentry.
Drawing.—Plans, Profiles, Elevations, Sections, etc.
Political Economy.
Natural History.—Zoölogy and Physiology.
French.—(Italian may be substituted.)
German.

III—Course in Chemistry.

Chemistry.—Pure and Applied. Quantitative Analysis. Preparation of Chemical Products. Special Researches.
Building Materials.—Stones, Bricks, Mortars, and Cements.
Drawing.—Apparatus. Machinery and Plans of Works.
Political Economy.
Natural History.—Zoölogy and Physiology.
French.—(Italian may be substituted.)
German.

IV.—Course in Mining Engineering.

Mining.—The Useful Minerals. Modes of occurrence. Prospecting. Boring. Blasting. Sinking Shafts,—Timbering, Walling, and Tubbing. Driving Levels. Methods of Mining. Ventilation. Lighting. Winding Machinery. Ladders and Man-Engines. Underground Transportation. Pumps. Dressing and Concentration of Ores.—Crushers, Stamps, Washers, Amalgamators, etc. Details of American Mining.
Machinery and Motors.—Hand Machinery. Water-wheels. Boilers. Steam-engines.
Engineering.—Structures of Wood, Stone, and Iron. Foundations, Walls, Arches, Domes, Beams, Trusses, Girders, Roofs.
Chemistry.—Quantitative Analysis. Laboratory Practice.
Geology.—Historical Geology. Palæontology. Detailed study of American Geology.
Building Materials.—Stones, Bricks, Mortars, and Cements.
Drawing.—Geological Maps and Sections. Plans and Sections of Mines, Quarries and other open Workings. Mining Machinery and Implements.
Political Economy.
Natural History.—Zoölogy and Physiology.
French.—(Italian may be substituted.)
German.

V.—Course in Building and Architecture.

Architectural Design.—Exercises in Composition. History of Architecture. The other Arts of Design.
Professional Practice.—Specifications. Contracts. Estimating and Measuring. Superintendence.
Drawing.—Architecture, Landscape, and the Human Figure. Lithography and Etching. Modelling. Drawing from Memory.
Engineering.—Structures of Wood, Stone, and Iron. Foundations, Walls, Arches, Domes, Beams, Trusses, Girders, Roofs.
Descriptive Geometry.—Applications to Masonry and Carpentry.
Warming, Lighting, Ventilating, Acoustics. Lectures.
Building Materials.—Stones, Bricks, Mortars and Cements.
Political Economy.
Natural History.—Zoölogy and Physiology.
French.—(Italian may be substituted.)
German.

VI.—Course in Science and Literature.

The Higher Mathematics.
Chemistry.—Special Researches.
Physics.—Special Researches.
Architectural Design.—Exercises in Composition. History of Architecture. The other Arts of Design.

The foregoing studies are elective. Each student must select one or more of them. He may in addition choose any of the special subjects of the other Professional Courses, such as Machinery and Motors, Descriptive Geometry, Engineering, Mining, or Geology. The following studies are required:—

Mental Science.
Building Materials.—Stones, Bricks, Mortars, and Cements.
Drawing.—Subjects determined by each student's choice of studies.
Political Economy.
Natural History.—Zoölogy and Physiology.
French.—(Italian may be substituted.)
German.

APPENDIX B.

COURSE OF STUDY IN THE

Sheffield Scientific School of Yale College.

NEW HAVEN, CONNECTICUT.

1870—71.

TERMS OF ADMISSION.

Candidates must be not less than sixteen years of age, and must bring satifactory testimonials of moral character from their former instructors or other responsible persons.

For admission the student must pass a thorough examination in Davies's Bourdon's *Algebra* as far as the General Theory of Equations, or in its equivalent; in *Geometry*, in the nine books of Davies's Legendre, or their equivalent: and in *Plane Trigonometry*, Analytical Trigonometry inclusive; and also in *Arithmetic*, including the "Metric System," *Geography*, *United States History*, and *English Grammar*, including Spelling. An acquaintance with the *Latin* Language is also required, sufficient to read and construe some classical author, and Allen's Latin Grammar is commended as exhibiting the amount of grammatical study deemed important. Practice in *Drawing*, if it can be obtained before entrance, will be of great advantage.

Candidates for advanced standing in the three regular classes are examined, in addition to the preparatory studies, in those already pursued by the class they propose to enter. No one can be admitted as a candidate for a degree after the commencement of the Senior year.

The arrangement of the studies is indicated in the annexed scheme.

Freshman Year—Introductory to all the Courses.

First Term.—*German*—Whitney's Grammar and Reader. *English*—Marsh's English Language; Exercises in Composition. *Mathematics*—Davies's Analytical Geometry, and Spherical Trigonometry. *Physics*—Atkinson's Ganot, with experimental Lectures. *Chemistry*—Eliot and Storer's Manual; Laboratory practice. *Elementary Drawing*—practical lessons in the Art School. *Laws of Health*—Lectures by Professor F. Bacon.

Second Term.—*Language, Physics, Chemistry, and Drawing*—as stated above. *Mathematics*—Church's Descriptive Geometry.

Third Term.—*Mathematics*—Surveying and Plotting. *Botany*—Gray's Manual. Other studies continued.

IN CHEMISTRY AND METALLURGY.

Junior Year.

First Term.—*Chemical Analysis*—Fresenius. Recitations and Lectures. Use of Blowpipe. *Laboratory Practice*—Qualitative Analysis. *English*. *German*. *French*.

Second Term.—*Chemical Philosophy*—Wurts : Recitations and Lectures. *Laboratory Practice*—Qualitative Analysis, continued. Examination for poisons. Quantitative Analysis, begun. *Zoology*—Lectures. *English. German. French.*

Third Term.—*Mineralegy*—Dana. Lectures and Practical exercises. *Organic Chemistry*—Lectures. *Zoclogy*—Lectures and Excursions. *Laboratory Practice*—Quantative Analysis, continued. *English and French*—continued.

Senior Year.

First Term.—*Metallurgy*—Percy. Lectures. *Agricultural Chemistry*—Recitation and Lectures. *Geology*—Dana. Lectures and recitations. *Zoology*—Lectures. *Laboratory Practice*—Volumetric and Organic Analysis. *Determinative Mineralogy, English and French*—continued.

Second and Third Terms.—*Metallurgy*—Lectures. *Agribultural Chemistry*—Lectures. *Geology*—Dana. *Anatomy Physiotogy*—Academical Lectures. *Laboratory Practice*—Mineral Analysis and Assaying. *Determinative Mineralogy. English and French*—continued.

In Civil Engineering.

Junior Year.

First Term. — *Mathematics* — Church's Descriptive Geometry, with applications. Analytical Geometry of Three Dimensions. *Surveying*—Higher Surveying. *English, French, and German.*

Second Term.—*Mathematics*—Davies's Shades, Shadows, and Linear Perspective. Church's Differential Calculus. *Astronomy*—Norton's Astronomy, with practical problems. *English French and German.*

Third Term. — *Mathematics* — Isometrical Projection. Differential and Integral Calculus. Topographical Surveying. *Drawing*—Topographical. *English and French.*

Senior Year.

First Term.—*Field Engineering*—Henck's Field Book for Rail Road Engineers. Location of Roads. *Mechanics*—Peck's Elements. Thermodynamics. *Military Science*—Lectures. *Geology*—Dana. *Drawing*— Architectural. *Stone Cutting*, with graphical problems. *English and French.*

Second Term.—*Mechanics*—Peck's Elements, continued. Application of Calculus to Mechanics. Principles of Mechanism. Theory of Steam Engine. *Civil Engineering*—Strength of Materials. Bridge Construction. Stability of Arches and Walls. *Military Science*—Lectures. *Geology*—Dana, continued. *Drawing*—Mechanical. *English and French.*

Third Term.—*Mechanics*—Mechanics applied to Engineering. *Hydraulics*—Theory of Turbines and other Water Wheels. *Civil Engineering*—Building Materials (Lectures). Mahan's Civil Engineering. *Mathematics*—Geodetic Surveying. *Drawing*—Structural.

Students who pursue a higher course in Engineering, for one year after graduating as Bachelors, may receive the degree of Civil Engineer.

In Mechanical Engineering.

Junior Year.

Pure Mathematics—Descriptive Geometry, with applications. Analylitical Geometry of three dimensions. Differential and Integral Calculus. *Mechanics*—Analylitical Mechanics. Principles of Mechanism. *Drawing*—Shades, Shadows, and Linear Perspective. Elements of Mechanical Drawing and Principles of Construction. Shading and tinting, and drawing from patterns. *Metallurgy. English, French, and German.*

Senior Year.

Applied Mechanics—Strength of Materials. Thermo-dynamics. Theory and construction of the Steam Engine and other prime movers. Theory of Machines. Mill work. Examination of Machinery. Mechanical Construction. Use of Tools. *Drawing*—Drawing from actual Machines. Designs of Machines. *English French, and German.*

IN NATURAL HISTORY.

Either Geology, Mineralogy, Zoology, or Botany may be made the principal study some attention in each case being directed to the other three branches of Natural History

Junior Year.

FIRST TERM.—*Zoology*—Daily laboratory instruction ; Zoological Excursions. *Botany*—Gray's Text Book ; Use of the Microscope. *Chemistry*—Academical Lectures. *French*—begun. *German*—continued.

SECOND TERM.—*Zoology and Palæontology*—Laboratory Practice. Lectures. *Botany*—Lectures ; Gray's Text Book. *Physical Geography*—Lectures and Recitations. *Chemistry*—Laboratory Practice. *French and German*—continued.

THIRD TERM.—*Zoology and Palæontology*—Laboratory Practice. Lectures. Excursions (land and marine). *Botany*—Excursions. Practical Exercises. Gray's Manual. *Mineralogy*—Dana. Lectures. Practical Exercises. *French*—continued. *Drawing*—Free Hand Practice.

Senior Year.

FIRST TERM.—*Language*—Whitney's Language and the Study of Language. *French*—Selections. *Zoology and Palæontology*—Laboratory Practice. Lectures. Excursions. *Botany*—Excursions. Herbarium studies. *Geology*—Dana's Manual. Excursions.

SECOND TERM.—*Zoology and Palæontology*—continued. *Botany*—Herbarium studies. Botanical Literature. Essays in Descriptive Botany. *Geology*—Dana. Lectures. *Anatomy and Physiology*—Academical Lectures. *French*—Selections. *Whitney on Language*—continued.

THIRD TERM.—*Zoology, Botany, und Palæontology*—continued, with Excursions. *Photography*—Practical instruction.

Besides the regular courses of lectures on structural and systematic Zoology and Botany, and on special subjects, students are taught to prepare, arrange, and identify collections, to make dissections, to pursue original investigations, and to describe Genera and Species in the language of science. For these purposes large collections in Zoology and Palæontology belonging to the College are available, as are also the private botanical collections of Professor Eaton.

IN PEEPARATION FOR MEDICAL STUDIES.

During one year the work of this course will be chiefly under the direction of the instructors in Chemistry; during the second year under that of the instructions in Zoology and Botany. In Chemistry especial attention will be given to the examination of urine and the testing of drugs and poisons Zoology to comparative anatomy, reproduction, embryology, the laws of hereditary descent and human parasites ; and in Botany to a general knowledge of structural and physiological Botany, and to medicinal, food-producing, and poisonous plants. The studies of the Select Course in Physical Geography, History, English Literature, etc., are followed by these students.

IN STUDIES PREPARATORY TO MINING.

Young men desiring to become Mining Engineers, can pursue the regular course in Civil or Mechanical Engineering, andat its close can spenda fourthyear in the studyof metallurgy, mineralogy, etc. Should there be a sufficient number of students desiring it, a course of lectures on the subject of Mining will also be provided.

In Select Studies preparatory to other higher pursuits, to business, etc.

Junior Year.

First Term.—*Mechanics*—Peck's Elements. *History*—Modern History of Europe, Recitations and Lectures. *English Literature.* *German*—Selections. *French*—Fasquelle's Course, and Reader.

Second Term.—*Astronomy*—Norton's Astronomy, with practical problems. *Agricultural Chemistry*—Lectures. *Physical Geography*—Lectures and Recitations. *Zoology*—Lectures. *Botany*—Lectures; Gray's Text Book. *History*—continued. *German*—Selections. *French*—Selections from Classic Authors.

Third Term.—*Botany*—Gray's Text Book. Excursions and practical instruction. Gray's Manual. *Zoology*—Excursions and Lectures. *Mineralogy*—Dana. *Literature*—Study of Classical English authors. *Drawing*—Free Hand, and Architectural. *French*—Selections.

Senior Year.

Language.—Whitney's Language and the Study of Language. Hadley's Brief History of the English Language. *French*—continued. Compositions.

Natural Science.—*Botany and Zoology*, continued. *Agriculture*—Lectures. *Agricultural Chemistry and Physiology*—Lectures. *Geology*—Recitations and Lectures. *Human Anatomy and Physiology*—Lectures. *Astronomy*—Lectures.

Philosophy and History.—Lectures and Recitations in *Military Science, History, Political Philosophy, International Law, Political Economy*, etc.

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