Aberdeen is not a place one happens to pass through. It is a place one deliberately goes to. So it is in the 21st century and so it was in the 19th century. James Clerk Maxwell chose to go to Aberdeen not only because a vacancy there had appeared at a convenient time in his life but because it was certainly an appropriate place to be. Edinburgh, the city whose people and places Maxwell knew so well, is 120 miles to the south. There is no indication that Maxwell had ever visited Aberdeen before his application for the job but it was a place he undoubtedly would have known by repute. By way of introduction to Maxwell’s Aberdeen years, let us look briefly at the city Maxwell chose to leave Cambridge for. There have been several histories written of Aberdeen that cover its changing character; a briefer view of its situation in the 1850s is revealed in contemporary encyclopaedias.

Aberdeen was a centre for academic life. There were two Universities, both of which could boast centuries of serious scholarship and teaching reputation. In the ‘New Town’ was Marischal College, founded in 1593 by Earl Marischal as a post reformation University that within its Arts syllabus established a reputation for progressive teaching in Mathematics and the Sciences. In Old Aberdeen, a city that was still separated from the commercial Aberdeen by charter, ecclesiastical jurisdiction, administration and a mile of cobbled road that passed through the Spital village, lay King’s College. By 1850 King’s was the smaller of the two Universities, founded by Papal decree in 1495. Old Aberdeen was little more that King’s College, the ancient St Machar’s cathedral, the Old Town house and a few streets of housing that served these places; a city of 1000 souls, not many more. The Aberdeen of Marischal College was a thriving, expanding, modernising city of some 35,000 in Maxwell’s day, the most important city in Scotland north of Edinburgh. An academic city it may have been but it was certainly no Cambridge of the north.

Until the beginning of the 19th century, mercantile Aberdeen had been a small town of narrow, twisting streets set back on small hills from a usable but not outstanding natural harbour at the estuaries of the Denburn, the Holburn and the river Dee. In 1801 the city fathers had initiated a visionary rebuilding of the city, beginning with laying out two streets, Union Street and King Street, approximately at right angles, artificially level and each about a mile long. Union Street, the main street, was 70 feet (21 m) wide and over the next few decades would be lined with fine granite buildings that set the scene for the future expansion of the whole ‘granite city’ [Fig. 1]. A self-sustaining sense of civic pride brought with it a high quality building and development programme utilising the native stone. New schools, churches of several denominations, banks, a central hospital, asylums for the poor and mentally ill, a large public indoor market, assembly rooms, the seven incorporated trades’ building, a permanent building for the Mechanics Institution, and other public buildings were
erected to designs by architects of stature. Marischal College itself was completely rebuilt in the late 1830s.

Aberdeen was a thriving commercial city, a centre for textile production, fishing, the rapidly expanding granite industry that served both the locality and exported finished and polished granite, and the shipbuilding industry that was producing not only coasters and fishing smacks but the great Aberdeen clippers that opened up trade with the East Indies and China. Aberdeen was also an expanding rural centre, as agricultural reform over preceding decades raised both the extent and productivity of North East of Scotland farming. Not far from the town, several large papermaking mills using the waters of the rivers Dee and Don were making the area into one of the leading paper producers in Britain. Industry on this scale needed good connections with the outside world and these were provided by the expanding harbour facilities and, from 1850 onwards, the rail link south and to London in particular, a distance of 542 miles (870 km) by the shortest route.

It was to this elegant, bustling, dynamic city that Maxwell came in 1856. It was from this city and its surroundings that most of the pupils in his classes would come. It was with the permanent and temporary residents of Aberdeen that Maxwell would mainly engage during the years he was a resident.

Maxwell was appointed by the Crown as Regent and Professor of Natural Philosophy at Marischal College in April 1856, only weeks before the death of his father. The competition had been strong, with about a dozen candidates, some of whom were highly qualified. He was 24 years old, though he would be 25 when he was formally inducted into the office in August of that year. In April he had also been elected a Fellow of the Royal Society of
Edinburgh. He took lodgings from Mrs Buyers at 129 Union Street, above the premises of J. D. Milne, Advocates, within five minutes walking distance of Marischal College.

Maxwell’s lodgings at 129 Union Street.

The entrance between the ground floor shops leads via a spiral staircase to the upper floors that were leased.

This was his first professorial post and would be his only Scottish Chair. A Regius Chair in an ancient University is a post that is hard to better in academic life. William Thomson and P. G. Tait were both appointed to the corresponding Chairs in Glasgow and Edinburgh in their 20s and both stayed in their posts for their academic life. Maxwell might well have been anticipating the same prospect, though he did know in 1856 that proposals were afoot to merge the two Universities in Aberdeen. If that issue worried him, it does not come through in any correspondence. He set to, pursuing interests that had already caught his attention in optics, in colourimetry, in electricity, in the challenge of further understanding the dynamics of Saturn’s rings and in the broader field of understanding the nature of Nature. One of these topics was probably never far from his thoughts but what would occupy most of his time while at College would be his teaching, an aspect of the post that he clearly enjoyed.

Maxwell came to Marischal College as a brilliant young man. He would leave in four years time as one of the leading scientists of his age, to use the modern description.

MARISCHAL COLLEGE

MARISCHAL COLLEGE

Fig. 3 shows the almost new, sparkling, grey granite Marischal College building that welcomed Maxwell. The College’s motto, taken from that of the Earls Marischal, ‘Thay haif said, Quhat say thay, Lat thame say’ promised a place that valued independence of thought. The clan motto of George Keith, 5th Earl Marischal and College founder was ‘Veritas Vincit’ – ‘truth conquers’, which was also fitting. Looking at the College from the entrance, his rooms were one floor up towards the rear on the left. The business of the College was its general MA degree, its substantial medical school and its small post-graduate schools in law and divinity. In 1856, almost 250 students were enrolled in the four years of the MA course.
There were subject entrance exams for the regular students (called ‘gowned’ students), 216 in all, but courses were open to private students as well. Private students of Natural Philosophy were exempt from any entrance examination but were required to have a ‘competent knowledge of mathematics’. Maxwell himself knew the Scottish system very well, for he had been a private student in the University of Edinburgh for three years in his late teens.

Maxwell taught the major component of the degree programme in a student’s third year, or tertian year as it was known. Typically he had around 50 students in this class. He also had other teaching, as will be discussed later. He was, of course, only one link in the chain of the four-year MA syllabus. Almost all Maxwell’s colleagues were at least twice his age. Four were ‘divines’, in the sense that they were licentiates of the Church of Scotland, and taught either the religious component of the degree, philosophy or Greek. In addition there was Robert McLure, the Professor of Humanity, whom Maxwell had known in McLure’s previous career as a schoolteacher in Edinburgh Academy. Finally, the other two principal scientific staff besides Maxwell were John Cruickshank, the elderly but very competent Professor of Mathematics who had devoted his life to teaching and James Nicol FRSE, FGS, at 46 Maxwell’s youngest colleague, formerly Professor of Geology and Mineralogy at Cork, a geologist who can justifiably be placed in the same room as his great Scottish contemporaries Murchison, Lyell and Archibald Geikie for his perceptive interpretation of the geological record. There were also Professors for the optional classes, such as Chemistry and Agriculture. The staff in total comprised 14 professors and 6 lecturers, covering the MA degree and the degrees in law, divinity and medicine.
Marischal College was serious about its MA teaching. It had introduced both an entrance exam and final exams long before they became general University requirements in Scotland. The MA degree was available only to enrolled students who had successfully completed their four years’ study of the traditional subjects of Latin, Greek, Natural History, Mathematics, Natural Philosophy, Moral Philosophy, Logic and Evidences of Christianity. In addition, they had to pay a significant fee to graduate. Some took the subjects but did not pay to collect their degree. There were also optional classes in Chemistry, Agriculture, Roman History, Rhetoric and English Literature and in advanced Greek, Latin, Natural Philosophy (introduced by Maxwell) and Mathematics. In Maxwell’s time, the degree was known by its Latin initials of AM (Artium Magister).

Marischal College shared in the Scottish reputation for providing good and accessible education. We think of 19th century Britain as being highly structured by the largely unwritten rules of social status. This was not the case within the Scottish Universities. Fees were low (about £5 per annum at Marischal College and King’s College, Aberdeen) and many entrance bursaries were available. More than half of Maxwell’s pupils came from farms or the trades. The poor rubbed shoulders with the well off and all were judged on how they performed. Little else mattered. The motivation for most students was, of course, not only to use one’s brains but to escape from following one’s father’s occupation of long hours, low pay and little status. As it transpired, some exceptionally talented students came from poor backgrounds.

The session ran continuously from early November until early April. There followed a break of seven months, during which pupils went home to their farms or their parents’ trades and professions. Non-graduating students were, by and large, boys in the age range 17 to 19 by the end of a session, well capable of earning their keep and contributing in labour towards next year’s University expenses. Maxwell followed their example of decamping from the College at the end of session to base himself at his estate in Glenlair, now his own responsibility having inherited it in June 1856.

MAXWELL’S UNDERGRADUATES

We would not be writing about Maxwell in the 21st century if he had been simply an exceptional teacher in his day. Few people earn a reputation for their teaching that lasts much beyond their own retirement and the dispersal of their audience to their separate lives. Maxwell, though, seems to have earned himself a ‘bad press’ in relation to his teaching, a press based on very little contemporary evidence and that only in the form of a few anecdotal comments. His friends, such as P. G. Tait and William Garnet described him as a lecturer who would lose most of his audience, though they had never been students in Maxwell’s class. Comments quoted in the biography of David Gill, who was a pupil of Maxwell’s at Marischal College, cast some light on the enigma that was Maxwell’s teaching. ‘He was not a schoolmaster at all’ said Gill, ‘his lectures were terrible’ but ‘his teaching influenced the whole of my life’. Gill never lost an opportunity throughout his life of praising Maxwell’s teaching.

Maxwell may have been no schoolmaster but the bad press that labelled him a poor teacher has been misguided. Maxwell was well aware that his insight was both hard-won and, set against the knowledge of society at large, exceptional. He shared with Faraday, and others now remembered particularly for their research, the ethos that searching for the truth is only part of the task; passing on one’s knowledge is equally important. Education in its broadest
sweep was a motivation for Maxwell throughout his life. When he came to Aberdeen he threw himself into his teaching, conscientiously prepared his coursework, discoursed with his students long after the lecture hour was up, inspired some and impressed many. Gill related how Mrs Clerk Maxwell would come into the College wondering why he hadn’t come home for dinner and find him discoursing with his students. He maintained more private students than his predecessor, larger Natural Philosophy classes than at King’s College and a thriving optional fourth year class that he introduced. In October 1857 after a year in post, he was asked to present evidence to the Royal Commission of enquiry into the possible union of Aberdeen’s two Universities. In his opening remarks he commented “I have not so much studied the interests of [the] Colleges as those of the classes and students”\textsuperscript{12}. It was plain where his own interests lay.

Teaching hones clarity of thought, at least in the conscientious teacher, and there is a good case to be made that the exceptional clarity of thought that Maxwell brought to all aspects of his work and writing was in part developed through his teaching experience, particularly that of his Marischal College years. In addition, teaching provides an opportunity both for breadth of coverage of one’s expertise and for general reflection. For example, one can read in such places as Maxwell’s inaugural lecture\textsuperscript{13, 14} his general thoughts on ‘What is Natural Philosophy?’\textsuperscript{15}.

Even today, with specialist honours degrees occupying most of the undergraduate work in a University, graduates often take up careers in areas other than the narrow discipline of their degree. Maxwell was teaching a course that all MA students took, whether they would become future doctors, lawyers, teachers, preachers, engineers, traders, explorers, academics or professionals in some other way. Thanks to the efforts of graduates to keep in touch with each other and with the College, we know much more about many of Maxwell’s students than simply their names\textsuperscript{16}. The class memoirs contributed to by graduates later in their lives tell of their careers; the College records give details of their background as students.

Reid\textsuperscript{17} has presented some statistics relating to Maxwell’s pupils. By birth, the majority of the students were from NE Scotland. The greatest proportion of students were sons of tradesmen: masons, wrights, millers, saddlers, shoemakers, merchants, booksellers, smiths, ironmongers, druggists and so on. These trades, however, got little direct return on their investment, for over two thirds of his students entered one profession or another, in medicine, religion, teaching or the law. In the 1850s, ‘scientist’ was not a recognised profession within the educational system. The word had barely been coined. Only a single Aberdeen student became a recognised scientist - David Gill, mentioned above, one of the leading observational astronomers of the century who would become the Queen’s Astronomer at the Cape of Good Hope, FRS and President of the Royal Astronomical Society. David Gill was a private student in Maxwell’s final year at Marischal College and has written briefly about his experience\textsuperscript{18}.

The fact is that very few men out of the total number who obtained degrees anywhere did become scientists of note. David Thomson, Maxwell’s ‘rival’ who taught Natural Philosophy at neighbouring King’s College for 35 years, had four students who went to Cambridge and emerged Senior Wranglers. None became physicists\textsuperscript{19} but their achievements attest to the standard of teaching and students in Aberdeen. However, in contrast to Maxwell’s experience at Aberdeen, when he himself was to finish his professorial career at Cambridge, he would have very few students in his class but a significant number of them would make a name for themselves in the physical sciences. That era of his career is the subject of a later chapter.
MAXWELL’S TEACHING

At Marischal College, Maxwell had a pretty free hand in constructing his undergraduate course; he could choose his own syllabus and his own recommended textbooks. He settled on the monographs of Galbraith and Haughton as supplementary reading. There were no external examiners, and no quality assurance schemes - not that he would have feared either. He inherited a common level of preparation of his students, private ones excepted, who had already received lecture courses in Natural History and elementary Mathematics but no previous Natural Philosophy. He also inherited the use of a very large amount of demonstration equipment, some of it made to a high standard over 50 years previously by a predecessor, Professor Copland\textsuperscript{20}. He had his own lecture theatre, one of 16 in the College, with a private room attached.

Maxwell’s inaugural lecture at Aberdeen outlining his philosophy of knowledge was summarised in the press at the time and more recently has been printed. Maxwell writes quite frequently and positively in his correspondence about his teaching (a sure sign of his commitment) but we can be even more precise about what he did, for two sets of student notes have come to light, one from his first year and one from his third year of teaching. The first year notes were taken by Angus Fraser\textsuperscript{21}, son of an Aberdeen grocer who went on to become a doctor and later a representative for the University of Aberdeen on the General Medical Council\textsuperscript{22}. The second set of notes was taken by Alexander Davidson\textsuperscript{23}, a man who continued his father's paper-making business on the river Don that flows through Aberdeenshire and whose mill survived into this century under the family name, but closed in 2005.

Both sets of notes refer to Maxwell’s tertian course, the course that was the main reason for his College employment. He chose to include a modest range of subjects, unlike his predecessors. Also unlike his predecessors, he emphasised the numerical and mathematical side of his selected subjects.

Angus Fraser’s notes cover 156 pages of a small notebook significantly less than A5 in page size. He dates many of his entries, showing that in this year Maxwell typically gave four lectures per week at 11 am and also two to three 9 am sessions per week that were either problem sessions or in-course examinations. In all there were 14 examinations, each containing 10 questions, written out within the notes and each followed by brief answers. Some days when one might have expected lectures they are missing, with no indication if the absence is due to the student or to Maxwell. On the whole the topics flow.

The notes are indeed ‘notes’, an hour’s lecture being condensed into typically one to two small pages. [Harman has printed a manuscript version of an introductory lecture by Maxwell in November 1856 on ‘Properties of Bodies’ that is contained in the University Library, Cambridge\textsuperscript{24}. It runs to six printed pages.] Fraser’s notes read as if they are a condensation in the student’s own words of the ideas Maxwell was trying to get across, written up as a fair copy from rough draft made during the lecture. Nonetheless they start out with two sentences that sound like Maxwell’s. He begins: \textit{“The most simple things are the most abstract. There is nothing simple in Nature.”} A brilliantly succinct message for those bright enough to read it that Natural Philosophy is going to be a challenging subject that will get you thinking.

Fraser appends three pages of ‘Contents’ to the notes which show at a glance the balance of the course. Pages 1 – 106 cover statics, dynamics and related concepts; pages 107 – 127 hydrostatics and pneumatics; pages 128 – 145 heat and a section on determining altitude with
a barometer; pages 149 - 156 a little on basic optics, namely reflection from plane and curved mirrors. The final date is the 10th of March. It has to be said that the notebook represents simply Fraser’s notes of Maxwell’s course and not necessarily the complete course. In fact as the course progresses the emphasis in the notes is increasingly on the numerical work. Some of the in-class exam questions ask for facts not recorded, confirming that Fraser’s emphasis is on recording the numeric aspects.

The lectures include flashes of nice visual imagery. For example his picture of compounding velocities is: “This is best seen by a fly walking along one side of a sheet of paper and the paper moved in a direction perpendicular to its motion”. However, unlike the notes of his predecessors, Fraser’s notes do not contain multiple examples of practical applications of concepts. Some practical applications come though in worked numerical examples and in the examination questions. The mathematical skills expected of the students are manipulation of algebraic equations, reading the geometry of diagrams, resolving forces into components at right angles (sine and cosine), manipulating expressions involving trigonometrical quantities, properties of a parabola (in connection with trajectories), manipulation of logarithms (in connection with the relation between barometric pressure and height).

One needs to compare the course not with today’s third year of a University degree but with what one might teach a bright 19 year old who had not done any physics before, for that was the average age of Maxwell’s students. It is also worth reflecting that every undergraduate in the University took this course in his third year, not just those intending a career with some technical background. Look very briefly at a few examples from the notes. The first examination after a fortnight’s work includes the question “ABCD is a horizontal rod, 1 yd [yard = 3 feet] long. A weight of 1 lb [pound] is hung at A, 2 lbs at B one foot from A, 3 lbs at D. What is the moment about C of a point 2 feet from A and which way does it act?”. This sets the tenor of the course. In the problem class six days later the following problem is discussed (Fig. 4). “AB is a rod placed between a smooth wall and a smooth floor. Put a [smooth] peg C to prevent it sliding and there follows a worked example showing how to find the force S exerted by the peg as $Wacosa/(b-acos2a)$; ‘a’ is the half-length of the rod and ‘b’ the distance from the peg to the centre of the rod. Such an example shows the power of the formalism to be precise and tacitly assumes that boys who have passed exams in Latin, Greek and Maths are possessed of significant powers of deduction and logic.

Not long before Christmas, having dealt with motion under constant acceleration the subject of trajectories is discussed. It is at this point that the majority of Physics texts launch into a discussion of guns firing at targets, the maximum range attainable and so on. Maxwell, avoiding this aspect, discusses balls being projected but his worked example is “In a certain waterfall the stream shoots horizontally over a rock and falls into a pool below clearing a
horizontal distance equal to one fourth of the height of [the] fall. The time of descent is 3” [seconds]. Find the height of the fall in feet and the velocity of the stream above the fall in miles per hour.” The acceleration due to gravity is taken as 32 ft s\(^{-2}\) and the answers are shown to be 144 feet and \(8\frac{2}{11}\) mph. With a sporting slant, a later example discusses what conditions need to be satisfied for a partially inelastic ball to rebound to its initial point when it hits a vertical wall. The reader is invited to answer this question.

Alexander Davidson’s notes made two years later are substantially fuller and could have been made ‘on-the-fly’ in the class, or perhaps copied to some extent from Maxwell’s own manuscript. He records 109 lectures altogether, excluding exams and problems sessions. Optics is dealt with much more fully, 19 lectures on the subject running to the end of March 1859. Reid\(^{27}\) discusses these notes in some more detail.

There can be no doubt that Maxwell developed his undergraduate courses himself\(^{28}\), designing them to put across his own views on the relevance, desirable content and purpose of Natural Philosophy. The great majority of his extant letters written during the first three sessions he was in College mention some aspect of his teaching. None acknowledge any specific input into it from other sources. In his fourth session he was applying for the equivalent Edinburgh post and had other things on his mind.

Maxwell was now delivering a parallel course to that of James D. Forbes in Edinburgh, whose lectures had benefitted him over the years 1847 to 1850 and whose friendship had continued beyond Maxwell’s departure from Edinburgh. Forbes has been credited with introducing in the 1830s a more numerate course than that of his predecessors John Leslie and John Playfair. Forbes’ extant notes attest that his course was a fine example of a broad ‘old style’ Scottish course: full of facts, not shying from numeracy, well illustrated by practical examples of applications of principles and including lecture demonstrations\(^{29}\). Maxwell’s course differed from Forbes in many ways but particularly in Maxwell’s ethos that it was important to show how principles plus mathematics resulted in quantitative deductions about nature.

Maxwell certainly included demonstrations and went out of his way to make up his own demonstrations for the students, doing more than simply using the College’s large stock of equipment. Indeed, Maxwell not only put on demonstrations but also ran experiments, as he put it, being done by the men on their feet and the experiments not cooked in any way\(^{30}\). One of the messages he wanted to get across was that simply ‘doing an experiment’ is not enough: accurate results require accurately performed experiments. Maxwell’s introduction of practical physics work for students was an early example of such initiatives, albeit on an occasional basis rather than as a formal requirement. William Thomson had introduced practical work for students at Glasgow\(^{31}\) even earlier. The Scottish Universities were well placed for such a development. The popularity of teaching by demonstration ensured that the Professors had access to a large cabinet of equipment and were well practised in its use, and the egalitarian atmosphere of the University in which social divisions were largely ignored contributed to the recognition that students were participants in the educational process and not mere recipients of wisdom handed down ‘ex cathedra’.

In his first year of teaching Maxwell inaugurated a voluntary “advanced class” for final year students. In his second year he formalised the arrangement and commented to his aunt Jane Cay “I have a large attendance of my old pupils....This is not part of the College course, so they come here merely from choice.”\(^{32}\) To P. G. Tait: “My regular class is small this year as I expected from the character of the men below, last year. My advanced class (an institution of mine) is large and evidently jealous. With them I expect to do Newton 1, 2, 3 with a sketch of
Physical Astronomy, Magnetism and Electricity in the poor weather and Undulatory theory when the Sun appears in Spring. His ‘ordinary men’, as he called them, covered Statics, Dynamics, Hydrostatics, Heat and some Geometrical Optics. This comment agrees with Fraser’s notes. He related to Tait in a tone of some surprise and pleasure that when his first class returned after the summer break of almost seven months (early April to November) he set them an exam and four men got full marks and only four less than half marks. Try that experiment today and even the best in the lecturing profession would be very pleased with a comparable performance.

Maxwell was not alone in Aberdeen in offering advanced classes and the system was essentially the pre-cursor to the introduction of an Honours degree, which did not formally exist in Aberdeen in Maxwell’s time, though they had the next best thing. Since Cruickshank introduced the degree exam, after 1828 the best students were declared to have attained their degree ‘with honourable distinction’. Formal Honours appeared in 1860 in the new, merged, University of Aberdeen.

With Maxwell in particular, it is easy to fall into the trap that snares scientific biographers of raising their subject to saintly status. It is true that one can be knowledgeable, enthusiastic and have well organised course material but if one’s oral delivery doesn’t match the expectation of the audience then the lecture has fallen at the last hurdle, as it were. It seems from some contemporary comments that Maxwell fell down here. Most in the audience saw past any difficulty; some badged him inappropriately as a poor teacher. His biographers Campbell and Garnett devote two pages to discussing Maxwell as a teacher but the fact remains that if he wrote a better lecture than he sometimes delivered, which seems to be the case, a far wider audience have reaped the benefit than had the reverse been true.

In many ways both Maxwell’s courses and his methods of delivery look thoroughly modern, and certainly much more closely aligned with 20th-century practice than with 18th-century practice. With his intimate knowledge of both the Scottish and Cambridge educational systems, he shared with Thomson and Tait the ability to blend the best of both systems: the breadth of vision of the Scottish, which encouraged intellectual versatility, with the attention to detail cultivated at Cambridge. Thomson and Tait’s textbooks (their Treatise and its simplified version) and Tait’s shorter, more specific, textbooks used this expertise to fill a conspicuous want for good English language textbooks. The Aberdeen years grounded Maxwell’s teaching expertise. It is often forgotten that Maxwell wrote teaching textbooks that were not only highly successful in the 19th century but were valued well into the 20th century. His “Theory of Heat” first appeared in 1871, where he introduced the public to Maxwell’s demon. 2000 copies were printed. Before 1872 had passed another two editions each of 2000 copies had been printed. By the time of the posthumous 10th edition in 1891, Lord Rayleigh had taken on the role of providing updates and 1921 saw the 18th ‘edition’, albeit a reprint of the 1897 version. At least 5 ‘modern’ reprints have appeared since 1968. Maxwell’s “Matter and Motion” first appeared in 1876 and was reprinted before the year was out. The first American edition was printed in 1878. Following several reprints on both sides of the Atlantic, Sir Joseph Larmor added notes and appendices to produce a new edition in 1920. This edition was reprinted in 1925 and at least half-a dozen times since 1952. Maxwell’s “An Elementary Treatise on Electricity” was conceived of in 1873 as containing simplified material from the now famous “A Treatise on Electricity and Magnetism”. It was not published, however, until 1881, under the editorship of William Garnett. It ran to a second edition in 1888 and two modern reprints.
One reason for the success of Maxwell’s teaching texts, and those of Thomson and Tait, is that they were not simply recycling long-established results but were expounding in clear and persuasive language the new understanding in basic physics that their authors had been responsible for developing – concepts such as energy, the molecular picture of thermodynamics, the new understanding of electricity and more. In a way Maxwell’s contributions to the great ninth edition of the Encyclopaedia Britannica were a natural development of his zeal for teaching. They covered Atom, Attraction, Capillary action, Constitution of bodies, Diagrams, Diffusion, Ether, Faraday, Harmonic analysis and Physical sciences. All this was long after his Aberdeen years but these years laid the foundation of his proficiency. Maxwell deserves to be remembered as one of the 19th century’s notable pedagogues. From his second year onwards at Marischal College he was, as he remarked in a letter to his friend Henry Droop, talking to classes for 15 hours a week. His expertise was built upon understanding, enthusiasm, hard work and experience.

MAXWELL’S EVENING CLASS

In October 1857, Maxwell undertook to give the Natural Philosophy evening course of the "Aberdeen School of Science". This course of some two dozen lectures ran for one evening per week (Monday, at 8.10 p.m.) for exactly the same span as the College classes, namely five months from early November until early April. The fee was 8 shillings per student, per annum. Maxwell had already had the experience of lecturing to ‘working men’ in Cambridge and had clearly found the experience rewarding. In Aberdeen, he had been present at the meeting to inaugurate the Schools of Navigation and Trade earlier in 1857 and was appointed to the Committee of the School of Science.

The Aberdeen School of Science and Art, which was already established when Maxwell arrived, was aimed at mechanics, tradesmen and others who could not attend daytime lectures. Indeed most local tradesmen of the day worked from 6 am to 6 pm and then went home to clean up and be fed. The School was also open to ladies, though it had ‘the special object of affording to young Mechanics, Tradesmen, &c., instruction in those branches of Science which are of the greatest practical utility in the chief, trades, arts, or professions, followed in this locality...’. It was operated in conjunction with the Aberdeen Mechanics Institution and, in a pioneering venture that was later to be adopted in other cities, with the Committee of the Privy Council on Education. The 34th report of the Mechanics Institution incorporates the report on the School for the last year that Maxwell taught there (1859/60). Appendix II of this report is a table listing the professions and age groups of all the male attendees at all the evening classes. Maxwell’s class isn’t singled out but the table shows clearly the ages of the men who attended these classes. The numbers are: ages 11-15 (55 pupils), 16-20 (145 pupils), 21-25 (42 pupils), 26-30 (10 pupils). 55 named professions are listed for the 252 pupils, covering a wide range of the service and manufacturing industries. Apart from the obvious Blacksmiths, Brassfinisher, Brassmakers, Engineers, Mechanics, Shipwrights, Tinsmiths and others on the mechanical side there were Basketmakers, Carvers and Gilders, Combmakers, Ropemakers, Stonecutters, Stonepolishers, a Tobacco-spinner and a Wirefence maker, Wrights and 39 other professions, an eye-opening testament that self-improvement had percolated into the pores of pretty well every trade.

Students of the School were given access to the extensive library of the Aberdeen Mechanics' Institution, and could expect the lectures in Natural Philosophy and in Chemistry to be illustrated by Marischal College apparatus, courtesy of the College Senate. The classes took place in the College. Although it was not stated in the advertisements for the class, it would
seem that the Natural Philosophy class was seen as a sequel for those who had acquired the accomplishments of both the junior and senior mathematics classes. It was intended as a serious professional class, in a way the pinnacle of what the School offered, and hence expected to attract only modest numbers. The Natural Philosophy course had been started by Maxwell’s predecessor at Marischal College, Professor Gray, at the opening of the School in 1854. It involved not only preparing and delivering the coursework but marking the attendees’ weekly homework exercises.

Gray had given a wide-ranging course but Maxwell’s course concentrated on mechanics, with perhaps some electrical theory relevant to the telegraph. In one letter of 1857 to C. J. Munro, Maxwell wrote that he had "also a class of operatives on Monday evening who do better exercises than the University men about false balances, Quantity of Work etc." His choice of topics may have been influenced by outside considerations, since participants could present themselves for an exam instatics and dynamics at the end of the course, overseen by the Department of Science and Art in London. Few did. The Aberdeen Journal reported in April 1858 just four Natural Philosophy results, by a draughtsman, a watchmaker, a blacksmith and a clerk.

Marischal College had an enviable track record of supporting extramural lectures to tradesmen, professionals and a social audience that went back more than 70 years before Maxwell’s time. A predecessor in Maxwell's Chair, the same Professor Copland who built up such a tremendous stock of demonstration equipment, had given a much longer extra-mural course on Natural Philosophy over a period of almost 30 years from the mid 1780s. Copland's successor at Marischal College, Professor Knight, was the founding lecturer in Natural Philosophy at the Aberdeen Mechanics' Institution in 1824 when he lectured to an audience of over 500. In many towns the Mechanics Institutions of the early 1820s foundered as enthusiasm for them waned but in Aberdeen the local Institution survived this dip in interest and secured an established place in the educational framework of the city. Edinburgh’s Watt Institution and the Glasgow Mechanics’ Institution were the only two other Scottish examples to conspicuously survive. In fact The Robert Gordon University in Aberdeen can trace its 19th century roots to the Aberdeen Mechanics Institution.

MAXWELL’S RESEARCH

This chapter has spent some time on Maxwell as teacher, for it is an aspect of his life and character that has been underplayed in his other biographies. However, what still astonishes modern scientists is Maxwell’s penetrating insight into a wide range of disciplines. The eminent Charles Coulson, a 20th century successor to Maxwell at King’s College, London, has rightly commented that ‘There is scarcely a single topic that he touched upon which he did not change almost beyond recognition’. The diversity of Maxwell’s interests come out both in the papers he published in his Aberdeen years and in the topics he discussed in his personal correspondence.

Glenlair beckoned for a good half year in the closed season of teaching but in the 1857 season Maxwell had to establish himself as a worthy successor to his father as landlord of the estate, overseeing the building of houses and dykes (field walls), cutting drains, sowing seed, attending to the welfare of his tenants and generally running Glenlair house as owner. Maxwell had been made a JP (Justice of the Peace) in Edinburgh in 1854, though he does not mention this in any of his letters. 1858 was the year of his marriage, a time for relaxation and enjoyment and introducing his wife to the locality and the estate. 1859 was the year of the
Aberdeen meeting of the British Association for the Advancement of Science (BAAS), discussed later. In short, the Glenlair months were not half a year of free time to concentrate on research interests. Nonetheless, Maxwell wrote seven short papers for the BAAS and seven substantial papers while in post at Marischal College, spanning some 200 published pages. His great achievements in this period were his continuing analysis of the dynamics of Saturn’s rings, his quantitative colour-matching experiments that laid the foundations for modern colourimetry and his fundamental work on the kinetic theory of gases. The following brief sections on Maxwell’s research while at Aberdeen introduce topics mainly dealt with in depth in other chapters of this book and in books devoted to particular aspects of Maxwell’s work and in more detail in the well researched biographies by Everitt, Tolstoy and Goldman.

Technically the first papers Maxwell presented as Professor of Natural Philosophy at Marischal College were the four short papers he delivered at the August 1856 Cheltenham meeting of the British Association for the Advancement of Science. These are summarised in the meeting report and in Maxwell’s collected papers. The first three were on what is now known as tritanopia of the yellow spot of the eye, on a method of drawing Faraday’s lines of force without calculation and on colour mixing. His final paper of the quartet was ‘On an Instrument to Illustrate Poinsôt’s Theory of Rotation’, an early version of his dynamical top.

THE DYNAMICAL TOP

Maxwell’s main paper describing his dynamical top was his first substantial production while at Marischal College. Nowadays the vector concept of angular momentum is introduced at a fundamental level in all mechanics textbooks as a natural application of Newton’s laws to the motion of rigid bodies. What is generally not made clear to students is that the application of vector calculus to mechanics (and electricity and magnetism) was a development of the second-half of the nineteenth century and the rôle of angular momentum, far from being an obvious development from Newton’s laws, was really only made clear by Maxwell and his contemporaries.

“The complexity of the motion of the particles of a body freely rotating renders the subject so intricate, that it has never been thoroughly understood by any but the most expert mathematicians”, as Maxwell remarked early in his paper. Euler, D’Alembert, Lagrange and others (to cite Maxwell’s examples) were able to tackle problems of rotational motion only through the use of involved mathematics. What they lacked were the ‘appropriate concepts’. The work of Louis Poinsôt in the second quarter of the century on the theory of rotation had attracted the attention of both Maxwell and Robert Baldwin Hayward at Cambridge. Hayward developed Poinsôt’s approach, and may well have coined the term angular momentum in 1856. The theme of finding ‘appropriate concepts’ runs though much of Maxwell’s work. He recognised in Hayward’s angular momentum the key appropriate concept for this kind of problem. The use of vector notation was still some years off but Maxwell’s completely adjustable dynamical top was designed to clarify the use of the concept of angular momentum and the complex rotational motion of rigid bodies in the most general circumstances. It showed, in a way, Maxwell the pedagogue at work, not teaching students now but teaching himself, first and foremost, and his peers.

Other tops had been made earlier to illustrate, for example, the precession of the Earth’s axis but Maxwell’s version allowed for the variation of all the relevant parameters (the moments and products of inertia and the rotation point relative to the spinning body). His original
model presented to the British Association was wooden. He continued to develop his top at Aberdeen, substantially refining the design and commissioning John Ramage of the instrument making firm Smith and Ramage at Marischal Quay (appropriately enough) to make several copies. Another version of the top, even more polished than Ramage's, was produced later in the 19th century by the instrument firm of Harvey and Peake and is shown in Fig. 5.

It’s fair to say that the top impressed his contemporaries and did much at the time to publicise the relevance of the concept of angular momentum to the treatment of rotating bodies. Notwithstanding, his paper is seldom cited these days, mainly because the dynamics of general rotary motion is now so embedded in standard physics that references are considered unnecessary. Maxwell drew conclusions about the precession and nutation of the Earth’s rotational motion from considerations of his dynamical top. He had tops made for Trinity College, Cambridge, one for R. B. Hayward, by then Reader in Natural Philosophy at the quite recently founded Durham University but soon to move to Harrow School, one for J. D. Forbes in Edinburgh, one for Christian Peters, Professor of Astronomy at Königsberg, and he kept one for himself. His own top survives at the Cavendish Laboratory and J. D. Forbes’ is in the Royal Museum of Scotland.

SATURN’S RINGS

The work that made the reputation of Maxwell in his day amongst his contemporaries in Britain, at least, was his Adams’ Prize essay “On the Stability of the Motion of Saturn’s Rings”. Perhaps spinning tops engendered thoughts on the spinning rings of Saturn. We don’t know. The prize topic was announced by the University of Cambridge in 1855 for submission in 1857, following correspondence between James Challis, Director of the Cambridge Observatory, and William Thomson. It was a subject that was particularly topical on both sides of the Atlantic. Maxwell’s submission, one third of a kilogram in weight of closely argued mathematical physics of the highest calibre, was received in December 1856 and he was awarded the prize in 1857, barely three years after he was an undergraduate. Maxwell did not publish his submitted manuscript but spent more time on developing it while at Aberdeen than on any other research topic. He had some lengthy correspondence with William Thomson in particular, notably on issues connected with the stability of the rings. The final version was published as a free-standing work in 1859. His study was a theoretical tour-de-force, effectively Maxwell’s trial piece submitted to the guild of the elect professoriate in Britain as an entrance test. Challis, Stokes, Airy, Thomson and others absorbed the argument.
The essay is largely an exploration of the stability of a number of physical models for the constitution of the rings. Maxwell makes significant deductions on points of detail and overall his analysis proved beyond doubt to his contemporaries that "The final result, therefore, of the mechanical theory is, that the only system of rings which can exist is one composed of an indefinite number of unconnected particles, revolving around the planet with different velocities according to their respective distances". This before a single clear photograph of Saturn’s rings had been taken. Smith and Ramage also made a mechanical model that illustrated some of the wave motion that Maxwell predicted could exist within the ring system.

Maxwell’s work has spawned the modern theory of planetary discs and astronomical accretion disks that are found around dwarf stars orbiting close to giant stars and in matter orbiting black-holes. The rings of Saturn and other disks are now recognised to be substantially more complicated than Maxwell could model with his analytical mechanics and are most frequently treated by a combination of theoretical insight and computer modelling.

ON COLOUR PERCEPTION AND OPTICS

Maxwell wrote at least ten articles on colour perception. It was a subject that fascinated him from his youth. Most of his papers were written just before, during and just after the time he was at Aberdeen. In the 1850s, colour awareness in society was not what it is today and colour science scarcely existed as a topic. The impact of colour science today is almost as pervasive as the impact of electricity and magnetism yet judging by the minor place it seems to have in university syllabi and undergraduate optics texts, Maxwell seldom gets the credit for the major steps that he took to establish this now essential branch of applied science.

A well-known photograph shows a youthful Clerk Maxwell holding an early version of his spinning colour disk. A variant of this apparatus used a spinning top. Both devices were used by the young Maxwell in his colour matching experiments. The fact that three colours are generally enough to match another colour had been postulated by Thomas Young early in the century but the theory and practice had not advanced much since. Maxwell brought his mathematical skills to bear. "It is easy to see" he wrote in talking of the number of primary colours needed "that the number of these sensations corresponds to what may be called in mathematical language the number of independent variables, of which sensible colour is a function". Moreover, the experimental

Fig. 6 Maxwell’s colour triangle (shaded grey) is actually a figure in three dimensions. It is formed to span three axes $R$, $G$, and $B$ (representing the full amounts of the colours red, green and blue) drawn from an origin $O$. Any colour $C$ has fractional coordinates $r$, $g$, $b$ on these axes and is represented mathematically as $C \equiv rR + gG + bB$. The example shown is approximately $C \equiv 0.24R + 0.37G + 0.39B$. All points on the triangle are colours of the same total intensity. Normally the triangle is drawn flat on a page, not showing the colour space it really occupies.
evidence Maxwell accumulated demonstrated beyond doubt that when mixing colours the variables are combined linearly. Maxwell mapped these variables onto a plane triangle, using the constraint that the sum of the variables always adds to a constant (Fig. 6) So was born the Maxwell colour triangle, used for quantifying the measurement of colour in terms of a mixture of three primaries. The CIE chromaticity diagram, the basis of all modern colourimetry work and colour standards, is essentially this same diagram using transformed co-ordinates.

Maxwell's first paper on colour that he wrote at Aberdeen described extensive experimental testing of the linear model of the 3-colour mixing hypothesis, going as far as he could. He highlighted the importance of the illuminating conditions in colour matching, adding the observation "that the results would differ far less if observed by different persons, than if observed by different lights; for the apparatus of vision is wonderfully similar in different eyes". Although he hadn't fully explored it yet, Maxwell was setting the academic basis for colour photography. He would comeback to the topic, but colour wasn’t his only optical interest.

Before he came to Aberdeen, at Cambridge Maxwell had been struck by the unusual structure of the crystalline lens of a fish and set off exploring the imaging properties of a spherical lens with a radial refractive index gradient. In 1854 he published the conditions under which such a lens can give a perfect image. The result is known as the Maxwell fish-eye lens. Until recently it has been mainly a theoretical curiosity, though the idea is now of interest to microwave engineers. Perhaps spurred by this investigation, Maxwell went on while at Aberdeen to write a general paper on the conditions imposed on optical devices that formed perfect images. He demonstrated that useful results could be obtained by considering the whole instrument as a single imaging device rather than as a sequence of image forming surfaces. However, in retrospect, we can see that the cutting edge of theoretical optics in 1856 was the exposition of lens aberrations by von Seidel in Munich, though it took several decades for this work to be fully appreciated. In addition Maxwell’s paper was found some 90 years later to be less general than he had hoped. It was actually Maxwell’s practical optics that would prove more influential than his theoretical excursions.

The most innovative instrument of the decade was Maxwell's own colour box, conceived of before he came to Aberdeen but developed into an accurate tool there. Maxwell realised that the purest primary colours that he could obtain for his colour matching experiments were spectral colours, not the colours of paint or card he had been using on his disks, which each necessarily reflected a range of spectral colours. Maxwell's 'colour box' was the first modern colourimeter. Maxwell thought hard about how to obtain uniformly illuminated fields of view to match his test field (daylight) with a superposition of fields of red, green and blue. The resulting novel arrangement of lenses is called the Maxwellian view and as a sideline Maxwell thus introduced a new optical design principle that is to this day a useful tool for the optical instrument designer. The Maxwellian view imaged the slit onto the entrance pupil of the detector (the eye’s iris here), unlike the standard spectrometer in which the slit is imaged onto the image plane of the detector (the retina in the case of direct observation).

Maxwell made his most developed colour box in 1858, with the help of John Ramage again, and designed a smaller version in 1859. He had been in communication with G. G. Stokes (the Lucasian Professor at Cambridge) on his colour experiments during much of his time at Aberdeen and through Stokes (who was also Secretary of the Royal Society of London) sent the main account of his results using the ‘colour box’ to the Royal Society in late 1859. Stokes had been won over by Maxwell from an agnostic position on colour perception to the
realisation that Maxwell had pretty well single-handedly put colour science on a quantitative basis. The Royal Society Council responded by appointing him as Bakerian Lecturer, an appointment that was advertised in the press but later had to be withdrawn, following a comment by Maxwell that he had not yet been elected a Royal Society Fellow.

The paper was published in full, with an addendum on results obtained from one of Maxwell’s students, who was a dichromat. It reports an extensive set of observations by himself ‘J’ and his wife ‘K’ designed to determine the position of the spectral curve on the colour triangle. This curve is the key to quantitative colourimetry, as Maxwell realised, “since all natural colours are compounded of the colours in the spectrum” Maxwell’s method overcame the difficulty that some spectral colours have negative colour coefficients, which means they cannot be matched by real amounts of three given primaries. It was this problem that led the CIE some 70 years later to use imaginary primaries (in the sense of physically unrealisable) when establishing the international standard colour measurement system. Maxwell’s paper laid down the academic foundation, and limitations, of the 3-colour photographic process, discussed in further detail in the chapter on his King’s College, London, years.

**MAXWELL ON MOLECULAR SCIENCE AND KINETIC THEORY**

Maxwell’s work on the foundations for understanding properties of matter, particularly gases, by treating them as collections of moving molecules is absolutely fundamental. Maxwell’s work on molecular science and kinetic theory has had two books devoted to it. This work was started, but by no means completed, while he was at Marischal College.

With Saturn and its myriad fragment rings at last out of the way, Maxwell had turned his attention early in 1859 to the work of Rudolf Clausius, who was trying to build up a dynamic molecular theory of gases from first principles. Laying the foundations of a subject on strict mechanical principles (essentially Maxwell’s words) was just the sort of task Maxwell was drawn to. It is hard to credit nowadays that the default picture of a gas in mid 19th century was that it was a tenuous medium in which the constituents were held apart metaphorically at arms’ length by long-range repulsive forces. This is just about tenable as a hand-waving suggestion if one has no idea about the size of the constituents, how far apart they are or tries to work out detailed numerical properties of gases. Surprisingly enough in an age when water power and wind power were clearly giving way to steam power, and lighting was increasingly depending on gas, properties of gases were not a popular subject of investigation. Graham in Glasgow, Stokes in Cambridge and the Meyers on the Continent had produced experimental results on diffusion and viscosity that could not be explained by the de facto model. A new viewpoint was clearly needed.

Maxwell announced some key results of his first-principles approach at the British Association meeting in 1859 (discussed later) and published his first formal paper on the subject in January and June of the following year in two parts under the title “Illustrations of the Dynamical Theory of Gases”. It is an extraordinary paper. Almost every topic relevant to the foundations of the kinetic theory of gases is discussed: the distribution of velocities, the average velocity and root mean square velocity, the pressure exerted by a gas, the equipartition of energy among molecular constituents, the mean free path between collisions, the viscosity of a gas, the thermal conductivity of a gas, the diffusion of a gas through a porous plug, and the diffusion along a pipe connecting two containers, the specific heat of a simple
gas, and other topics. The paper is full of intuition, fundamental physics, incomplete arguments and a few numerical mistakes.

In spite of some blemishes, the paper is still one of Maxwell’s greatest. He conjured the *Maxwell distribution* of molecular velocities in a gas almost out of thin air by an argument that still astonishes 150 years later, based on little more than the independence of velocity components along perpendicular directions. The Maxwell distribution is the first law of physics discovered that involves probability. His intuition that the equi-partition of energy has to be true exceeded the strength of his argument, which was based upon a consideration of special cases. However, this paper moved on Clausius’ work considerably. Maxwell was able to estimate the mean free path of a molecule by two independent means and hence the number of collisions per second molecules would have on average, since average speed could be found from pressure and density; he showed that Avogadro’s hypothesis (the number of molecules of all gases in unit volume at a given temperature and pressure is a constant) followed from kinetic theory. In fact in broader terms it became clear from Maxwell’s work that the kinetic theory of gases provided a new way into understanding molecules that would complement the insight of chemists gleaned from chemical reactions.

The prediction that both caught people’s attention and offered the prospect of experimental verification was the unexpected result that the viscosity of a gas should be independent of its density. The result seems counter-intuitive. If you reduce the pressure of a gas in a container (and hence its density) by taking out more and more of it, how can the viscosity of what is left remain the same? There were no trustworthy experimental results that could be used immediately to test the idea but the paper had the effect of stimulating an interest in the three transport properties of gases discussed, namely diffusion, thermal conduction and viscosity. Maxwell had to leave the topic, for by mid 1860 he was leaving Aberdeen and would have other concerns when he got to London. As it turned out, he would provide definitive results himself that were influential in convincing his contemporaries of the validity of the kinetic theory of gases, but not until 1865. By this time his work in yet another field, electricity and magnetism, had born fruit.

**MAXWELL’S MARRIAGE**

Maxwell’s years at Marischal College generally have been covered quickly in his biographies yet in many respects they were more formative on a personal level than almost any other similar period in his life. Maxwell had been a precocious youth but it was in the Marischal years that he went from youth to manhood. He began 1856 as the son of a respected Edinburgh lawyer with a modest estate in Kirkcudbrightshire. By the middle of that year he had become laird of Glenlair with all the responsibilities for the upkeep of the estate, its tenant farmers, Glenlair house and its small staff. He began 1856 as a young Fellow of Trinity College, with much time for solving problems of his own choosing, rowing, some tutoring and giving a number of lectures mainly on hydrostatics and optics. He ended the year as Regius Professor, responsible for generating and teaching most of the coursework for the third year of all the MA students in his University, and more, as we have seen. He came to Marischal College after five years of life among the privileged and relatively narrow surroundings of Cambridge academic life to the bustling commercial and manufacturing environment of Aberdeen with its range of students representing a wide cross-section of society. He now had to judge the abilities of men who would never have made it to university in Cambridge and the experience would have reinforced his own tendencies to judge people by what they could do rather than who they were. He came to Marischal College a serious
and thoughtful young man of independent spirit who partly by choice and partly from circumstances had never been part of the social crowd. He left the College a married man with someone closer to him than he had ever had, his parents excepted.

Following on from the example of Maxwell’s first biographers, Campbell and Garnett\(^69\), successive biographers have left us with but a shadowy outline of Maxwell’s wife Katherine Mary Dewar, though all mention that she was the daughter of Principal Dewar of Marischal College. Maxwell himself in his letters has given only fleeting glimpses of his family life, just enough to paint the picture of a devoted couple, a picture echoed by some of his friends. This lack of detail has been a spur to biographers to look in the writings and correspondence of contemporaries for further details. Not a lot has been uncovered. From 1858 onwards Katherine is ever present in the background to Maxwell’s scientific life and this account will add to Maxwell’s story a glimpse of the kind of family Katherine grew up in. It is, surely, the key to her character.

The Reverend Donald Sage has left us some biographical detail of Principal Dewar\(^70\). “He was a native of Argyllshire [corrected to Perthshire in a longer account by another contemporary\(^71\)], and was born in the humblest circumstances. His father was a blind fiddler, who earned his bread by travelling through the country and playing at weddings, etc. He was attended by his son Daniel for the purpose of being the bearer of the fiddle-case, and his father’s guide. Some wealthy individual took notice of the musician's son, and thought he could discover, under the guise of his poverty, the germs of future greatness; and so, at his own private expense, sent him to a public school.” Dewar built up his career in steps from these humble beginnings. He went to London to train as an independent preacher and then to Glasgow, found there was insufficient call for his message in Scotland and enrolled in the University of Edinburgh to become a licensed Minister of the Church of Scotland. He had the extraordinary record of being awarded an LLD by the University of Glasgow in the same year (1815) he graduated from Edinburgh. His first post was in a small community in Argyllshire but he preached at times in the Gaelic Church in Edinburgh. Dewar became the minister at Greyfriars Church in Aberdeen, the college church, and on the strength of this and his publications was appointed in 1817, after some professorial wrangling, as Professor of Moral Philosophy in King’s College, Aberdeen. Sage says he was “on a very friendly footing with him” while he was at King’s College. Dewar became an extremely popular speaker in Aberdeen, for Sage relates; “No public meeting could be conducted without Dr. Dewar. No sermon could be preached for any religious or charitable object but by him only. Not any new scheme could be formed, nor recent society established, without his countenance.” This and Dewar’s reluctance to give up his ministry of Greyfriars annoyed King’s College so much that Dewar left Aberdeen in 1819 for Tron Church in Glasgow. In 1826 he published his extensive two-volume work on Elements of Moral Philosophy and of Christian Ethics\(^72\), after which he returned to Aberdeen in 1832 to fill the vacancy as Principal of Marischal College. The College records note that his appointment had "the unanimous disapproval of the College"\(^73\). It was a Crown appointment and the Crown overruled the College’s choice. Sage concludes unexpectedly harshly, perhaps throwing light on this comment, “He sat in a vehicle drawn by two horses, Ambition being the name of the one and Avarice that of the other.” In 1832 he was awarded a second doctorate (DD) by the University of Glasgow and, perhaps motivated by ambition or just plain responsibility, in the following years he played a significant part in obtaining government money to support the complete rebuilding of Marischal College in tasteful and practical style. The picture painted by Sage, by other comments and Dewar’s own works is of a man of considerable ability and independence of thought, evangelical, knowledgeable on philosophy, biblical hermeneutics
and church history who at least until middle age could preach strongly. He continued to publish theological works throughout the 1850s.

What may have brought Maxwell to the Dewar’s home was the arrival in 1856 of a 125-page treatise in Gaelic on *Gaelic Astronomy* sent to the Principal by the author D. M. Connell, a teacher in Aberdeen. Daniel Dewar had co-authored a Gaelic/English dictionary published in 1839. He had been asked to offer a testimonial for Connell’s work, which he duly gave in December of 1856. What would be more natural than to invite the new Professor of Natural Philosophy to discuss the book’s contents? We shall never know, but when he died Clerk Maxwell had in his scientific library of over 400 titles,²⁴ well populated with French and German texts, just one book in Gaelic: Connell’s treatise on *Gaelic Astronomy*. Was it kept as a memento of how he first met Katherine?

Katherine’s mother, originally Susan Place, was a grand-daughter of George Gordon, third Earl of Aberdeen. This made her a cousin of George Hamilton-Gordon, Prime Minister from 1852-1855.¹⁷⁶ 11 years younger than Daniel and born in Yorkshire, she was described in a letter by Maxwell to his aunt as “a first-rate lady, very quiet and discreet, but has stuff in her to go through anything in the way of endurance”. There we have the in-laws. In the 1851 census covering the extensive Old Machar parish of Aberdeen, Daniel is recorded as aged 66, Katherine, who was born in Glasgow, 27, brother Donald 19. However, there had been a younger daughter Susan Place Dewar, who had died in 1844 in York, a son John Dewar who had died in 1849, another son the Reverend Edward Place Dewar, who died in 1855, and there was also a son William Gordon Dewar and another daughter Ann Gordon Dewar.⁷⁸

According to Campbell and Garnett,⁸⁰ Maxwell was a frequent visitor in 1857 to Dewar’s house (Fig. 7). *His deep and varied knowledge, not only of his own and kindred subjects, but of history, literature, and theology, his excellence of heart, and the religious earnestness which underlay his humorous “shell,” were there appreciated and admired.* In the comfort of one of Dewar’s armchairs, Maxwell must have enjoyed articulating and refining his own sentiments on religious and moral topics with the learned Principal. He was invited to join the Dewars in September 1857 for their annual visit to Ardhallow near Dunoon, the house in 10 acres of land of John McCunn, the husband of Ann Gordon Dewar. Maxwell was engaged to Katherine in February 1858 and married on Wednesday June 2nd (Fig. 8) in...
the Old Machar district of Aberdeen (in which Dewar’s house was located at 13 Victoria Street West). The witnesses were John McCunn and Katherine’s brother Donald. Katherine’s address is given as Craiglochie in the Parish of Kilspindie, near Perth, a property that had been gifted to Principal Dewar some years earlier and to which he and his wife retired in 1861. Brief announcements of the marriage appeared subsequently in the Aberdeen Journal and the Aberdeen Free Press. Maxwell was 27 years old and his bride 33. At least Lewis Campbell, as a representative of his Edinburgh and Cambridge friends, was able to attend the ceremony.

Katherine nourished Maxwell’s spiritual and artistic side. Although Maxwell had a hugely productive academic life, he also had a life outside academia. His past-times included serious literature, plays, theology, walking and riding. In all of these Katherine and James shared. Campbell & Garnett published a substantial selection of Maxwell’s poetry and verse as an appendix to their biography. Some poems had already given Maxwell a public following through their appearance in the pages of Blackwood’s Magazine. Most poems are either humorous or philosophical in overtone, excepting his romantic poems of the late 1850s addressed to Katherine. “Will you come along with me,/ In the fresh spring tide,/ My comforter to be,/ Through the world so wide?!”

It is well documented that Katherine assisted in Maxwell’s colour matching experiments in Aberdeen and in his experiments in London to measure the viscosity of air over a range of temperatures. Both of these activities were carried on in their home. There is no evidence, though, that she involved herself with any of the technicalities of Maxwell’s science or took an interest in the science of Maxwell’s circle. It is hard to avoid the conclusion that she never escaped from the shadow of her father and her father’s preaching. She was brought up in a strongly religious household by comparatively elderly parents. At least two of her brothers became Ministers of the Church (Donald was ordained in 1860 in the Church of Ellon, 20 miles north of Aberdeen). She became a woman of exceptional piety. Nothing announces this more strongly than the much reproduced studio portrait of Maxwell, Katherine and their dog Toby in which over a dark dress hangs her bright cross that would not be out of place in a convent.

When Daniel Dewar died in 1867, his estate that included 637 acres of farmland near Perth and land in Rubislaw, Aberdeen, was valued at £1180 (about three times his former annual salary and not exactly the fortune one might expect of a man of ‘avarice’). It passed into a trust with his wife effectively sole trustee while she lived and upon her death (which happened in 1876) the Maxwells and the McCunns shared as trustees. No sons are mentioned in either the trust deed or in his will, for it is likely the Principal had outlived all four. The
daughters were close to their father and *vice versa*. Maxwell felt he had a mutual understanding with Katherine that there was no need to explain. A letter in London’s Daily News following his own death commented that although he was by then recognised as a scientist without equal to those who knew him his social virtues outshone all. Katherine would have agreed but to the outside world, Maxwell had chosen a wife who was deeply religious, conventional, dutiful, private, tolerant and supportive, a wife to share his private life. They had no children.

In later years Maxwell’s wife was accused of being possessive about Maxwell. It was all gossip, though there may have been some substance to it. Katherine clearly married Maxwell for his personal qualities, not because she wanted to display herself in society on the arm of Professor Maxwell. The more famous he became, even if it was mainly in the circles of the scientific elite in Britain and beyond, the harder it would be to find the privacy that they both enjoyed. To make matters worse, Katherine is said to have suffered prolonged spells of ill health, so her home life became her only life. In short, Maxwell’s marriage was strong but in the scientific circle in which he lived, almost invisible.

MAXWELL AND THE BRITISH ASSOCIATION AT ABERDEEN

The British Association for the Advancement of Science (frequently abbreviated BAAS in the 19th century and often, simply, BA or, as Maxwell and his circle jocularly put it, British Ass) was one of the great successes of 19th-century science in Britain. It was re-branded in 2009 as the British Science Association. The BAAS was founded in 1831 in response to a perception that had grown during the first quarter of the century that science in the round was largely unappreciated by government, the public and the state, and that such scientific organisations as existed were disconnected and had little influence on the political process. The Association was modelled on the Deutscher Naturforscher Versammlung, founded in 1822 and still thriving as the GDNÄ. David Brewster was particularly influential in the Association’s founding and his vision for it was that it would possess no funds, property or artefacts but would organise annual meetings that would bring together scientists from all disciplines to overview the state of their subjects, bring up-to-date science to public notice and propose measures for advancing science. These broad aims, differently worded, were more or less made the objects of the Association.

Following its initial meeting in York it quickly began to achieve all that Brewster and others had hoped for – not least because almost all the leading scientists in every discipline made a point of participating regularly. It became the place to go to hear the latest developments in subjects familiar and unfamiliar, to meet those responsible, to listen to speculation, to debate in a national forum issues and trends in specific areas of science and, for those engaged in science, to present ones work. The BAAS attracted all who had an interest in science: academics, manufacturers, the gentry, medics and the clergy, civic and private individuals. For the aspiring scientist there was no better place to network.

Maxwell must surely have attended his first BA meeting in Edinburgh in 1850, where the President was Brewster himself. Maxwell is recorded in Campbell and Garnett’s biography as speaking impromptu from the floor on the subject of Haidinger’s brushes (a visual phenomenon within the eye) and producing a small polarising analogue that he had made himself. He spoke formally on this topic in the 1856 BA meeting in Cheltenham. He certainly attended the Glasgow meeting of 1855 (the year he was elected to life membership
of the BA) but there is no indication he went to Dublin in 1857 and with his marriage in the summer of 1858 there was no question of going to the meeting in Leeds that year. 1859 was different. The BA meeting was to be in Aberdeen.

The final decision to meet in a town was not made until the meeting of the previous year. Aberdeen had two universities but it had no large meeting hall. Prior to the Leeds BA meeting, a proposal had been promoted to build a new hall at the back of the Assembly Rooms in Union Street under the aegis of the Music Hall Company, established for that purpose. Maxwell was a shareholder. The proposal would go ahead quickly if Aberdeen were granted the venue. It was, and within the year the ‘Music Hall’ was built of granite, 150 feet long, 50 feet high internally and able to accommodate over 2400 people. The proposers said the building would be a ‘permanent benefit’ of locating the BA in Aberdeen. Over a century and a half later the Music Hall is still one of the city’s principal entertainment venues, restored to close to its original 1859 appearance, excepting that the gas lights have given way to computer controlled electrical illumination.

The Music Hall and Marischal College were the main meeting places for the 1859 BA. Had Maxwell wished to advertise his work and his credentials he could not have done better. The world would come to him, or at least the British scientific community would and there was scarcely a branch of science at the time that did not have leading representatives in Britain. Would they actually come to remote Aberdeen? Certainly. H.R.H. Albert Prince Consort had accepted the BA Presidency. He could combine his genuine interest in science with his
equally strong interest in the Upper Deeside royal estate of Balmoral where he had invested a substantial amount of time and energy in building a new castle that had been finished only three years earlier. As it would turn out, the week-long Aberdeen BA meeting would be the largest and possibly the highest profile meeting in the history of the BA until that date. Over 2500 tickets were sold and the Music Hall was packed for the opening ceremony and on the two subsequent evenings it hosted public lectures [Fig. 9]. Among the participants were over 60 Fellows of the Royal Society of London, some 30 FRGSs and FGSs and representatives from every University in Great Britain and Ireland. Such a presence might have been expected in Oxford; it was truly exceptional in Aberdeen.

Modern attendees at a large scientific conference would find the organisation of the Aberdeen BA meeting very familiar. The opening address by Prince Albert lasted an hour and was subsequently published. There were two keynote evening public lectures, one by Sir Roderick Impey Murchison on the geology of the North of Scotland and one by Dr Thomas Romney Robinson of the Armagh Observatory, past President of the BAAS, etc. on electrical discharges in highly rarefied media. This talk was illustrated by ‘magnificent experiments’ conducted by Mr Gassiot (who was a Vice President of the Royal Society and had given the Society’s Bakerian Lecture on this subject the previous year) and the optician and instrument maker William Ladd. At parallel daytime sessions, 361 papers were read including the valuable reports on progress in each area of science; there were evening conversaziones in the Assembly Hall rooms, visits to local sites and manufactories of interest, commercial displays of the latest scientific instruments, a room with experiments displayed and the spacious Marischal College Museum collection was augmented by donations and a special geological display open to all participants, including public ticket holders. H.R.H. Prince Albert was given a four-hour tour of Marischal College and attended some of the Section A papers.

Maxwell was not only a local host and a Secretary to Section A (Mathematical and Physical Science) at this cornucopia of science, and one of the few local Life Members of the BA, but he was the principal local presenter in the mathematical and physical section that really had something to say. He presented three of his papers to the meeting: ‘On the dynamical theory of gases’, ‘On the mixture of the colours of the spectrum’ and ‘On an instrument for exhibiting the motions of Saturn’s rings’. Harman has published the summaries that appeared in the 1859 annual report of the British Association for the Advancement of Science. The first of these papers contained the announcement of the Maxwell distribution law of molecular velocities in a gas, probably the only fairly fundamental law of physics that can be associated with Aberdeen. It was a nice Maxwellian touch that he chose to announce it at a public meeting of the BA.

The session proceedings were reported at some length in the local press and even more extensively in three editions of the weekly Athenæum. Physical topics of the moment were notably optics, meteorology and telegraphy. One curiosity of the meeting was a talk by James Bowman Lindsay of Dundee on “Telegraphing without wires”, listened to with interest by Faraday, Lord Rosse, Airy, William Thomson and others. It was followed up by a successful demonstration of Lindsay’s proposals in which two stations communicated across the river Dee without wires. This was not a demonstration of ‘wireless’ some 30 years before Marconi but it was a demonstration that if some other medium could conduct a signal (water in this case) then wires were not a necessary part of electrical signalling.
The attendance at the Aberdeen meeting was some 750 greater than the previous year’s meeting at Leeds. When Sir Roderick Murchison summed up in the concluding meeting he remarked “little could I have anticipated that we should have had such a meeting as we have had, and which, I will say, has been second to no one held by the Association”91. Maxwell had been in the spotlight on the stage of British science in September 1859. There is no indication he had any inkling that he would be considering a new job before the year was out, but it would be so. In the following year of change, testimonials would be collected, academic papers listed; it was a fortunate coincidence but the hugely successful BAAS meeting in 1859 would have done as much as the more formal requirements to raise Maxwell’s profile, not among those already familiar with his work but among those who were not.

MAXWELL’S DEPARTURE FROM ABERDEEN

During the summer break of 1859, Maxwell had heard that the Chair of Natural Philosophy at St Andrews was becoming vacant but, even though the Commissioners’ report on the merger of the two Aberdeen Universities could not be long in appearing, he did not apply. News broke in early November 1859 of the imminent resignation of his old mentor J. D. Forbes in Edinburgh to take up the Principalship at St Andrews. This spurred Maxwell to collect testimonials from the Aberdeen professoriate and influential parents of some of his pupils, one of whom was John Webster, Lord Provost of Aberdeen and Vice President of the BA in 1859. All were of course strongly approving. It was likely a ‘once-in-a-lifetime’ opportunity for Maxwell to move to arguably the most prestigious of the four Scottish Universities, one that was, into the bargain, significantly closer to Glenlair. In the event, he was up against two contemporaries who had been Senior Wranglers and Smith’s Prizemen in P. G. Tait and E. J. Routh. Tait was appointed over him this time and stayed in the Chair until 1901. [Tait had also been a candidate for the Marischal College post].

The myth that Maxwell was sacked by the University of Aberdeen deserves to be buried. Nonetheless it lives on because we like to hear stories that seem to bear witness to the stupidity of authority. Maxwell did lose his job in 1860 but it was thanks to the Royal Commission that oversaw the fusion of Marischal College and King’s College into a single University, with one Professor in each discipline. Fuller details of the circumstances have been related by Reid92. The single Chair of Natural Philosophy in the new University of Aberdeen was awarded by the Commission to David Thomson, Maxwell’s counterpart at King’s College. It was a remarkable piece of politicking by Thomson. Both Chairs were Royal appointments, technically not in the hands of the two Universities concerned, who were therefore in a weak position to dispute the assignation had they wanted to. Curiously, though, the Regius status of the Chair was relinquished by the Crown, thereby losing their right to make subsequent appointments. What fuelled the myth about Maxwell was that he was the only younger incumbent to lose his job among the pairs of professors in each subject in King’s and Marischal Colleges.

One aspect of the loss of post for Maxwell that has not been clear to historians was whether Maxwell received any compensation for the decision. It seems that he did, for his case was considered separately by the Commissioners under the Universities (Scotland) Act 1858 who reported in 1863. Their decision on Maxwell’s pension made in 1861, after requesting details of Maxwell’s new appointment, was that “the amount should be an annuity during his life, equal to the average income derived by him, both from endowment and from fees, at the time
when he was deprived of his office in Aberdeen”[^93]. This would have been close to £400 per annum[^94].

Maxwell could have retired to Glenlair in 1860 but he chose to apply for the post of Professor of Natural Philosophy at King’s College, London that had been vacated by T. M. Goodeve. He secured the position from a field of five considered applicants (according to the College Council Minutes), and before the newly named ‘University of Aberdeen’ had opened for business in its inaugural session under that title, Maxwell found himself in London with new colleagues.

**Notes & References**


[^3]: A plaque was erected on the building to mark the centenary of Maxwell’s residence. Details of the occupancy of all premises in Union Street are contained in the annual *Aberdeen Post Office Directories of 1856 – 1860* (A. King, Aberdeen).

[^4]: A mass of factual information on Marischal College was accumulated by two Royal Commissions in the nineteenth century, investigating the possibility of a merger with neighbouring King’s College. Detail quoted here is not individually referenced throughout. See *General Report of the Commissioners under the Universities (Scotland) Act 1858*, (Edinburgh, HMSO 1863) A useful summary of the Arts teaching was published by the University Librarian and former assistant to the Professor of Natural Philosophy, Peter J. Anderson, *The Arts Curriculum* (Aberdeen, 1892).

[^5]: Both for information and to attract private students, the courses at Marischal College were advertised in the press. See, for example, The Aberdeen Journal, October 22nd 1856 for the first appearance of Professor Maxwell’s name in the advertisements.

[^6]: Murchison, Lyell and Geikie were among a strong contingent of geologists who attended the 1859 BAAS meeting, discussed later in this chapter, in which James Nicol played a significant part.

[^7]: Joseph Ogilvie, *John Cruickshank, Professor in Marischal College and University of Aberdeen* (D. Wylie & Son, Aberdeen, 1896) pp 42-43 discusses the Marischal College reforms that took place in the late 1820s, some sixty years before similar actions became legislative requirements in Scotland.
Graduation cost £5, comparable to the annual class fees and equivalent to at least £500 in year 2000 currency. The reluctance of some able students to collect their degrees was understandable.

Parliamentary paper 1874 [C.899] Scotland. Owners of lands and heritages 17 & 18 Vict., cap. 91. 1872-73. Return I. The name and address of every owner of one acre and upwards in extent (outside the municipal boundaries of boroughs containing more than 20,000 inhabitants) records Glenlair as comprising only 68 acres (27.5 hectare). Glenlair had been part of a larger estate inherited by the Clerk Maxwells that had been divided and partly sold off earlier in the century. Other authors have quoted much larger figures for the size of Glenlair but Clerk Maxwell was still alive and running the estate at the time of this return.

Tait remarked in his tribute to Maxwell after his death¹⁰ ‘But the rapidity of his thinking, which he could not control, was such as to destroy, except for the very highest class of students, the value of his lectures. His books and his written addresses (always gone over twice in MS) are models of clear and precise exposition; but his extempore lectures exhibited in a manner most aggravating to the listener the extraordinary fertility of his imagination.’ P. G. Tait, Proc. Roy. Soc. Ed. 1879 vol. 10 pp 331-9 (p334); the comment being repeated in Nature, Jan 19th 1880 and in C. G. Knott, Life and Scientific Work of Peter Guthrie Tait, p262 (Cambridge University Press, 1911). A similar comment by W. Garnett, Nature 1879 vol. 13 pp 43-46 (p45) ‘As a professor he was wonderfully admired by those who were truly his disciples. He had not the power of making himself understood by those who listened but casually to his pithy sentences, and consequently he was not a so-called popular lecturer; nor was he a most successful teacher of careless students.’


¹⁰ Aberdeen Universities Commission. Report of Her Majesty’s Commissioners appointed to enquire into the State of the Universities of Aberdeen, with a view on their Union. Together with the Evidences and Appendices, pp 80-81, (HMSO, Edinburgh, 1858).


¹⁴ Maxwell’s inaugural address at Aberdeen was reported at some length at the time in the Aberdeen Journal, 5th November 1856. Piazzi Smyth (Astronomer Royal for Scotland) was among the attendees. It is printed in full by P. M. Harman, SLP1, pp 419–431 and in R.V. Jones, “James Clerk Maxwell at Aberdeen 1856 - 1860” Notes & Records of the Royal Society of London vol. 28, pp 57 – 81, (1973).

¹⁵ This raises questions much too lengthy to be discussed her. The philosophy in Maxwell’s Natural Philosophy has been discussed in the context of his life’s work at book length by P. M. Harman, The Natural Philosophy of James Clerk Maxwell, (CUP, 1998).

²⁰ The class rolls of Marischal College from 1605 to 1859 have been published by P. J. Anderson, Fasti Academiae Mariscallanae Aberdonensis, (New Spalding Club, Aberdeen 1898), vol. II, p30.


19 Four Senior Wranglers came from Aberdeen in the decade 1858 to 1867. They were: James M. Slesser (briefly Professor of Mathematics at Belfast before succumbing to illness); James Stirling (later Sir James, Lord Justice of Appeal and Privy Councillor); Thomas Barker (Professor of Mathematics in Owen’s College) and Charles Niven (at first Professor of Mathematics at Queens College, Cork and from 1880 David Thomson’s successor as Professor of Natural Philosophy at Aberdeen).


21 A. Fraser “Lecture notes of Professor Maxwell taken by Angus Fraser on Natural Philosophy”, Aberdeen University Special Libraries and Archives Ms AMCS/3/17.

22 Anon, “Alma Mater” [The student magazine of the University of Aberdeen], p202, 7th June 1893 contains a brief biography of Dr Angus Fraser, with photograph opposite.

23 A. Davidson, “lecture notes” in Cambridge University Library Ms Add 8791.

24 P. Harman, SLP1, pp 432-437.

25 Fraser, op. cit. ref. 21, p65.

26 Fraser, op. cit. ref. 21, p21.

27 John S. Reid, op. cit. ref. 17.

28 Not only would it be completely out of character for Maxwell to use his predecessor’s notes but by way of confirmation an advertisement appeared in the Aberdeen Journal, 5th November, 1856, advertising for sale the personal apparatus and a substantial number of diagrams used by the late Professor Gray in teaching Natural Philosophy in the College. Given the frequency with which Maxwell mentioned teaching in his letters, he would certainly have mentioned had he purchased even some of this material.

29 James D. Forbes own notes for his Edinburgh lectures are preserved in St Andrews University Archives: see msdep7 items IX/9, IX/12, IX/13 for topics taught in years covering Maxwell’s presence and msQ113.F88, msQ113.F8, msQA821.F8 and msQB51.F8 for lecture contents. The notes are not written to be read verbatim, being well filled with phrases and bald statements in slightly spidery, closely spaced writing that would at best constitute lecture prompts. Forbes delivered about 110 lectures per session plus six topical exams and two general exams. His subject matter was not constant over the years. For example in Maxwell’s first year under Forbes (1847-1848) the course included 37 lectures on Astronomy that were replaced in the following year by a sub-course on Optics and lectures on Properties of Bodies and more on Heat. In subjects in common between Maxwell and Forbes, their treatment is different. Forbes gave ‘extra lectures’ on individual selected topics in which he
introduced more advanced concepts and some detailed mathematics but he does not seem to have had formally an ‘advanced class’.


33 P. Harman, op. cit. ref. 30.

34 The formalisation of the Honours degree was one result of the 1858/1860 Scottish Universities’ Commission that, amongst other reforms, set up Honours in Scotland as an additional year of study beyond a 3-year ordinary degree. It clearly took time to establish itself. A student at the University of Aberdeen after Maxwell left was the formidably able George Chrystal who studied under Maxwell in Cambridge after taking his Aberdeen degree. He commented: When I went to the University of Cambridge, I found that the course there for the ordinary degree in Arts was greatly inferior in educational quality to the Scottish one. On the other hand, the courses in honours were on a very much higher standard. G. Chrystal, Promoter's Address to Graduates of Arts, University of Edinburgh, The Scotsman, Edinburgh, 11 April, (1908).

35 Professor Alexander Bain of the University of Aberdeen, who had in his early days been a driving force behind the Aberdeen Mechanics’ Institution, is quoted in Ogilvie, op. cit. ref. 7, p116 as saying that Maxwell’s oral exposition suffered ‘from misplacement of emphasis in his articulation’. David Gill, op. cit. ref. 18, leaves the impression that Maxwell frequently flew off at a tangent on an idea that had just occurred to him in the lecture, abandoning the formal remit of the topic, but the two extant sets of lecture notes made by students in the class tell the story of a coherently delivered course. In truth, a student who just wants to be filled up with knowledge that can be written out in haste in an exam needs a different kind of lecturer from a student who is hoping to be inspired by the subject. Maxwell had done enough exam swatting at Cambridge to know the score on the first account but his hopes were clearly to swing the balance from exam style formalism to the inspirational. At Aberdeen he gave his students regular questions but there were no serious exams, allowing him to be discursive.


37 Extensive details of the various editions of Maxwell’s published books are given by Edward Fenwick, A Bibliography of James Clerk Maxwell: Part I, Books by Maxwell, (2009), privately published by Edward Fenwick, 3 Thirlestane Lane, Edinburgh EH9 1AJ.


39 Adverts for enrolment in the School of Science during Maxwell’s involvement appeared in the Aberdeen Journal on 21st October 1857, p4 col. 5; 20th October 1858, p4, col. 4; and 19th October 1859, p4, col. 3.
This wording comes from the 1857 advert, op. cit. ref. 39.


The link with the Aberdeen Mechanics’ Institution is discussed by G. M. Fraser Aberdeen Mechanics’ Institute (Aberdeen University Press, 1912) Chpt. X. See also Aberdeen Mechanics Institution Minute Book No. 3 in Aberdeen Public Library Lo370.6 Ab 3.4 for details of the running and examinations of the School of Science and Art from 1856 - 1859. Further details in Minutes of the School of Science & Art Aberdeen Book no. 9 in Aberdeen Public Library Lo 3706/Ab3.4/52215.


Aberdeen Journal, Wed. April 28, 1858. In the Aberdeen Journal, Wed. 27th April 1859, only the prize list was published, giving details of three prize-worthy performances in Natural Philosophy.


Report of the Twenty-Sixth Meeting of the British Association for the Advancement of Science; Held at Cheltenham in August 1856 John Murray, 1857, ‘Communications to the Sections’ pp12-13; also in W. D. Niven SP1, pp 238-247.
31/34


56 Brush et al. have given a detailed overview of the context, op. cit. ref. 48.

57 Maxwell’s essay is contained within W. D. Niven, SP1. The quotation comes from p373.


59 For example, I. Tolstoy, op. cit. ref. 51 and M. Goldman, op. cit. ref. 52 include full page photographs.


65 E. Garber et al, op. cit ref. 46.

66 E. Garber et al, Maxwell on Molecules and Gases, op. cit. ref. 49.


68 The inventory of John Clerk Maxwell’s personal estate at his death (Ref. SC16/41/20, Kirkcudbright Sheriff Court, 1856) valued the estate at about £2500.


A lengthy account of Principal Dewar running to over 50 pages is included in James Bruce, *The Aberdeen Pulpit and Universities: A Series of Sketches of the Aberdeen Clergy and of the Professors in the Aberdeen Colleges*, (J. Strachan & Co., Aberdeen, 1844).


There is no record of Maxwell mentioning the aristocratic connection of his mother-in-law in any of his published correspondence. Susan Place’s father, Edward Place, had married Lady Anne Gordon, the second daughter of George Gordon, 3rd Earl of Aberdeen, in 1787. The Place’s family home was Skelton Grange, Yorkshire. Catherine was Susan’s grandmother’s name on the Gordon side. The 4th Earl of Aberdeen was also a grandchild of the 3rd Earl and hence a cousin of Susan. He had been Prime Minister from 1852-1855 and was Chancellor of King’s College, Aberdeen, from 1847-1860, amongst many other offices.

The now sizeable city of Aberdeen on Hong Kong island with its famous harbour was named in 1845 after George Hamilton-Gordon, 4th Earl of Aberdeen and Foreign Secretary who had overseen Hong Kong becoming a British Crown colony. The 4th Earl would later become Maxwell’s cousin-in-law, creating a tenuous link between Maxwell and the Far East.

*The Aberdeen Journal* announcements included the death of Susan Place Dewar, youngest daughter, on 22nd December 1844 at Clifton, York (announced 25th December, 1844); death of Edward Place Dewar, a Marischal College AM graduate of 1845, on 21st November 1855 (announced 19th December 1855); death of John Dewar, the youngest son, on 12th July 1849 (announced 25th July 1849); death of Donald Dewar, a Marischal College AM graduate of 1850 (announced 18th June 1862). Another son, William Gordon Dewar, is mentioned by P. J. Anderson, op. cit. ref. 73. Maxwell’s mother-in-law died on 17th March 1876 (announced 22nd March 1876).

Donald Dewar took ill with typhus in the summer of 1861 and then with suspected cancer. He was persuaded to stay with the Maxwell’s in London later that year and have a leg removed by surgery. He remained with the Maxwell’s for several months into 1862, rallied but died that summer. By then Katherine had lost three brothers, at least, and a sister, all before they had reached middle age.

Parliamentary papers 1874 [C.899] Scotland. Owners of lands and heritages 17 & 18 Vict., cap. 91. 1872-73. Return I. *The name and address of every owner of one acre and upwards in extent (outside the municipal boundaries of boroughs containing more than 20,000*
inhabitants) show the Trustees of the late James Dewar, Mrs Susan, as owning 637 acres at Overdurdie in Kilspindie and 5 acres at Blairgowrie.


83 The perception of decline was articulated forcefully by Charles Babbage, Reflections on the Decline of Science in Britain, and on some of its causes, (B. Fellowes, London, 1830).


85 A list of attendees of the 1859 BA meeting was printed for the association by W. Bennett, Aberdeen, 1859. Among the astronomers who attended were George B. Airy, Warren De la Rue (who spoke on celestial photography), Wm. Rowan Hamilton (Astronomer Royal of Ireland), Thomas McLear, T. Romney Robinson and William Lassell. Other notable natural philosophers included Neil Arnott, David Brewster, Michael Faraday, Robert Fitzroy, James D. Forbes, William Hopkins (Maxwell’s former private tutor at Cambridge known academically for his contributions to geology), Moritz Jacobi (St Petersburg, known for his pioneering work on electric motors), Fleeming Jenkin (notable electrical engineer whom Maxwell would work with in London, later to become Professor in London and Edinburgh), James P. Joule, Humphrey Lloyd, Baden Powell (Oxford mathematician and writer on natural philosophy), W. J. Macquorn Rankine (Professor of Civil Engineering and Mechanics but whose work would intersect Maxwell’s in future), G. Johnstone Stoney, Balfour Stewart, John Tyndall, William Thomson and Robert Willis (Jacksonian Professor of Natural Philosophy at Cambridge).

86 Murchison was a leading geologists of his day, by then Director-General of the British Geological Survey, who had been one of the main protagonists behind the formation and expansion of the BAAS.


88 P. Harman, SLP1, pp 615-618.

89 The Mathematical and Physical Science section proceedings were reported in ‘The Athenæum’ No. 1665, Sept. 24 1859, pp 400-402; No. 1666, Oct. 1 1859, pp 432-434; No. 167, 8th Oct. 1859, pp 465-468.

90 A. H. Millar, James Bowman Lindsay and other Pioneers of Invention, (Malcolm C. Macleod, Dundee, 1925).


92 J. S. Reid, op. cit. ref. 17.
Scottish Universities Commission. General report of the commissioners under the Universities (Scotland) Act, 1858. With an appendix, containing ordinances, minutes, reports on special subjects, and other documents, p535 (HMSO, 1863). After Maxwell’s death in November 1879 the inventory of his Estate drawn up the following month includes the item “Balance of Compensation allowance due to deceased by H. M. Exchequer as formerly Professor of Natural Philosophy in Marischal College Aberdeen £34.6.7”. Maxwell’s estate on his death has been published on the web by Scotslandspeople, http://www.scotlandspeople.gov.uk/content/help/index.aspx?1145.

J. S. Reid, op. cit. ref. 17.