500 Years of Physics at Aberdeen

John S. Reid, Department of Physics, Aberdeen

[This piece is the gist of a talk to University of Aberdeen Natural Philosophy graduates in September 1992 given as part of a grand reunion celebration. Some post 1992 comments have been added].

Take your mind back to the late 15th century society in which our University was founded in Aberdeen: people's everyday lives were ruled by folk-lore, custom, mysticism and religion; it was an age when credulity and superstition were rife. Science, either as a concept, a philosophical framework or simply as a source of new technology was hardly anywhere to be seen. The academic knowledge of the day resided with a great association of learned men, held together across the continent of Europe by a unified Church. They founded in this apparently isolated corner of the NE of Scotland not just a third Scottish University but a seat of scholarship completely integrated with its fellow seats in Paris, Bologna, Orleans, Prague and other cities of Europe. The founding document speaks of *'learning as a pearl, pointing the way to a wise and worthwhile model of life: it opens the way to the secrets of the Universe*'. Our founder, Bishop Elphinstone, was not simply another bookish cleric. As a student of Glasgow University he had gained distinction in logic and physics, the essence of our own discipline. The three notable achievements of his life all had a strong technical element: he set on foot the building of the Bridge of Dee, over which almost anyone who comes by road to Aberdeen from the South still crosses, he raised a tower for St Machar's Cathedral and he built King's College, with its technically sophisticated crown. Elphinstone's university syllabus followed the learning of the times, in which Aristotle's work reigned supreme in logic, physics and metaphysics.

The University became a small, residential, European centre of culture, attracting Continental students in significant numbers. One historian of 1534 speaks of the College as being the most celebrated of the 3 Scottish universities. Degrees in those days were considered a divine institution, conferred through Papal blessing. With a little imagination, one can hear the words of the degree ceremony of the day: '*auctoritate divina, et in nomine Patris, Filii et Spiritus Sancti'*. In short, for the first 50 years we find in the NE of Scotland a thoroughly European University

The mid 1500s sees the old order crumbling; the Protestant religion swept through the country, accompanied by rolling heads and the smell of flesh burning at the stake. New rules and regulations governing Universities were drawn up. These were traumatic times for citizen and staff alike. Control of the Universities passed to the General Assembly of the Church of Scotland. The University became less European and more a national institution. Indeed, after 1625 we find no trace of foreign students.

As the 1600s passed, Cromwell came and went with the Covenanting cause and as part of this revolution in about 1640 control of the Universities was finally taken in hand by Parliament itself. Marischal College, the second University in Aberdeen, had by then been founded, as something of a protest that neighbouring King's College, with royal support, would not institute the educational reforms desired by government and the new church. The first MA of Marischal College was Robert Gordon of Straloch, who became an internationally renowned geographer. His grandson, who also attended Marischal College, was The Robert Gordon, merchant, moneylender and, through his will, founder of the institution part of which has now become 'The Robert Gordon University'.

Since I am facing a technical audience, I will give some extra emphasis to technical developments in our history. You may be interested that it was in the 1600s when the first scientific instruments appeared in the University. Gifts in 1632 and 1641 formed the basis of a collection which, by 1670, included quadrants, a plane table, drawing compasses, a theodolite and other surveying instruments, several sundials, astronomical instruments such as two astrolabes, cross-staffs and nocturnals, celestial and terrestrial globes, a mounted lodestone and magnetic compasses. There being no repository for instruments, they were housed in the College library.

I don't know how much of this apparatus was demonstrated to students, for the earliest lecture notes I have seen are those of Robert Gordon, the grandson, who attended the Natural Philosophy classes of Marischal College in 1688. They are closely written in Latin and have not been translated. One study of the period confirms that the Natural Philosophy (translate loosely as Physics) taught then was mainly philosophical, based on the writings of Descartes. At Aberdeen, there was the strongest teaching of Nat. Phil. in Scotland. We know this because the late 17th Century was a time of successive Parliamentary Commissions, trying to restore stability after the Civil war of mid-century, after the Restoration of the Monarchy, after the turmoil in Scotland following the demise of the presbytery, who administered church government via a system of committees rather than through bishops, and the subsequent re-instatement of the presbytery, after the revolution and forced flight of James VII to France, after all these troubles with corresponding compulsory removal of staff and installation of acceptable alternatives.

The Parliamentary Commissions of the end of the century tried to establish a single University education throughout Scotland. Kings College was chosen to provide the Natural Philosophy module (in modern language), which was to be written and distributed to the other four Universities. Likewise, other institutions would provide different elements of the unified course. We could yet see a resurrection of this scheme in the not too distant future. It harks back to the time of the foundation when Universities across Europe were united in outlook. The academics of 300 years ago did not take well to this perceived curtailment of academic freedom and imposition of central ideas. The scheme was opposed, not by revolution but by academic inertia and lack of willpower for a long fight on the part of the Commissioners.

In Natural Philosophy, moreover, change was to come at the end of the 1600s from within the subject itself. The Scottish Universities were among the first in Europe (or, indeed, anywhere) to introduce into their courses the ethic that nature was to be probed in the finest detail by means of apparatus and experiment in order to determine the underlying principles of the world. Out went Descartes; in came Newton, who was of course very much alive at the time. Apparatus was purchased, in small amounts, in the early 1700s so that the very phenomena themselves could be displayed before the eyes of the class. Marischal College now seems to have led the way but not until after a dramatic event. The retribution that followed the failure of the 1715 Jacobite rising necessitated that every member of staff except the Principal had to flee for their lives. The University was closed for 2 years and then new staff appointed in their place. Times have been worse than they are now.

The new staff at Marischal proved very able. Colin Maclaurin, appointed to the chair of mathematics, is still recognised as one of the leading mathematicians of the century, though he was castigated at the time for absence without leave. The other key professors were Regents, who followed the traditional custom of taking one class up through all four years. They set about trying to raise money for more apparatus, first petitioning to use

unspent salaries and secondly making an attempt to raise money from public subscription to purchase *entire setts of instruments for a compleat course of experimental philosophy covering Astronomy, Mechanicks, Opticks, Chemistry, Hydrostatics and Anatomy.* Part of the aim of introducing apparatus was that even those who *have not made progress in Mathematicks may understand some of the most useful and pleasant Parts of Natural Philosophy, especially all sorts of Machines in Husbandry and Common-Life.*

In practice the poverty of the College seemed matched by the poverty of the Public, and the Professors' high ideals were realised on only a very modest scale. In 1753 the teaching syllabus at Marischal College was completely re-organised and the Regents' duties re-assigned to give one Professor charge of one subject only. Natural Philosophy formed almost the entire syllabus for a whole year for all students, including intending clerics, schoolteachers, doctors, civil-servants, engineers and merchants. The year was the third in a four year *Artium Magister* (MA) degree programme. It was, I am sure, this prolonged exposure of educated Scots to physical science that contributed to the world-wide reputation of the Scots as being technically literate people – a reputation that was thoroughly deserved..

The most influential development at Aberdeen by far in the second half of the eighteenth century was one that did not involve apparatus. It is one you would not guess, nor probably would the instigators have guessed its importance. It was the formation of the Aberdeen Philosophical Society, known as the Wise Club, by Thomas Reid, Alexander Gerard, Wm Ogilvie, James Beattie, George Skene, all professors at either Marischal or Kings College who taught Natural Philosophy and other subjects. Out of their discussions grew the Scottish Common Sense school of philosophy which, it has been strongly argued, had a major influence on all the great Scottish Physicists and many of the Engineers of the 19th century, names such as William Thomson, James Clerk Maxwell, Peter Guthrie Tait, James Forbes, William John Macquorn Rankine and others. Scottish Physics led the world in the 19th century.

A product of the education of the Common Sense School was Marischal College's notable Professor of Natural Philosophy, Patrick Copland, who taught the subject there from 1775 to 1822. He was a red-hot enthusiast for lecture demonstrations and really pioneered their extensive use in University education. He was able to do this in spite of the College's continued poverty, by the application of several skills. Apart from being the best lecturer in the College, he was a craftsman instrument maker, *as good as the best London artist*s, skilled in metal, wood and glass, with his own personal workshop. Mechanics was his hobby and his passion. He made a large number of demonstration pieces to the standards of the best commercial products. He also raised a grant to employ a technician in the 1780s to make industrial and other models. John King, the employee, may well have been the first mechanical technician to be employed by any University in Britain. [Glasgow boasts James Watt but Watt was never employed by the University - he was allowed to practice free-lance on University premises to avoid being closed down by the Dean of Guild whose examinations he hadn't passed. That is another story.]

Notable students of Copland's in science were Robert Brown, who discovered Brownian Motion, Neil Arnott, Queen’s physician, a popular educator, an early advocate of medical physics and a benefactor of all the Scottish Universities as well as London University. There were William Ritchie and Robert Davidson, early nineteenth century electricians. Copland's reputation extended throughout Britain. One of the acts of the young London University in the 1820s, not long after its foundation, was to ask for a copy of the late

Professor Copland's inventory of apparatus. There were over 500 entries, some involving several pieces.

More notably, Copland pioneered in the 1780's a very extensive course of evening lectures for artisans, many years before the better known courses of Birkbeck and others. Copland's course was very long, providing a real education over some 80 evenings each winter. He kept this up at roughly two year intervals for 28 years. One notable attendee was Joseph Clement, the mechanical genius behind Charles Babbage's Difference and Analytical Engines. The success of these evening classes is said by some to have been influential in founding the Royal Institution in London in 1800. It, too, was initially aimed at tradesmen, before moving up-market to middle-class audiences in order to attract more money. When Mechanical Societies were founded all over the country in the early 1820s following the success of Birkbeck's evening classes, Aberdeen's flourished, for it was simply carrying on an already long established tradition. When other Societies folded, Aberdeen's did not.

Looking over any list of staff in a University Department that has spanned a long period, one is likely to think *sic transit gloria mundi*. Staff extremely well known in their day are forgotten by succeeding generations. Such has happened to Patrick Copland. It is also true that very few educators are remembered by posterity and education has been the prime business of most Universities. It has certainly been the prime business of Aberdeen University over the centuries.

Only 34 years after Patrick Copland, Marischal College gave the young James Clerk Maxwell his first professorial post. Maxwell is, of course, remembered for his research but he took a great interest in his teaching while at Aberdeen. His important research here involved a major theoretical study on the stability of Saturn's rings in which he demonstrated from mathematical arguments alone that Saturn's rings were neither gaseous, liquid nor completely solid but had to be composed of a jostle of small solid bodies. This was 130 years before close-up space-probe pictures confirmed the view. While at Aberdeen, Maxwell laid the foundations of quantitative colourimetry, devising the Maxwell Colour Triangle that is still used in various forms by colourimetrists and artists. In the year after he left, Maxwell used this work to have the first ever colour photographic picture projected in 1861. While at Aberdeen, Maxwell also developed the foundations of the kinetic theory of gases, our modern view on how gases owe their properties to the motion of the molecules that compose them. He announced the fundamental Maxwell velocity distribution at the British Association meeting in Aberdeen in 1859, perhaps the only law of Physics ever to have been discovered and made public in Aberdeen. Maxwell enjoyed his time here. He had the freedom to think and establish himself professionally; he enjoyed the discipline of clear thinking necessary to teach effectively; he married the Principal's daughter.

To reinforce my earlier point about education being the prime aim of the University, look at some of the notable scientists who studied Natural Philosophy at Aberdeen in the second half of the nineteenth century. There was Charles Niven, FRS, who returned to Aberdeen to teach here for over 40 years; his brother Wm. D. Niven FRS a very good theoretical physicist, later Sir William, Director of the Royal Naval College, Greenwich; the formidably talented George Chrystal, FRS who worked with Maxwell at the Cavendish lab on electrical measurements and later became Professor of Mathematics for many years at Edinburgh; William Cassie, the first Clerk Maxwell Scholar at the Cavendish, who studied with J. J. Thomson and the subsequently became the first real Professor of Physics at Royal Holloway College where he specialised in optical instrument making; Charles Chree FRS another very practical man who became a world authority on terrestrial magnetism and was

appointed Superintendent of the Kew Observatory; David Gill, a student of Maxwell's at Aberdeen, FRS, later Sir David, The Queen's Astronomer at the Cape of Good Hope and one of the nineteenth centuries finest observing astronomers. Every single one a local lad from Aberdeen or the surrounding countryside. Our Honours classes have never been large and were typically 4 - 5 students during these times.

Reaching, at last, the 20th century, the connection with Cambridge becomes even stronger. G. P. Thomson, son of J. J. Thomson, was appointed successor to Charles Niven in 1922. He had written a book on aircraft by the time he reached Aberdeen but he took up research on the electrons that his father had discovered. In 1926, Thomson saw how he could adapt his experimental apparatus to try and demonstrate that electrons could be diffracted like light. Such diffraction was an apparently absurd suggestion of the young French aristocrat Louis de Broglie but the possibility of such behaviour seemed to be at the heart of a whole new physics that was growing up, wave mechanics. Thanks to first-class work by his technicians, as well as his own insight, G.P. Thomson succeeded in demonstrating the diffraction of electrons in 1927 and was awarded the Nobel Prize for this work some 10 years later. de Broglie himself visited Thomson at Aberdeen.

Thomson always acknowledged the work of his chief technician, C. G. Fraser, not only in making immaculate equipment but in the crucial thinning of metal foils central to the experiment, thinning beyond anything available commercially. The definitive paper describing the Nobel Prize winning work was published in the joint names of Thomson and Fraser: a remarkable tribute to his technician. A former member of staff recounted to me that when Thomson was offered the Professorship at Imperial College in 1930 he asked Mr Fraser whether he would like to come with him. Fraser declined the invitation and upon being told this G. P. was heard to say '*in that case he doubted very much whether it would be worth his own while going to London*'. He did go. Thomson, too, enjoyed his time at Aberdeen: he brought the teaching standard right up to date; he had great success with his research and he married the Principal's daughter.

Following a Nobel Prize worthy professor is indeed a tough act. John Carroll took on the task. He had worked with Michelson and was a spectroscopist with a special interest in solar physics, an area that is still in the forefront of interest at the beginning of the 21st century. His career was seriously disrupted by the Second World War, during which he was seconded to the national cause and most potential students were called up to fight for their country. John Carroll was honoured with a knighthood for his work but did not return after the war.

One of Fraser's team of technicians was his younger son Sandy Fraser. When R.V. Jones took on the Chair of Natural Philosophy in 1946, instrument design and construction was a subject of high priority in British physics. Sandy Fraser became R.V. Jones' chief and valued technician. RVJ was an instrument designer of rare skill and intuition. Although he will be remembered for his work in military intelligence during the war, his contribution to physics during his 35 years here was strongly centred on instruments and their design. Building instruments that work to the limits of precision requires mechanical insight and a workshop staffed with skilled technicians. Henry Barber, who worked on the technical side with RVJ for over 15 years, played a key role in providing the necessary support, carrying on the expertise supplied in earlier years by Sandy Fraser. Some of RVJ's instruments have found their way into our Natural Philosophy Collection of Historical Scientific Instruments and can be seen at times on display. Our workshops expanded under RVJ to become arguably the best instrument shop in Scotland. Even after Professor Jones had retired in 1981 and the

oil industry had taken away some very good technicians, the workshop made in the mid 1980s the UV monochromator for beam-line 3 of the Daresbury Synchrotron radiation facility, to the optical design of John Bates, Reader in Nat. Phil. It has worked exceptionally well ever since and has seen over 20 years of service at Daresbury.

Looking back from near the end of the twentieth century, I see I have said nothing about much of the evolution of the Department and our degrees, about the merger of the two Universities in 1860 into the University of Aberdeen and the formal institution of Honours degrees then; about the decade of revolution in the 1890s that saw the introduction of women students, of the BSc and of medical physics teaching. The MA degree in Natural Philosophy or Natural Philosophy & Mathematics continued to be the main choice of students until after the Second World War when the BSc finally took over. Medical Physics evolved at that time into a separate spin-off department that became in due course the University's highest achieving research department. The early 1970s saw the introduction of the Designated, non-honours, BSc in Physics that allowed students to specialise in Physics for the whole of the third year. Many future Physics teachers benefited from this development. 1986 saw the demise of the name 'Natural Philosophy' both for the Department and for our main degree to be replaced, against the wishes of most of the Department, with the name Physics. We became the Department of Physics for the first time.

1990 saw modularisation reach the University, the year's teaching in Physics being broken up into somewhere between two and eight modules, depending on the year. With this development came the broadening of choice of degree for students, with a wider range of Joint Honours degrees and the introduction of Combined Honours options, offering a major component of 75% and a minor component of 25%. By the year 2000 there were a dozen Physics degree choices on offer. Course content changed significantly in the 1990s but course delivery changed more so. Out, by and large, went 'chalk and talk' with students spending the hour of a lecture copying down what was written on the blackboard (with information passing, as used to be said, from the lecturer's notes to the students' notes without being considered by the mind of either). In came PowerPoint presentations, detailed typed course notes, the web, virtual learning environments, computer-based study, student presentations, team-work, student-prepared web pages and more besides that now comprise the diverse programme of a modern university degree. The University has expanded from the elite, residential college that it was 500 years ago to a provider of education for some 13,000 students. In catering now not only for Scottish and UK students but for large numbers from abroad it has come full circle, being once again a fully international institution.

This has been a whistle stop tour through five centuries. Research is writ large in the strategic thinking of the University but looked at over 500 years, education has been our main business. Some 13,000 undergraduates on campus will attest that education is the reason they came to the University of Aberdeen and they will be glad to know that anyone who looks at our history will realise that in education we have a proud record to sustain. Our Physics graduates can hold there own anywhere and have done so many times over. We shall try to ensure that they continue to be equipped to do so in the future.

JSR