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Aller au sommaire du numéro

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Science Education at the University of New Brunswick in the Nineteenth Century

Contemporary science programmes at most Canadian universities are aimed at producing scientists, but this has not always been so. At one time science education was either non-existent or only a marginal part of a liberal arts curriculum. Indeed, steps toward the modern science education were largely innovations made in German universities in the early nineteenth century. Although some British medical schools, especially those in Scotland, had already required some original research, it was in the German schools that the writing of dissertations on scientific subjects truly began. The use of the laboratory as a teaching aid was another important German innovation; undergraduate as well as graduate students were expected to show proficiency in the laboratory. German educational methods also favoured the lecture rather than the tutorial system. As a result of these innovations, the production of scientists by universities accelerated (particularly in chemistry) in German-speaking countries during the nineteenth century, and a steady stream of British and American students made their academic pilgrimages to Germany, bringing back the new pedagogical techniques. The addition of laboratory work to science curricula was only slowly realized in England, but it was rapidly adopted by larger American schools, especially Harvard and Yale in the 1840's.[1]

The implementation of these techniques in Canadian schools was often indirect and partially unconscious, a result of the conflict between the English and Scottish views of science education. In early nineteenth-century England, universities, still in their eighteenth-century somnolence, maintained the classical form of education which consisted of Latin and Greek authors, other humanistic subjects, and mathematics for the training of the mind. This was

1 On higher education in England, see George F. Haines, IV, *German Influence upon English Education, 1800-1866* (New London, 1957) and Michael Argles, *South Kensington to Robbins* (London, 1964), esp. p. 46. On American universities, see George H. Daniels, *Science in American Society* (New York, 1971), pp. 276 ff. and D. J. Struik, *Yankee Science in the Making* (New York, 1962), pp. 421 ff.

intended to provide a sufficiently liberal education for the gentleman. Science, and its technological handmaiden, engineering, were almost entirely ignored except in the progressive centres at University College and King's College, London, which were consciously patterned after German models. The English emphasis upon tutorials rather than lectures and upon casual examination (excepting special contests like the Cambridge mathematical tripos) was of little use in the training of scientists. A very different picture was evident in Scotland. The universities in northern Britain had had close contacts with Continental centres during the eighteenth century and placed far greater emphasis upon science and medicine. Their science programmes were vigorous in the professors' reliance upon the lecture method of teaching and their demands that students attend classes and pass series of examinations.[2] It is no surprise that a large number of nineteenth-century scientists were educated in Scotland rather than England; indeed, a very large number of the early science professors in Canada were of Scottish rather than English origin, and those science teachers who immigrated to Canada from elsewhere were educated either in Scotland, America, or the Continent.[3]

Throughout most of the nineteenth century, Canadian schools offered science courses as cultural subjects. Practically every school had at least a course in chemistry, several in natural history (geology, mineralogy, botany, and zoology), natural philosophy (physics), and classes in mathematics from algebra to the calculus. The lectures were often demonstrated with apparatus, but students rarely if ever performed experiments themselves.[4] Natural science, if properly taught, needed a natural history cabinet or museum, to hold the rock, minerals, plants, fossils, and animals discussed in lecture and text and by the 'sixties nearly every Canadian college maintained cabinets or museums.[5] Physical science teaching was performed throughout most of the century with a small collection of apparatus, and, occasionally, with surveying or

2 At one point, the Oxford science professors petitioned to be relieved of lecturing to empty lecture halls. See Argles, *South Kensington to Robbins*, p. 10; *cf.* Haines, *German Influence upon English Education*, pp. 13f.

3 A partial list of important nineteenth-century science professors in Canada shows this well. James Williamson, George Lawson (holder of a Ph.D. from Giessen and a student of Liebig), and Robert Bell, all teachers at Queen's, were educated at Edinburgh and the first two were Scots; Dawson at McGill was an Edinburgh graduate; H. H. Croft, H. A. Nicholson, and W. H. Pike at Toronto were all educated in Germany (Nicholson also studied in Edinburgh); among their Toronto colleagues were E. J. Chapman (French educated) and R. R. Wright (a Scot educated at Edinburgh); at Laval, most teachers were instructed in the Petit Séminaire de Québec, but T. I. Hamel studied in Paris, E. J. Horan and Sterry Hunt both attended Yale.

4 Toronto students did not have to have laboratory certification until the mid-'eighties. See University College, Toronto, *Calendar for 1885-86*.

5 By the 'sixties, New Brunswick, Laval, Toronto, Queen's, and McGill all had collections of varying qualities. Even a college like Acadia, which in 1861 had but a single science professor, possessed a mineral cabinet.

astronomical instruments.[6] Science was an armchair occupation for most of the teachers in Canada, with the exception of several chemists like Sterry Hunt, H. H. Croft, and most geologists like Brunet at Laval, Nicholson at Toronto, and Dawson at McGill. Since no school was geared to produce research scientists until late in the century, a student with science as a career goal would study at London, Harvard, Yale, or schools in Scotland and Germany.[7] Gradually, however, a number of Canadian universities underwent an evolution from the liberal arts tradition to the highly specialized programmes of today. One university that clearly experienced the passage to modern scientific education, with its emphasis upon lectures, seminars, laboratory practice, and graduate instruction, was the University of New Brunswick.

Higher education in New Brunswick began in 1820 when James Somerville was named President of the College of New Brunswick (founded 1800). The course of study in the college was strictly classical in the English tradition, including some mathematics but no science.[8] King's College replaced the old school in 1828, but the central figure at King's during its entire history was the president, Dr. Edwin Jacob (d. 1868). An Oxford graduate and Anglican divine he tried to maintain King's as both a bastion of classical education and as an Anglican establishment. The college underwent severe criticism during the 'forties and 'fifties for its lack of a liberal charter, and, like its sister school, King's College, Toronto, it came to the same end: secularization. Although mathematics was taught by the Rev. George McCawley until he removed to King's College, Windsor, N. S. in 1836,[9] from 1828 until 1837 Jacob had no science colleagues. Even during the succeeding decades Jacob's views on how New Brunswick youth should be educated changed little. The eminent British geologist, Sir Charles Lyell (1797-1875), visiting Fredericton in the 'fifties, commented that King's College was ". . . rendered useless and almost without scholars, owing to an old fashioned Oxonian of Corpus Christi, Oxford, having been made head, and determining that lectures in Aristotle are all that the youth in a new colony ought to study, or other subjects on the strict plan which may get honours at Oxford."[10] Jacob clearly did not see the true needs of the

6 By the 'sixties, only New Brunswick and McGill maintained observatories, although Toronto students had access to the Magnetic and Meteorological Observatory in that city. No school had a physical laboratory as such.

7 There are no complete statistics on Canadian and American students who went abroad, but some interesting figures for English students have been compiled by G. F. Haines, IV (appendix to *German Influence upon English Education*), showing that roughly half of the English science and medical figures of importance in the nineteenth century were educated abroad (including Scotland).

8 Frances Firth, "King's College, Fredericton, 1829-1859," in A. G. Bailey, ed., *University of New Brunswick Memorial Volume* (Fredericton, 1950), p. 23.

9 *Ibid.*, pp. 23ff.

10 Lyell to Leonard Hoerner, 12 September 1852, quoted in D. G. G. Kerr, *Sir Edmund Head, A Scholarly Governor* (Toronto, 1954), p. 104.

province, for New Brunswick — thinly settled with a tiny upper class, an extractive economy and few occupational outlets for the classical-trained student — was ill-suited for an Oxford style education.

The motives for introducing the teaching of science into King's are unclear; nevertheless, chairs of natural philosophy and of chemistry and natural science were established and offered to two young Scots, David Gray, M.A. (ca. 1811-56), and James Robb, M.D. (1815-61), both of whom commenced their duties in October, 1837.[11] Gray, a graduate of the University of Edinburgh, the centre of British science at the time, remained at King's for only three years, teaching mathematics and natural philosophy, before returning to Scotland to take up the post of Principal of the Royal Academy at Inverness.[12] He was later named professor of natural philosophy at Marischal College, Aberdeen, where he remained until his death.[13] James Robb graduated from Edinburgh with a medical degree; after studying at the Sorbonne and travelling extensively on the continent, he arrived to teach chemistry and the natural sciences (biology and geology).[14] Fredericton became his adopted home and he remained until his death in 1861. Although he published little, he maintained a variety of scientific interests. He was an amateur meteorologist, keeping careful records of temperatures and precipitation in Fredericton and other New Brunswick towns.[15] In 1842, he delivered a course of lectures on the atmosphere at the Mechanics' Institute in Saint John,[16] and, in 1846, he suggested to the lieutenant-governor, Sir William Colebrooke (1787-1870), that a magnetic and meteorological observatory be established in Fredericton.[17]

Robb was also an accomplished amateur geologist; he made several tours of the province and produced, in 1849, a geological map of New Brunswick (which superceded that of Abraham Gesner). It was published the following year in J. F. W. Johnston's *Report of the Agricultural Capabilities of the Pro-*

11 The professorship of chemistry was the first of its kind in the Maritimes. See C. J. S. Warrington and R. V. Nicholls, *A History of Chemistry in Canada* (New York, 1949), p. 424.

12 Frances Firth, "King's College," *Memorial Volume*, p. 26.

13 F. Boase, ed., *Modern English Biography* (London, 1965), I, p. 1214.

14 Little is known about Robb's life. The only biographical notice of any detail is L. W. Bailey, "Dr. James Robb," *Bulletin of the Natural History Society of New Brunswick*, No. XVI (1898), pp. 1-15.

15 Robb's meteorological records, dating from the late 'thirties and early 'forties, are extant: University of New Brunswick Archives [hereafter cited as UA], RG 61, Box 3, folders 1-4, Fredericton.

16 James Robb, "Syllabus of a Course of Six Lectures on the Atmosphere," UA, RG 61, Box 3, folder 1.

17 Robb to Colebrooke, 12 November 1846, UA. The request was passed from Colebrooke to the army ordnance department; Col. Edward Sabine (1788-1883), who directed the magnetic and meteorological surveys, was in favour of a Fredericton observatory like that in Toronto (Sabine to Lord Clarence Paget, 13 January 1847, copy in UA). Nothing seems to have come of the proposal.

vince of New Brunswick (Fredericton, 1850). The agricultural potentialities of the province were of as great importance to Robb as they were to the lieutenant-governor, Sir Edmund Head (1805-68). Sir Edmund was convinced that New Brunswick could produce "unlimited abundance" if sufficient capital were employed,[18]. and Robb, who know Liebig's work on agricultural chemistry,[19] was willing to support the cause. In 1849, Sir Edmund wrote to the third Earl Grey and to the college council that he was ". . . extremely desirous that a course of lectures in Agricultural Chemistry should be delivered at Fredericton during the sitting of the Assembly . . . . I look upon the diffusion of scientific information relating to Agriculture as a most important object to this Province."[20] The council refused to pay Robb for the extracurricular lectures and Sir Edmund produced the money from his own pocket.[21] The lectures were a success, and at the request of the lieutenant-governor Robb made a lecture tour of the province in 1850.[22] He was a mainstay of the Provincial Society for the Encouragement of Agriculture, the virtual Secretary of Agriculture of New Brunswick, and the author of an *Outline of the Course of Improvement in Agriculture* (Fredericton, 1856).[23] He was also a founding member of the Fredericton Athenaeum.

In 1840, upon Gray's return to Scotland, a third Scot joined the faculty of King's. William Brydone-Jack (1819-86) had attended St. Andrew's and was a favoured student of the physicist Sir David Brewster (1781-1868). Although only twenty-one years old, Jack had wished to take a position in Manchester, to succeed the noted chemist John Dalton (1766-1844), but Brewster prevailed upon him to accept the appointment at King's College rather than risk his reputation at the much more important Manchester.[24] On his arrival, he took up the responsibilities for mathematics and natural philosophy and became close friends with Robb and later with Sir Edmund Head. His two chief interests were astronomy and engineering. At his insistence the first astronomical observatory in British North America was erected on the campus in 1851.[25] From the 'fifties to the early 'sixties, he determined a number of longitudes in New Brunswick, employing the telegraph links with Harvard College Observatory and Quebec Observatory.[26] He was even more involved in civil

18 Head to Earl Grey, 27 June 1849, quoted in Kerr, *Sir Edmund Head,* p. 54.

19 F. J. Toole, "The Scientific Tradition," *Memorial Volume,* p. 70.

20 Quoted in Kerr, *Sir Edmund Head,* p. 54.

21 *Ibid.,* p. 55.

22 Katherine MacNaughton, *The Development of the Theory and Practice of Education in New Brunswick 1784-1900* (Fredericton, 1947), p. 103.

23 L. W. Bailey, "Dr. James Robb," p. 5.

24 W. O. Raymond, *The Genesis of the University of New Brunswick* (Saint John, 1919), p. 9.

25 See J. E. Kennedy, "The Early Days of the First Astronomical Observatory in Canada," *Journal of the Royal Astronomical Society of Canada,* 49 (1955), pp. 181ff.

26 UA, RG 61, Box 1 contains a number of letters to and from Jack concerning his longitude work.

engineering. A surveyor of some merit, he was retained by the Surveyor-General of New Brunswick to test surveying instruments in the 'seventies and 'eighties,[27] and was responsible for teaching engineering in the university. After the province established the University of New Brunswick in 1859, Dr. Jacob retired from the presidency. An interim president was appointed but resigned and, in 1861, Jack became the school's president.[28] He retired in 1885, one year before his death.

The Scots — Gray, Robb, and Jack — brought the comprehensive science course from their universities: the course of science at New Brunswick was well-organized, demanding, and taught within the structure of required lecture attendance and strict examination current at Edinburgh and St. Andrew's.[29] The educational level of the New Brunswick science curriculum could not have been markedly inferior to that of Scottish schools. Professor Jack, for example, was adamant in his desire to see a full science curriculum implemented at Fredericton. In 1842, he declined a position profferred him by the newly-opened Queen's College in Kingston, partly on the grounds that

> So long as there is only one Professor of Science in the College, he certainly is, if not in duty, at least in justice to the students and to the College, bound to teach not only the physical sciences, but also much of experimental and natural science, which might not strictly belong to his department — such being the case he will with difficulty find time to perform duties I would consider incumbent upon him . . . [and since the standards of admission are so low] . . . I am afraid that [the professor] could not teach them even in a loose and popular manner so as to be satisfactory to himself, *far less pursue the rigid mathematical course which should be adopted in a College.*[30]

Yet at Fredericton, where Jack had the indefatigible Dr. Robb to relieve him of the natural sciences, he still had to teach mathematics, natural philosophy, astronomy, and later, some engineering. Such were the rigours facing mid-century science teachers in Canada.

27 Some of these examinations survive: UA, RG 61, Box 3, folder 4.

28 W. O. Raymond suggests that "Presumably the Governor and Council hesitated to appoint Brydone-Jack as President over the heads of Jacob and Robb, his seniors in the faculty, and so brought in an outsider [Joseph Hea], whose lack of tact and hasty disposition threw the institution into such a turmoil that a number of prominent undergraduates retired . . ." (*Genesis of the University*, p. 14). By 1861, however, with all likely candidates removed by death, retirement, or departure, Jack was the senior professor and the logical successor to Hea. For further information on Hea's short presidency, see W. S. MacNutt, *New Brunswick: A History, 1784-1867* (Toronto, 1963), pp. 371f.

29 Jack's grading system, employed for all undergraduates, was remarkably complicated and a pain to both students and teachers. See Raymond, *Genesis of the University*, p. 30.

30 Jack to Hon. William Morris, 14 April 1842, quoted in J. E. Kennedy, "Early Exchange of Correspondence between King's and Queen's," *The Queen's Review* (December, 1954), pp. 247, 264. Italics mine.

Both Robb and Jack were also involved in King's protracted struggle for survival. Robb defended the college eloquently in several Encaenial addresses; not only did he maintain that collegiate education was good for the province, but that his subject — science — was also a benefit to the students and the citizens. In the oration of 1839, for instance, he argued:

> There are not wanting, it is true, those who have thought the establishment of King's College was premature, that such an institution is needless and may be mischievous to so young a Country. But I am not one of those who foresee any ill consequences from the dissemination, however early, of the principles of science, of literature, of loyalty, and of morality . . . . That science (which is simply knowledge reduced to a system) should confer power, may easily be comprehended; because he who has most extensively examined and best understood the constitution of the material world, will be pre-eminently qualified to make it subservient to his own purposes.[31]

This utilitarian argument would lead his colleague Jack and others to recommend the introduction of practical science into the King's curriculum.

A movement toward practical education swept British North America in the mid-nineteenth century. Agriculture and engineering were taught at McGill from 1856, and the Ecole Polytechnique was founded in Montreal in 1874, while engineering was taught in fits and starts (from 1851) at Toronto.[32] But at King's College, Fredericton, the classical curriculum reigned supreme, since President Jacob felt that ". . . filling the College with agricultural, manufacturing, mechanical, or commercial students, . . . could have no better effect than miserable, disheartening, self-destructive disappointment."[33] Opposed to this position were Sir Edmund Head, Jack, and a number of citizens and legislators of New Brunswick.[34] By creating a reform commission like that of Oxford (with which Sir Edmund had co-operated), the lieutenant-governor hoped

> . . . to save the endowments if I can, for if popular agitation against their misapplication of public money begins in earnest it will be impossible to obtain any funds for superior education, whereas by popularizing the instruction in some degree and convincing the assembly that we wish to

31 James Robb, *Oration delivered at the Encaenia in King's College, Fredericton June 27, 1839* (Fredericton, 1839), p. 9.

32 For the Ecole Polytechnique, see L.-P. Audet, "La fondation de l'Ecole Polytechnique," *Cahiers de Dix,* V, no. 30 (1965), pp. 149-91; for engineering at Toronto, consult C. R. Young, *Early Engineering Education at Toronto, 1851-1919* (Toronto, 1958).

33 Edwin Jacob, "Encaenial Address for 1851," quoted in A. F. Baird, "The History of Engineering at the University of New Brunswick," *Memorial Volume,* p. 75.

34 *Ibid.,* p. 76.

> make it practically useful, I think it may be preserved and profitably applied.[35]

A commission (including William Dawson and Egerton Ryerson) was duly appointed and in their report concurred with Sir Edmund's views.

In 1852, Sir Edmund nudged the college council into action.[36] A committee of the council, including two friends of King's, J. A. Street and Lemuel A. Wilmot, a graduate and the Attorney-General, agreed that ". . . more specific attention be given Civil Engineering, that is its leading principles, and that if assistance be required in drawing, it should be provided by the council."[37] The committee evidently questioned Professor Jack on his willingness to co-operate, for the latter sent the committee a lengthy reply early in 1853. He declared "that I have devoted more attention than is usually given in a College curriculum to the practical applications connected with the sciences which I am called upon to teach" and pointed out that his mathematical course already included mensuration, surveying, navigation, pneumatics, statistics, dynamics, hydrostatics, hydrodynamics, optics, and astronomy — indeed, "practical" science.[38] He accepted that the engineer must learn his subject primarily in the field or factory but argued that he must also have a firm grounding in mathematical and scientific principles.[39] To realize the teaching of both pure and practical science, Jack suggested:

> . . . we should try to engraft upon [the scientific curriculum] as much of practical application as we possibly can. By doing so, and admitting to our classes all who may wish to enjoy the advantages that may result from attendance upon any of them, I trust we may have the satisfaction of increasing the number of our students, and adding to the popularity and usefulness of the College.[40]

As a result of Jack's, Sir Edmund's, and the committee's exertions, the legislature passed a statute on 2 April 1853 to provide funds for the teaching of

35 Head to Sir George Lewis, 18 October 1852, quoted in Kerr, *Sir Edmund Head,* p. 104.

36 A. F. Baird, "History of Engineering," *Memorial Volume,* p. 76.

37 "Report of the Committee of the College Council," quoted in *ibid.*

38 Jack to the Bishop of Fredericton, Hon. J. A. Street, and Mr. Justice Wilmot, 10 February 1853, UA.

39 In the same letter Jack alluded to the lessons taught by the Great Exhibition of 1851, which brought home to the English the need for more science education and government support for science. Jack seemed to be aware of the activities of Prince Albert and Lyon Playfair in furthering these goals. For the roles of the prince and Playfair in modernizing English scientific and technical education, see George Basalla *et al., Victorian Science* (New York, 1970), pp. 45-48, 60-64.

40 Jack to the Bishop of Fredericton, Hon. J. A. Street, and Mr. Justice Wilmot, 10 February 1853, UA.

civil engineering.[41] MacMahon Cregan, a railway engineer, was retained to offer lectures on engineering in the winter of 1854, and students were prepared by Jack with the mathematics and science necessary to understand the engineering lectures. It is uncertain whether Cregan taught after 1854, for there is no mention of a lecturer in civil engineering in the *Calendar* for 1861-2, but the New Brunswick legislature was interested in maintaining an engineering course at the college. The first paragraph of the University of New Brunswick Act, passed in 1859, declared it expedient ". . . to make provision for a comprehensive system of University Education, such as will embrace not only the usual subjects of a Collegiate course, but also those branches of practical science and art which are adapted to the agricultural, commercial, and mechanical pursuits of the great body of the inhabitants of New Brunswick . . . ."[42]

To further the teaching of science, practical and pure, the faculty needed sufficient apparatus. When Jack arrived in Fredericton in 1840, King's College possessed practically nothing in the way of instruments or equipment for demonstration purposes, let alone for research. Both he and Robb felt the impact of this inadequacy and wrote to the college council to complain:

> It is vain to found Chairs of Mechanical Philosophy or of the History of Nature, if the means of properly illustrating the same are to be withheld; it is vain to institute courses in Astronomy or Optics if the realities of the Telescope and the Microscope cannot be exhibited; in vain you attempt to teach the past history of the Earth if the "Medals of Creation" — the characters in which it is recorded — cannot be brought before the Eyes of the learner; in vain you speak of the wonders achieved by Chemistry, or Mechanics or Electricity or Magnetism, if you do not exhibit them and make the student imitate them for himself; in vain you attempt to describe the forms, the structure and the uses of Plant or Animal if they cannot be exhibited in their reality; in these Departments of Education we hold the principle that demonstrations to the senses is alone effectual teaching — "Nihil est in intellectu, quod non fuerit in sensu". . . if the true mastery which mind has acquired over Matter is to be clearly apprehended — if the glorious triumphs of Art in this 19th Century are to be realized by the Youth of New Brunswick, we do not see how it can be done without a great and early effort to procure an adequate stock of Philosophical Apparatus and to establish a Museum in this College, while the materials thus procured might be rendered useful not only to the students, but also to the collected leaders of the province during their annual sojourn at the Seat of Government . . . we cannot avoid expressing our conviction that a sum of not less than £1,000 is still required to put the Philosophical Apparatus and Museum upon anything like an efficient footing.[43]

41 Bertram Stirling, *The First Hundred Years* (Fredericton, 1954), p. 7.

42 *New Brunswick Statutes,* 22 Victoria, c. 63 (1859).

43 J. Robb and W. B. Jack to the Chancellor and Council of King's College, 22 February 1847, UA.

Appended to their letter was a memorandum listing the necessary equipment: a telescope, a theodolite, a sextant, surveying instruments, optical instruments, a working model of a steam engine, and a barometer for Professor Jack (for a total of £500); and a collection of rocks, minerals, fossils, casts and models, a lapidary lathe, chemical apparatus (including a "first-rate balance"), stuffed animals, skeletons, a compound microscope, and mechanical apparatus for magnetism, electricity, and meteorology for Professor Robb (another £500).

The college council was sympathetic and recommended that

> ... a sum of £ 550 Sterling may be devoted to the object in view which they recommend should be appropriated as follows namely £300 for the Mathematical Department to be applied to the purchase of a good 7 feet Achromatic Telescope and such other apparatus as may be more immediately necessary and the remaining £250, £150 for procuring materials, models and apparatus for the illustration of *Chemistry* and its application to the Arts and £100 to the purchase of machines, Batteries apparatus and models for the illustration of *Magnetism, Electricity, Galvanism* and *Meteorology*.[44]

Unfortunately, the procuring of the telescope and building of the observatory were troublesome and more expensive than originally anticipated. While the college council noted that a further £50 could be appropriated if necessary,[45] it later decided that £220 was all they would pay — £80 less than the amount first allotted for the telescope.[46] Nevertheless, the instrument was finally obtained and the observatory ready for operation in 1851. New Brunswick's observatory was the first (and for several years the best) in British North America.[47] More instruments for both astronomy and civil engineering were added by Jack over the years, including a transit instrument for time and longitude observations.[48] Although the observatory was employed for many years in student instruction, no serious research seems to have been accomplished there.[49] The beginnings of a natural history museum were also made during

44 Minute Book of the College Council of King's College, 23 March 1847, UA.

45 An additional sum of £;0 was advanced for the telescope. *Ibid.*, 21 June 1847.

46 *Ibid.*, 5 April 1848. In fact, the council had appropriated considerably more by the time the observatory was completed. A description of the observatory was sent by Jack to the Astronomer Royal, Sir George Airy (1801-92), in June, 1854 (UA, RG 61, Box 1). Airy, in typical form, did not comment on Jack's plan, leading the latter to remark: "From your saying nothing in the letter ... of my plan for a cheap Observatory on a small scale, I fear you do not approve of it, or think it worthy of attention; nevertheless, I find it answers exceedingly well." (Jack to Airy, 12 August 1854, UA, RG 61, Box 1).

47 A slightly larger telescope was erected in Kingston in 1855.

48 A small transit instrument assumed to be Jack's is now in the possession of the University Archives in Fredericton.

49 It has been occasionally stated that Jack made his historic telegraphic longitude determina-

the 'fifties; lacking sufficient funds from the college council, Robb procured many specimens through exchange and from his own excursions. His efforts were praised by both Jack and his own successor, Bailey.[50]

Although the fourth professor of science to arrive in Fredericton was an American, he effectively carried on the educational tradition of his Scottish predecessors. Loring Woart Bailey (1839-1925) — son of J. W. Bailey (1811-57), a science professor at West Point — was educated at Harvard where he received his B.A. in 1859.[51] At Harvard he had studied with three renowned scientists: Asa Gray (1810-88), the botanist; Louis Agassiz (1807-73), the natural historian; and Josiah Parsons Cooke (1827-94), the chemist and student at Yale of the famed Benjamin Silliman, Sr. Bailey had worked with Cooke for one year as a graduate student and had then studied at the chemical laboratory of Brown University. After Robb's death in 1861 had created a vacancy at New Brunswick, Jack wrote to Cooke asking for a possible candidate to fill the post; on Cooke's recommendation, the university tendered the position to the twenty-one year old Bailey.[52] In the autumn of 1861, he came to Fredericton as professor of chemistry and natural science. He maintained the classes in both subjects until 1900, at which time chemistry passed to the professor of civil engineering; thereafter, Bailey concentrated on geology and natural history until his retirement in 1907.[53]

Although he entertained interests on a wide front, Bailey felt his knowledge was insufficient:

> I have often wondered at the temerity which led me, then a youth of scarcely twenty-one years and wholly inexperienced, to accept so important a position involving duties now distributed among not less than four professors; and that too with a most insufficient preparation, — some knowledge of chemistry, but little of botany, still less of zoology, and very little indeed of geology or mineralogy.[54]

tions with the aid of the new telescope. The work seems to have been accomplished with a small transit instrument at the observatory of Jack's friend, Dr. Toldervy, in Fredericton (Jack to Airy, 19 April 1855, UA, RG 61, Box 1).

50 Jack, in his Encaenial address of 1861, remarked that the "University lies under the greatest obligations to him for the establishment of its geological museum, and for an extensive collection of the flora of New Brunswick . . . in the prosecution of which it was often necessary to spend not only time but money" (quoted in Raymond, *Genesis of the University*, p. 36). Similar comments were made by Loring W. Bailey in his Encaenial oration of 1872.

51 For Bailey, see Joseph Whitman Bailey, *Loring Woart Bailey, the Story of a Man of Science* (Saint John, 1925); B. Hansen, "Loring W. Bailey," *Dictionary of Scientific Biography* (New York, 1970), I, p. 397; and W. F. Ganong, "L. W. Bailey," *Proceedings and Transactions of the Royal Society of Canada*, 3rd Series, XIX (1925), pp. xiv-xvii.

52 J. W. Bailey, *Loring Woart Bailey*, p. 36n.

53 University of New Brunswick, *Calendar for 1900-01*.

54 Quoted in J. W. Bailey, *Loring Woart Bailey*, p. 85.

He learned quickly and became the most prolific scientist in the university's history. He became an accomplished botanist and zoologist, but he was most interested in geology. He collaborated with two outstanding local geologists — George Matthew and C.F. Hartt — and with them, he helped sustain the Natural History Society of New Brunswick.[55] He made many geological expeditions through the province and neighbouring areas, publishing two works of note, his *Report on the Mines and Minerals of New Brunswick* (Fredericton, 1864) and *Observations upon the Geology of Southern New Brunswick* (Fredericton, 1865). He also contributed to Sir William Dawson's (1820-99) *Acadian Geology* (Edinburgh, 1855; London, 1868 and 1878). In 1868, he was invited to join the Canadian Geological Survey by its director, Sir William Logan (1798-1875), and, as a member of the Survey, he produced many reports and papers on Maritime geology.[56]

As a Harvard student Bailey had attended one of the first two scientific schools in North America. Mid-century Harvard was well on the way towards becoming a modern science centre, and Bailey's education there prepared him well to carry forward the progressive movement initiated in New Brunswick by Robb and Jack. Yet the small efforts in science being made in Fredericton, when compared with Harvard's accomplishments, were painfully obvious to him. In his Encaenial oration of 1872, he made a wistful comparison:

> It may not be without interest in this connection, more particularly to those who are wont to cry out against university education as an expensive luxury, and who grudge a donation even of a few hundred dollars only towards promoting its efficiency, to call their attention to one single instance where a very different spirit is manifested with reference to the latter. I refer to the case of Harvard University (one only however among many where in the neighbouring republic a similar generosity has been displayed) where, in the single department of Natural Science alone, there are no less than *Five* distinct museums, with a staff of not less than *twenty-four* Professors, and to the perfecting of which there has been devoted, in the aggregate, no less a sum than a *million and a half dollars*.[57]

He rejected the idea of a scientific school in Fredericton because

> Such schools to be thoroughly successful, require a much larger staff of Professors and much larger endowments than we can at present reasonably

55 George Matthew (1837-1923) was a member of the Canadian Geological Survey and a Fellow of the Royal Society of Canada; Charles F. Hartt (1840-78) was a professor of geology at Vassar and at Cornell, and was the organizer of the Geological Survey of Brazil.

56 For a bibliography of Bailey's scientific works, see the appendix to J. W. Bailey, *Loring Woart Bailey*.

57 L. W. Bailey, *The Study of Natural History and the Use of Natural History Museums* (Saint John, 1872), p. 8n.

> hope for, as well as proximity to some large industrial centre, ... Such objections, however, do not apply to the study of simple Natural History, and there is no reason why the latter should not be taught, and taught to the fullest extent consistent with the means at our disposal and the wants of the student.[58]

Despite financial problems in his quest for a better science establishment, Bailey was not lured away from Fredericton by the several good offers made to him by American colleagues. He maintained a scientific correspondence with James Dwight Dana (1813-95) — the well-known American geologist and Silliman, Sr.'s son-in-law — Logan, Dawson, and Thomas Sterry Hunt (1826-92) — one-time professor of chemistry at Laval and Logan's right-hand man. Bailey, like Robb earlier, felt the isolation from scientific centres, and tried to keep as well informed of scientific advances as possible through his correspondence and reading. Writing to a friend in 1876, he expressed both the frustrations and compensations of his post at Fredericton:

> The isolation, more particularly from scientific centres and scientific co-laborers, has always been a great drawback in my position — there being not more than two or three persons in the whole Province, and *none* in Fredericton, who know anything or care anything about the pursuits in which my pleasure is chiefly sought. However, I have the satisfaction of knowing that I work in a comparatively unexplored field and hope to lay a good foundation here, upon which in the future others may build.[59]

As professor of natural history, Bailey was responsible for the college museum. Faced with financial difficulties as Robb had been, he made additions to the collection in similar ways. Many specimens were obtained through exchanges with his American friends, Silliman, Jr. at Yale, Agassiz at Harvard, Joseph Henry at the Smithsonian Institution, and others.[60] He remarked to a friend:

> I have already, I think, made good progress towards the establishment of a museum, which, while it is daily proving of inestimable value in connection with our educational course, shall at least prove a safe repository of whatever is interesting and valuable in the natural productions of the country.[61]

He attempted, in the Encaenial addresses of 1868 and 1872, to excite more interest in his museum project with hopes that a combined provincial and

58 *Ibid.*, p. 8.

59 Bailey to W. B. Rogers, 1876, quoted in J. W. Bailey, *Loring Woart Bailey*, pp. 72f.

60 *Ibid.*, p. 44.

61 Bailey to W. B. Rogers, 1876, quoted in *ibid.*, p. 73.

university museum might be established on a firm financial footing.[62] He admitted that "the nucleus of such a Museum we already possess, and thanks to the liberality or the exertions of a few friends by whom the importance of the subject is duly appreciated, the University can even now boast a cabinet unequalled by that of any other institution in the Maritime Provinces . . . ."[63] Nonetheless, Bailey felt this was insufficient for modern science teaching. The new museum should have a systematic, well-classified collection; it should not imitate the museum at the Mechanics' Institute in Saint John, because "the latter contains a considerable amount of really valuable material, but so entirely without arrangement, so buried in dust, and so encumbered with much that is absolutely worthless, as to be almost entirely useless for the furtherance of its true purpose . . . ."[64] Although his appeals largely went unheeded, by the 'seventies the university museum had four basic collections: a mineralogical cabinet strongly oriented towards the geology and mineralogy of Acadia; a zoological collection with various preserved animals, skeletons, etc.; a botanical collection including most of the known species of New Brunswick, and collections of North American and European plants donated to the museum by Bailey's friends; and a palaeontological cabinet containing a large number of fossils from Acadia, Canada, and the United States as well as Europe.[65] There was also a small collection of mounted slides for microscopy. The New Brunswick museum was roughly on a par with those of Toronto, Queen's, and McGill, but all Canadian natural history collections in the 'seventies were inferior to that of Laval.[66]

While the museum was a great aid to the teaching of biology and geology, laboratories necessary for the modern teaching of chemistry and physics were not established until later. Robb created the first small chemical laboratory in the fifties; Bailey said of him that

> [his] choice of apparatus, like that of books, was most judicious. Nothing but the best would satisfy him, and his chemical laboratory, though small, was a model of convenient arrangement, and, for the time and place, of ample equipment. The necessities of the case made him also his own mechanic . . . . His laboratory was fully supplied with carpenters' tools, and there is no doubt that he knew how to use them.[67]

62 The 1868 oration can be found in the 8 July and 15 July 1868 numbers of the Fredericton *Headquarters;* for the 1872 oration, see L. W. Bailey, *The Study of Natural History.*

63 L. W. Bailey, *The Study of Natural History,* p. 12.

64 *Ibid.,* p. 10n.

65 A detailed description of the museum is in the university *Calendar for 1868-69.*

66 The extensive collections of Laval are catalogued in the successive numbers of the *Annuaire* from 1874-75.

67 L. W. Bailey, "Dr. James Robb," p. 13.

By Bailey's time, however, the chemical apparatus used for demonstration was clearly inadequate. During an absence from Fredericton in the 'sixties, he asked his brother, William Whitman Bailey (1843-1914) — a professor of botany at Brown University — to teach his classes for him. The latter wrote to his brother that "with the Freshmen in Oxygen I did not do so well. I could not manipulate the primitive appliances so as to show what was produced by oxydation. On the whole I like lecturing itself well enough, but such infernal difficulties as I had with the oxygen confuse me."[68] Toward the end of the century, Bailey had acquired more and better chemical apparatus for adequate instruction to science and engineering students, but a large laboratory was unnecessary as long as the numbers of students remained so low.[69]

Nonetheless, in spite of the lack of sufficient apparatus, the content of the science course when Bailey joined the faculty was not inferior to other Canadian institutions. The first *Calendar* of the University of New Brunswick, for the academic year 1861-62, outlined the necessary course of study for the bachelor of arts degree. There is no reason to suppose that the science curriculum of King's College differed from that of the university; Robb may have employed different texts from those of Bailey, but the course in the 'forties and 'fifties was likely similar to that of 1861. According to the 1861-62 *Calendar*, each student was required to study science under both science professors, Jack and Bailey, in each of the three years (in addition to the usual complement of classics, literature, and philosophy). By the end of this period, the student's science course had included chemistry, zoology, botany, mineralogy, natural philosophy, physical geography, geology, and astronomy; although this is a formidable sounding programme, most of these sciences were given a superficial treatment.

The books that a student must study were listed in the *Calendar* from 1861 onward.[70] Freshmen in Jack's mathematics class studied the first six books of Euclid, along with Elias Loomis' *Treatise on Algebra* (New York, 1846); the honours student would, in addition, read Loomis' *Elements of Geometry and Conic Sections* (New York, 1847) and his work on algebraic theory or J. R. Young's *Theory and Solution of Algebraical Equations* (2nd ed., London, 1843). The initial year in mathematics seems quite elementary compared with modern university curricula, but Jack's course was equivalent to most of those taught in Canada during the 'sixties.[71] That mathematics had to be introduced

68 Quoted in J. W. Bailey, *Loring Woart Bailey*, p. 43.

69 The honours students in natural science rarely exceeded a half-dozen. See Honours lists in the University of New Brunswick, *Calendar for 1900-01*.

70 The titles are given in abbreviated form in the *Calendar*. I have supplied the full titles and (when possible) the place and date of the first edition. Several works were published in both Britain and the United States, but I have generally given the American publication date, as American books were likely more available in Fredericton. Most of the works cited went through numerous editions.

to the university student on such a low level was irksome to Jack, but in a country lacking uniform public education, he had little choice. As he commented in 1853:

> I need scarcely remark that the slender mathematical attainments of most of the students on first coming to College, and the extent of ground I am obliged to go over during the three years which they attend, compel me to enter upon some portions of the course much less fully than I could wish or would be desirable.[72]

One might note, however, that the Victorian textbook was usually far more difficult and sophisticated than those of today; Jack's mathematical course may have been elementary, but it was not easy.

In the junior (second) year, the mathematics course continued with Loomis' *Elements of Plane and Spherical Trigonometry* (New York, 1848) and his *Elements of Analytical Geometry and of the Differential and Integral Calculus* (New York, 1851). The honours student also mastered Benjamin Peirce's *Elementary Treatise on Plane and Spherical Trigonometry* (Boston, 1840) and his *Elementary Treatise on Curves, Functions, and Forces* (Boston, 1852). In the senior year, Jack turned to physics and astronomy. Robert Main's *Rudimentary Astronomy* (London, 1852) and W. G. Peck's *Elementary Treatise on Analytical Mechanics* (New York, 1887 and earlier eds.), along with J. A. Galbraith and S. Haughton's popular works, *Manual of Optics* (London, 1854) and *Manual of Astronomy* (London, 1852), constituted the ordinary course, but the honours student was further required to read Loomis' *Introduction to Practical Astronomy* (New York, 1855). It might seem incongruous that Jack employed so many books by American authors: Loomis (1811-89) was a teacher at Western Reserve Academy in Cleveland and Peirce (1809-80) was a famous mathematician at Harvard. A survey of the calendars of other Canadian colleges of the time shows that British-educated professors similarly employed American texts. That many of these works were competently-written, up-to-date, easily available, and relatively cheap, must have resulted in their popularity in Canada.

The majority of textbooks required by Bailey, according to the *Calendar* for 1861-62, were also American. His freshmen in natural science studied J. A. Stöckhardt's *Principles of Chemistry* (Boston, 1851) and a book of problems written by Bailey's teacher, Cooke. The honours student was expected to read Part I (discussions on molecular physics, heat, light, and electricity) in the

71 A comparison of calendars shows that the New Brunswick mathematics curriculum was as good as, or better than, that of Acadia (1861), Dalhousie (1866), McGill (1860), Queen's (1864), or Toronto (1857).

72 Jack to the Bishop of Fredericton, Hon. J. A. Street, and Mr. Justice Wilmot, 10 February 1853, UA.

Elements of Chemistry (Philadelphia, 1843) by the famous Scottish chemist Thomas Graham (1805-69). The junior year included lectures on physical geography and meteorology, the reading of J. D. Dana's *Manual of Mineralogy* (New Haven, 1837), Asa Gray's *Botanical Textbook* (Boston, 1842), and the *Elementary Geology* (2nd ed., New York, 1841) of Edward Hitchcock (1793-1864), a student of Silliman, Sr. In addition, the honours student read Mary Somerville's *Physical Geography* (Philadelphia, 1848).[73] In the senior year, Louis Agassiz and A. A. Gould's (Gould, 1805-66, was a New England invertebrate zoologist) *Principles of Zoology* (Boston, 1848), the remaining parts of Asa Gray's book, and Dionysius Lardner's *Animal Physiology* (London, 1858) — the latter read in its entirety by honours students — were studied.

The *Calendar* for 1861-62 also included requirements for a B.A. with an engineering diploma, the student to pass agriculture, natural philosophy, zoology, botany, physical geography, geology, mineralogy, commerce, navigation, chemistry, and astronomy — a course which was essentially the same as that of the ordinary B.A. and along the lines proposed in the University of New Brunswick Act. The courses seem to have been taught by Jack and Bailey alone; a full-time professor of engineering was not appointed until 1889.[74]

The science curriculum at the University of New Brunswick in 1861 was similar to that of most Canadian and American schools of the period. The programme was practically identical to that of Dalhousie, McGill, and Toronto,[75] and superior in content and coverage to those of Queen's and Acadia.[76] Like most Canadian schools, New Brunswick offered no options but required all arts students to pass the extensive science course. Since two of the four professors at the university were science teachers, the arts course was approximately half scientific and mathematical — a far cry from the classical education still dispensed in several English schools and once provided by King's College, Fredericton. Unlike larger, better-endowed schools like Harvard and Yale, which could staff professors for separate sciences and provide laboratories for them, the University of New Brunswick was forced to rely upon two teachers to offer the full range of courses. As Loring Bailey remarked:

> It was a Professorial Chair, — but was in reality a professorial *settee.* It covered a large extent of ground, and, as you may suppose, a good deal of it, for some years at least, was covered very superficially, while there

73 It is interesting to see one of the works of Mary Somerville (1780-1872) in use in Fredericton. A Scot, she was a leading science popularizer and was responsible for the introduction of Laplace's *Mécanique Céléste* to the educated British public.

74 A. F. Baird, "History of Engineering," *Memorial Volume,* p. 81.

75 *Cf.* Dalhousie, *Calendar for 1866-67;* McGill University, *Calendar for 1860-61;* and University College, Toronto, *Calendar for 1857.* The chemistry course at Toronto, however, was far superior to all others due to the work of the German-trained Henry Holmes Croft (1820-83). See John King, *McCaul, Croft, Forneri* (Toronto, 1914), pp. 119ff.

76 *Cf.* Queen's College, *Calendar for 1864-65,* and Acadia College, *Calendar for 1861-62.*

> was always that tendancy to recline and take things easily which a settee naturally suggests. But I saw at once that to achieve success it would be necessary to bestir myself, and first of all to obtain as far as possible some practical knowledge of the Province which was to constitute my field of labour.[77]

But Bailey's position was no different from that of his colleagues like William Dawson at McGill, William Hincks (1794-1871) at Toronto, George Lawson (1827-95) at Queen's and others.

The course of study outlined in 1861 was to be retained practically unaltered for the next twenty years. The *Calendar* for 1870-71 announced a strictly scientific course, roughly equivalent to a B.Sc. course in other schools.[78] The student had to have English, logic, mental and moral philosophy, but neither classics nor French (still required for an arts course). The only additions to the old science course were navigation and nautical astronomy, land surveying, and engineering, all taught by Jack. Some additional texts were also required, including Silliman's *First Principles of Physics* (Philadelphia, 1859) and William Dawson's *Acadian Geology.*

After Jack's retirement in 1885, the presidency and professorship of mathematics passed to his occasional assistant and Professor of English and Philosophy, Thomas Harrison, who remained president and chancellor until 1906.[79] A New Brunswick native and graduate of Trinity College, Dublin, where he had been a student of the noted algebraist and geometer George Salmon,[80] Harrison taught both mathematics and physics. At the time of his appointment to the presidency (1886), the university opted for a four-year curriculum for the bachelor's degree with a concomitant change in the structure of the science programme. By that time, most universities in North America maintained four-year arts courses. It has been suggested that the change in presidency in 1885 did not necessarily bring about a number of reforms which occurred thereafter,[81] but it would be interesting to know whether the failure to adopt a four-year programme earlier was due to the hesitancy of Jack. Since he had taught within the same curricular structure for forty-five years, it seems a reasonable assumption a change in presidency in favour of a younger, more recently educated man should result in reform.

Under the revised programme, the student in the ordinary course for the B.A. was still required to study both biological and physical science each

77 L. W. Bailey, "Autobiographical notes," quoted in J. W. Bailey, *Loring Woart Bailey,* p. 85.

78 University of New Brunswick, *Calendar for 1870-71.*

79 Harrison's short history of the university and description of its state at the end of the century can be found in J. Castell-Hopkins, ed., *Canada, an Encyclopaedia of the Country* (Toronto, 1898), IV, pp. 275-84.

80 *Ibid.,* p. 282.

81 K. A. MacKirdy, "Formation of the Modern University," *Memorial Volume,* p. 40.

year.[82] The course seems to have intensified somewhat, for the level of mathematics and science being taught could be raised with the additional year. Harrison, styled Professor of Mathematics and Mathematical Physics — no longer natural philosophy — expanded the physics course to include more mechanics and optics. The honours student in mathematics could pursue the calculus somewhat further than hitherto, but the physics student was not yet required to have laboratory practice. Bailey's course in natural science was now spread over four years instead of three, but remained essentially the same in content. For the honours student, field work in geology and botany was now required during the long vacation, and a chemistry laboratory became mandatory for the honours student in natural science. Why Bailey chose to require practical experience of honours students at this point is unclear, but class excursions for botanical collection and geological observation had probably always been a part of Bailey's (and Robb's) course, and the introduction of chemistry laboratory practice was certainly no strain on Bailey's small establishment.

In 1889, the University of New Brunswick appointed its first full-time professor of engineering, A. W. Strong, who remained until 1891.[83] In 1890, a separate chair of physics was created and offered to Alexander W. Duff (1864-1954).[84] Duff graduated from the University of New Brunswick in 1884 and won a Gilchrist Scholarship by passing a competitive examination set by the University of London. Gaining a B.A. from London in 1887, he studied at Edinburgh where he was a Vans Dunlop physics scholar and where he attained his M.A. in 1888. After teaching one year at the University of Madras, he returned to his alma mater and remained in Fredericton until 1893, when he removed to Purdue University and a better-paid position. Edinburgh awarded him a B.Sc. in that year, and a D.Sc. in 1901. He was well-known in the United States and was the author of a number of successful textbooks.

At the time of Duff's arrival, the bachelor's degree courses were again altered.[85] The pursuit of the ordinary B.A. included chemistry in the first year, mathematics in the first two years, physics in the second and third years, natural science in the third, and a choice of either physics or natural science in the fourth year. Thus, the ordinary B.A. student had a lighter, but still demanding, course of science. The B.Sc. course, introduced as a science

82 The new course is outlined in University of New Brunswick, *Calendar for 1887-88.*

83 Thomas Harrison, "University of New Brunswick," *Canada, an Encyclopaedia,* IV, p. 283.

84 The details of Duff's career are slightly inconsistent in several sources: K. A. MacKirdy, "Formation of the Modern University," *Memorial Volume,* pp. 41f.; F. J. Toole, "Scientific Tradition," *Memorial Volume,* p. 73; and Thomas Harrison, "University of New Brunswick," *Canada, an Encyclopaedia,* IV, p. 283. The most consistent version seems to be that in the *National Cyclopedia of American Biography* (New York, 1953), XXXVIII, pp. 572f., which I have followed.

85 University of New Brunswick, *Calendar for 1890-91.*

equivalent of the B.A. in 1890,[86] was structured similar to the arts course, except that both physics and natural science were mandatory for seniors and laboratory work in both physics and natural science was required. The B.Sc. student could "major" in one of three areas: mathematics and mathematical physics; experimental physics and chemistry; or natural science and chemistry.[87] While Bailey's courses did not depart radically from their earlier character, he did introduce two newer textbooks written by University of Toronto professors: H. A. Nicholson's *Manual of Palaeontology* (Edinburgh, 1872) and R. Ramsay Wright's *Introduction to Zoology* (Toronto, 1859). Duff, on the other hand, dispensed with many of the older "natural philosophy" texts and required works that reflected current research in physics, such as the books of Clerk-Maxwell, Lodge, Stokes, J. J. Thomson, Helmholtz, etc. He even introduced a dollop of the philosophy of science with W. S. Jevons' *Principles of Science* (London, 1874). Under his direction, a laboratory for student work and research in physics and engineering was established in 1892. It was equipped with newly-purchased instruments (mostly of German manufacture) for acoustics, electricity, and optics.[88] The university financed the laboratory only with difficulty, prompting the provincial legislature to grant a special sum of $1,000 in 1893, but at the cost of withdrawing support for the collegiate school.[89] By 1901, the university erected an engineering building and the science laboratories were removed to their new quarters.

The curriculum changes of 1890 came just as the two new professors arrived in Fredericton. Professor Duff was fresh from the important science centres of London and Edinburgh, bringing with him the latest ideas in physics and an interest in research. With the appointment of Strong — virtually the institution of a faculty of engineering — came a further need for practical science education. The curriculum changes and the arrival of Duff and Strong could scarcely be coincidental.

From 1893 until the end of the century, physics was taught by George Downing, who held a B.A. and an M.Sc. from Pennsylvania State College.[90] He had studied at M.I.T. and had been awarded the graduate degree in electrical engineering at Brooklyn Polytechnic Institute, His title at Fredericton was Professor of Physics and Electrical Engineering and he taught both arts and engineering students.[91] In 1899, he was succeeded by Arthur Melville Scott,

86 The B.Sc. was introduced as a graduate degree equivalent to the M.A. See University of New Brunswick, *Calendar for 1889-90.*

87 This structure was similar to that of Toronto, where "majors" in mathematics and physics and in biology and chemistry had been instituted in 1877. University College, Toronto, *Calendar for 1877-78.*

88 University of New Brunswick, *Calendar for 1891-92.*

89 K. A. MacKirdy, "Formation of the Modern University," *Memorial Volume,* p. 43.

90 Thomas Harrison, "University of New Brunswick," *Canada, an Encyclopaedia,* IV, p. 283.

91 University of New Brunswick, *Calendar for 1893-94.*

a graduate of the University of Toronto, and presumably, a onetime student of the physics professor there, James Loudon (1841-1916), founder of the physical laboratory in Toronto and a key figure in that university's rapid expansion in science.[93] Scott then studied physics at the University of Göttingen, from which he received his Ph.D. He was thus the first professor of science at New Brunswick to have held both a doctorate and a graduate degree from a German university.[94]

The science programme remained essentially the same until after the turn of the century. Neither professors Downing nor Scott changed the modernized curriculum of Duff in physical science, and Bailey continued teaching his natural science course until 1900. The formation of the engineering faculty in the 'nineties strengthened the move toward science education with laboratory work. The only new additions to the programme in the latter part of the century were graduate degrees in science. Graduate programmes were first outlined in the *Calendar* for 1887-88, for prior to this time the M.A. degree and doctorates were awarded more as honorary than as research degrees, rather like the older British schools had been doing. While several Ph.D.'s had been awarded from 1870, all went to churchmen, not scientists, although Professor Bailey was made an honorary doctor in 1873.[95] In 1887, however, new regulations specified that the candidate for a master of arts degree was required, two years after being awarded his B.A., to either pass an examination or present a thesis and the Ph.D. for science students was to be awarded five years after earning the B.Sc., provided the candidate passed an examination in mental and physical science.[96] This Ph.D. was not quite the equivalent to the research degree offered by many German, American, and Canadian schools. In 1894, the first earned Ph.D. in science was given to Philip Cox, who had received his B.Sc. from the university in 1890. The University of New Brunswick, small as it was, produced its first science doctorate six years before the University of Toronto awarded its first Ph.D.'s.

How did the science programme at the University of New Brunswick compare, in 1900, with the programmes of other Canadian schools? In 1860, the university's curriculum was on a par with the majority of both Canadian and American schools. In Canada, few schools were larger, better equipped, or better financed than New Brunswick; neither were their teachers better educated. By 1900, however, there was a much wider spread of capabilities in Canadian science programmes. The two outstanding schools for science (and en-

92 University of New Brunswick, *Calendar for 1900-01.*

93 For Loudon's role at Toronto, see H. H. Langton, *James Loudon and the University of Toronto* (Toronto, 1927), and James Loudon's unpublished memoirs, University Archives, Toronto.

94 K. A. MacKirdy, "Formation of the Modern University," *Memorial Volume,* p. 44.

95 See the list of graduates, University of New Brunswick, *Calendar for 1900-01.*

96 University of New Brunswick, *Calendar for 1887-88.*

gineering) were Toronto and McGill; each had enrolments greater than 1,000 and had many science professors. McGill counted professors of pure mathematics, chemistry and mineralogy, botany, physics, geology and palaeontology, zoology, and thirteen additional professors, instructors, and lecturers.[97] Toronto's faculty was even larger, with three mathematics, four physics, five chemistry, six biology, and two mineralogy and chemistry teachers.[98] Both universities were producing graduates who went on to distinguish themselves in science. The calendars of both schools reveal that a student could graduate in a wide variety of scientific subject areas; McGill awarded B.Sc., M.Sc., and D.Sc. degrees, while Toronto had just introduced the Ph.D. Both schools maintained laboratories and primary research was being produced by men of the calibre of Ernest Rutherford, Ramsay Wright, J. C. McLennan, B. J. Harrington, and others.

At the opposite end of the scale were the small, mostly Church-supported, liberal arts colleges like Acadia, Mt. Allison, and Laval.[99] Calendars of these schools at the turn of the century show that science was still regarded as an integral part of a liberal education and no attempts at true research-oriented courses were intended. Midway between the extremes were schools which were still too small to maintain large scientific establishments, yet cultivated science and engineering to a larger degree than ordinary liberal arts colleges. In this category would be found Dalhousie, Manitoba, and New Brunswick, with Queen's an upper borderline case. Queen's provided a number of honours courses in science and the D.Sc. degree as early as 1890.[100] Dalhousie's programme provided work toward a B.Sc. but no graduate degree by 1900.[101] The undergraduate courses of both schools were nearly identical with that of the University of New Brunswick, even though the latter was much smaller than either Queen's or Dalhousie. Indeed, considering its size and financial support, the University of New Brunswick provided a remarkably varied and advanced science programme at the turn of the century.[102]

By 1900, the university was comparatively well-equipped in science apparatus and laboratories, considering its still small enrolment. In the Maritimes, only Dalhousie, with science, engineering, and medical programmes, was in the same league.[103] To the west, three universities had superior facilities: Toronto, McGill, and Queen's (Laval, the important French-Canadian school,

97 McGill University, *Calendar for 1900-01.*

98 University of Toronto, *Calendar for 1899-1900.*

99 Laval was a special case during the nineteenth century. The majority of science teaching was done in the Petit Séminaire de Québec, the parent institution of Laval. While there were a number of professors and courses in science, Laval did not evolve into a research-oriented school until this century. See H. Provost, *Historique de la Faculté des Arts de l'Université Laval, 1852-1952* (Québec, 1952).

100 Queen's University, *Calendar for 1889-90.*

101 Dalhousie University, *Calendar for 1899-1900.*

did not develop laboratory science courses until the twentieth century). Toronto's physical laboratory, the first in Canada, was established as early as 1879,[104] and separate, well-equipped buildings for biology and chemistry were erected before the turn of the century.[105] McGill, through the beneficance of Sir William MacDonald, boasted large, superbly furnished buildings for physics (1893), engineering (1893), and chemistry (1898).[106] The Redpath Museum (1892) accomodated the natural history collections previously made by Sir William Dawson. Queen's laboratories were not as extensive as those of Toronto and McGill, but adequate for research programmes for the D.Sc.[107] The decisive factor in the establishment of scientific laboratories in the late nineteenth century seems to have been the maintainance of an engineering faculty. Toronto, McGill, Queen's, Dalhousie, and New Brunswick all taught engineering and all maintained laboratories before 1900; that New Brunswick's facilities were the least extensive was a function of its very small size and limited financial resources.

It is nearly impossible to assess the success of New Brunswick's science programme and the influence this programme had upon the student's choice of occupation or outlook, but a survey of the graduates in the nineteenth century gives some indication of occupational choice.[108] Science was intended to be a liberalizing factor in the New Brunswick curriculum, and the introduction of a science course to produce scientists and engineers was a late

102 A comparison of enrolments, incomes, and endowments in 1898 shows New Brunswick's position:

School	*Enrolment*	*Endowment*	*Income*
Toronto	1,269	$ 1,042,000	$ 85,000
McGill	1,250	1,400,000	145,000
Queen's	525	400,000	40,000
Dalhousie	169	— no figures —	
New Brunswick	60	8,844	12,000

Adapted from a table in *Canada, an Encyclopaedia of the Country,* IV, p. 324.

103 Dalhousie University, *Calenaar for 1899-1900.* Dalhousie had a Faculty of Pure and Applied Science as early as 1891 and was able to establish a number of chairs of science through the philanthropy of George Munro and others.

104 W. J. Alexander, ed., *The University of Toronto and its Colleges, 1827-1906* (Toronto, 1906), p. 90.

105 *Ibid.* The facilities at the turn of the century are described in the university calendar for 1900-01.

106 All described in the McGill University, *Calendar for 1900-01.* Separate laboratories for physics, chemistry, botany, zoology, petrography, various branches of engineering, and a botanical garden were all established before 1900. McGill's facilities were the most extensive in Canada by that date.

107 Queen's University, *Calendar for 1889-90.*

108 See list of graduates in the University of New Brunswick, *Calendar for 1900-01;* occupations for many graduates have been provided in this list, from which I have taken my data. Unfortunately, the list is not exhaustive.

addition to the curriculum. Considering that most King's and New Brunswick graduates were destined for the professions, politics, the church, or commerce, we should not expect a large number of scientists among the graduates. In fact, of the pre-1900 graduates, only two went through the science course and into graduate work at the university: Philip Cox and J. Z. Currie (B.Sc., 1890; Ph.D., 1895). Four others, who received B.A. degrees from the university, went into pure or applied science careers: W. Ganong (B.A. 1884), A. W. Duff (B.A. 1884), W. K. Hatt (B.A. 1887 — later an engineering professor at New Brunswick and Purdue), and W. D. Matthew (B.A. 1899 — later a Columbia D.Sc. and palaeontologist for the American Museum in New York). Several other graduates became civil or electrical engineers. The efforts of Jack, Sir Edmund Head, and others had made the university a pioneer in engineering education in the 'fifties, and the addition of laboratory work to the curriculum, the organization of a strict science course, and the provision for graduate study in science — in short, the adoption of the German-style of science education — were made at New Brunswick only about a decade after similar moves had been made at McGill, Queen's, and Toronto. Considering the miniscule size of the university and its financing, the strides toward a modern science programme were considerable, yet those efforts did not propel New Brunswick into the same rank as McGill, Queen's, and Toronto.

A number of factors contributed to the failure of the university to attain importance as a science centre by 1900. The school was in a small province which had a scattered population, no diversified industrial base, and a small intellectual class. Fredericton, by virtue of being the seat of government, had acquired the university; Saint John, the metropolis of the province, would have been a more logical choice. The chief universities of central Canada were located in the commercially and intellectually important towns. The small enrolment figures of the university did not seem to require the greater funding necessary for a modern scientific establishment. By 1897, the university counted only 69 students;[109] The annual income by 1900 was a paltry $8,844.48 per annum.[110] Twenty years later the annual grant had reached only $25,000.[111] Unlike its more fortunate sister schools like Dalhousie and McGill, which had their George Munro, Sir William MacDonald, and Peter Redpath, the University of New Brunswick could look to no private source of income for enlarging its scientific facilities.[112] The wealthy commercial families of Saint John withheld what might have been decisive gifts; indeed, very few of them even sent their children to the university as Jack lamented in his

109 Thomas Harrison, "University of New Brunswick," *Canada, an Encyclopaedia,* IV, p. 284.

110 W. S. MacNutt, "The University in the Twentieth Century," *Memorial Volume,* p. 49.

111 *Ibid.*

112 K. A. MacKirdy, "Formation of the Modern University," *Memorial Volume,* p. 37.

1876 Encaenia.[113] The government and public of New Brunswick never seem to have been sufficiently warm to the university to provide the necessary aid for expansion and the poisoned relationship between school and society during the long years of strife before the university replaced Anglican King's College seems to have lived on to the end of the century. A study of public attitudes toward higher education in New Brunswick would be well worth undertaking, and by illuminating the difficulties of the science programme, it could also provide reasons for the failure of the university to add professional faculties before the present century. Nonetheless, despite these difficulties, the younger generation of science teachers at the University of New Brunswick, fully in sympathy with the modern approach, faced fewer problems and could look forward to better prospects than had David Gray and James Robb when they arrived in Fredericton in October 1837.

113 "For many years past I have witnessed with astonishment and regret the small number of pupils sent from St. John to receive a University training. Considering the large population of that city and its suburbs, and the wealth and social position of many of its citizens, one would naturally expect that the University would obtain from it a larger number of students than from all the other parts of the Province taken together. There, however, the moving spirit which animates and pervades society seems to be an intemperate haste to get rich; and as business and money-making forms the chief topics of conversation, the prevailing idea is implanted in early youth, and strikes deeper and deeper root with advancing years." W. B. Jack, "Encaenial Oration for 1876," Saint John *Daily Telegraph*, 23 June 1876.