Scottish Scientific Heroes from the East Coast

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(*Based on a talk given to the ASE in Dundee early in the year 2000*)

It might not sound like it but one of my credentials for taking on this topic is that my ancestors are firmly embedded in the North-East of Scotland. However, you know the thrust of traditional Aberdeen humour. One such joke runs like this: "*In the old days Scotsmen emigrated to London, now they are being born there, to save the expense of railway travelling.*" I'm one of the Scots who was born there. Well, it was an accident of circumstances. Joseph Black, the great, dour, Scottish Chemist who invented the ever-useful concepts of specific heat capacity and latent heat, was born in Bordeaux in the South of France. If a Frenchman of Irish extraction can pass himself off as a Scot, so can I.

"What is fame?" asked one of my colleagues. Fame is partly being in the right place at the right time, and doing a little too! My first hero is Mary Somerville. She has an island named after her. If you look on the map of the frozen wastes of the North West Territories in Canada, amongst Dundas Bay, Melville Island and other evidence of Scots involvement in the exciting days of Arctic exploration around the 1820s, you may find it - Somerville Island. Her story is that she was introduced to the explorer Edward Parry and his small expedition fleet not long before they set off to look again for the North West passage. Putting her cooking skills to use she made a large quantity of orange marmalade for the expedition. Parry's men survived 2½ years in the Arctic and good Scots marmalade, even if it wasn't Dundee marmalade, must have seemed like nectar from heaven and well worth naming an island after the cook. Good fortune for her, you may say.

More substantially, Mary Somerville has had an Oxford College of high repute named after her, not to mention a crater on the Moon. I'm going to begin with her as an example of a Scot who did an enormous amount of good for science and deserves to be better remembered at home than she is.

Mary Fairfax, as she was christened, also had the unusual good fortune of being born in the household of her future husband, William Somerville. Not many of us can say that. Mary was brought up in the 1780s at her parents home in Burntisland on the shores of the Firth of Forth. Her father was a successful naval

captain much more often absent than present.

Mary seems to have been something of a wild kid, exploring the seashore and the countryside on her own or with her elder brother. As she grew well into her teens she was taught the usual ladylike accomplishments of playing the piano and painting, the latter by none other than Alexander Nasmyth. She was also a keen reader and what I find amazing in her account of her life is that general reading was not encouraged for young girls 200 years ago. You should have been able to read the Bible, and Shakespeare perhaps, but the amount of censorship there was on women's education is astonishing. Mary was in a worse pickle. She felt an unfulfilled urge to find out about algebra and geometry. She says "*Unfortunately, not one of our relations knew anything of science or natural history; nor, had they done so, should I have had the courage to ask any of them a question for I should have been laughed at…as to going to a bookseller and asking for Euclid*", she continues, "*the thing was impossible!*". When she finally got hold of a couple of books through the good offices of a tutor hired to teach her the niceties of life, she had to read them by candle-light after going to bed at night. The depletion of the family store of candles soon became obvious and a servant told her mother the cause, "*whereupon*", as Mary says, "*the order was given for her candle to be taken away as soon as she went to bed*". When her father came home and found that his daughter had been reading algebra and geometry he is quoted as having said to his wife "*Peg, we must put a stop to this, or we shall have Mary in a straightjacket one of these days. There was X, who went raving mad about the longitude*". This was for real. If you want reminding as to why so few women appear in the history of science, the cause, I believe, lies far outside science.

Many Scots, men and women, are natural born scientists. We have an instinctive curiosity, an independence of spirit, a love of finding out the 'go' of things, or at least the order of things, and many have a love of making things, all traits that underlie the character of successful scientists. Scots have an impressive record of contributions to science and it's not because we have great specialist institutions that match Caltech, MIT or Bell Labs. Many people learned some of their science through personal and independent study. Mary Fairfax describes one visit to the Boswells of Balmuto, north of Burntisland. The Boswell son had a turn for chemistry and his father took Mary to visit his laboratory, whatever that might be, Mary knew not. It contained curiously shaped glass pieces and other apparatus. The son put a substance on the table and took up a hammer as his father said, "*now you will hear a fine report*". Young Mary ran out of the room saying "*I don't like reports*" (there's a good quotation to remember). Sure enough, a very loud report followed and when she went back inside, the son had been knocked unconscious, the father was trembling from head to foot and the apparatus had been smashed to smithereens. They had had a lucky escape. Incidents like these never make the history books but to me they illustrate that real science isn't just about mugging up the success stories of others as written in textbooks but it's also about finding out for ourselves how nature works and is organised, at least on some level. In reality, what we were looking for may not show. So long as we survive, we can often learn more from mistakes than from getting it right.

I haven't told you yet why Mary Somerville comes in to my story at all. She couldn't go to University. She was 100 years before her time. I think it was 1893 before my University allowed women entrance. I've no doubt the other Scottish Universities were much the same. Mary Fairfax became the widowed Mary Greig, in her mid 20s, and lived at home with two young sons. She was introduced to William Wallace of the University of Edinburgh. Wallace told her to read LaGrange's "Theory of Analytic Functions", Biot's "Analytic

Geometry and Astronomy", Poisson's "Treatise on Mechanics", Laplace's great "Mecanique Celeste". Mary acquired these books, all in French, and went though them, no doubt very slowly. I've wondered whether Wallace ever told her that there were probably scarcely a couple of dozen people in the country who understood mathematical physics at this level. It was red-hot science.

The widow became Mary Somerville in a couple of years and it was not long before she and her new husband were themselves in Paris. She not only met the Marquis de Laplace, Poisson, Biot, Arago and others, all names well-known to some in the audience, but dined with their families and discussed science with them. French mathematics and physics was going through a flowering of its talent, but it was all in Paris. Go to Bordeaux or Marseilles and, they agreed, you would find few scholars who could perform simple arithmetic, let alone who knew who the current celebrated savants were or what they did.

Biot came to Aberdeen in 1817 on his way to Shetland, as leader of an expedition to measure the shape and size of the earth as part of a more accurate definition of the metre. In Aberdeen, where he was awarded an Honorary Degree by Marischal College, he was astonished at the depth and diversity of their collection of physical demonstration apparatus. He expressed his surprised that it should be allowed to remain in a provincial town and said that "*in his country the whole would be conveyed at once as by royal mandate to the metropolis"*. Well, so much for the French revolution giving 'power to the people'. Biot wrote home saying that in Aberdeen he had found not one alone but many who perfectly understood the object of his journey and were competent to converse on the subject. Yet, in France, only a few years before, when Delambre had taken his observing instruments into the French countryside, the ignorance and hostility of towns and villages to the appearance of the apparatus was such that it would all have been smashed by the crowd on several occasions if it had not been for the protection of the local military. It is said that what saved Delambre's life more than once was his own cool. The conclusion I draw from this story is that we have a great tradition in Scotland that science is not an elitist occupation for the few to pursue under generous patronage in centres of excellence, but is truly an area of knowledge and interest that we should all take part in. In the past, the science in our education system has gained the respect and envy of other countries. I hope we can keep it that way.

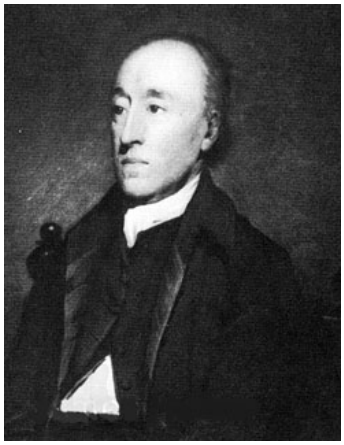
I'm digressing again. Why has Mary Somerville an Oxford College named after her? Mary didn't discover any laws of science but she was a great communicator. She didn't keep her knowledge to herself but wrote several books popularising the advanced science she had learnt. These include her "*The Mechanism of the Heavens*", "*The Connection of the Physical Sciences*" and "*Molecular and Microscopic Science*". More than anything, she showed that women could grasp the most advanced science of the day and she helped change society's view of what it was acceptable for women to do. By the end of her life, and she lived to the age of 91, women no longer had to learn science in secret by candle-light or risk being taken away in a straightjacket if they had an interest in algebra. They could even read science books written by women, albeit rather few. Everyone in this room owes something to Mary Somerville for starting the process of breaking down the enormous barriers that were preventing women realising their natural interests and talent.

What astonished me recently when I was chatting with my scientifically learned colleagues over a paper cup of coffee out of the machine – it's called progress – was how few had heard of Scots I'd have thought were at the top of the board in the hall of fame. Who in the audience associates the Gregorian telescope with one of the 16 Pope Gregories? Who doesn't

associate Brownian motion with a gifted son of Montrose? I'll mention some famous as well as less famous names in an imaginary train journey north from Burntisland. Knowing that our predecessors gave Scotland a great reputation in science builds our own self esteem, reminds us that we have been operating on a world stage for a long time and can hold our heads high.

My first stop is naturally just across the "Beautiful Railway Bridge of the Silvery Tay", according to the notable bard. Dundee is near enough the home town of John Playfair, who was born in 1748. Playfair was a great talent, and like Mary Somerville a great educator. One year after graduating at St Andrew's University he applied for the Chair of Mathematics at Marischal College, Aberdeen, at the age of 18. He was greatly ambitious and confident too! He was defeated in a competition for the post but later was appointed Professor of Mathematics at Edinburgh. After 20 years, he moved across to become Professor of Natural Philosophy there.

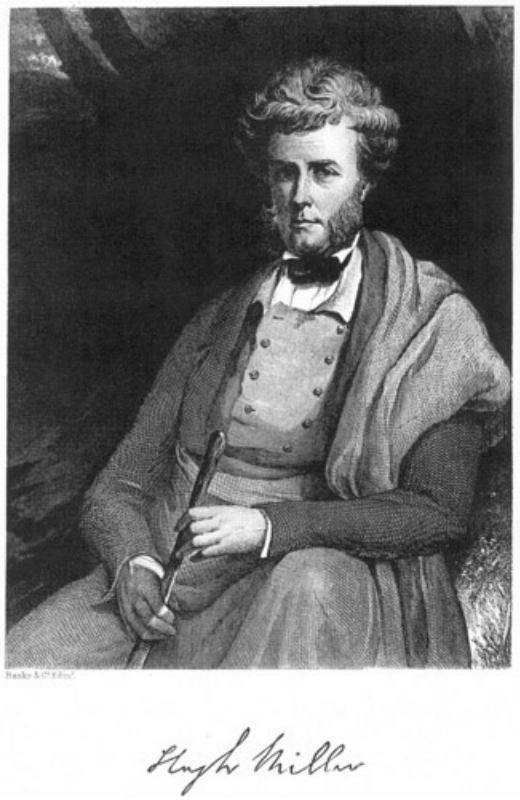
Playfair was one of the men who put Scotland on the world stage, along with Adam Smith the Economist, Joseph Black the Chemist, Robert Adam, Architect and Engineer, and philosophers Thomas Reid and David Hume, and others, too. He wrote widely on physical topics and less widely on mathematical ones, but I'm just going to mention his role in bringing the work of James Hutton to an international audience. Playfair did this through a very sympathetic presentation of Huttons' views in a booklength publication in 1802 entitled "*Illustrations of the Huttonian Theory of the Earth*". I must digress a little again.



For me, a whole handful of heroes are the Scottish founders of modern geology. The story starts with James Hutton, who was born in Edinburgh and spent most of his life in Scotland after studying medicine in Paris and Leyden. He took the subject of cosmogony, how the Earth and all around was formed, out of the sterile hands of the philosophers and theologists and made it into the modern subject of geology. In Hutton's "*The Theory of the Earth*" first published in 1785 he outlined how natural forces we can see at work in the atmosphere, in the sea, in volcanism and in Earth movement could account for the complex rock structures we can find all about us in Scotland, and everywhere on Earth. Moreover, as he memorably put it, "*in the economy of the world* [by which he meant its geology] *I can find no traces of a beginning, no prospect of an end*". The religious fundamentalists were incandescent. Their argument that the world was only 6000 thousand years old was pretty generally accepted dogma. Hutton changed the viewpoint of all Christian folk. He was the Darwin of Geology. John Playfair acted as his Huxley, promoting his ideas, spreading the word, extending the arguments from evidence of his own collected over years of extensive travels in Europe.

Following Hutton into the 19th century came the great developers of geology: men of the highest international quality such as Charles Lyell from near Kirriemuir, in Angus, Roderick Impey Murchison, who was born at Tarradale on the Black Isle, and Archibald Geikie, born in Edinburgh. These could detain us for a while but I'd like to dwell on a man of a different

stamp, Hugh Miller, born in 1802 in Cromarty, who acquired his enthusiasm for geology while a quarry stonemason and carver of tombstones. He wrote vividly and his book "*The Old Red Sandstone*" became a best seller that had the middle class Victorians fascinated by geology.



Geology in those days was largely about sharp observation and accurate deduction. Miller did it superbly and the great academic geologists acknowledged this. I spent some of last weekend reading from another of his books "*The Cruise of the Betsey*" which describes a summer trip in the 1840s from Tobermory, through the small Isles of Muick, Eigg and Rhum to Skye. I know the area quite well. Let me read a little to you to give you a flavour of his description. He's on Eigg, climbing the impressive summit, the Sguir of Eigg, that gives the whole island its character. Basalt columns stretch all the way from the Giant's Causeway in N. Ireland to this region. Have you ever been there? Listen to Miller's description of the basalt on the Sguir "*In one bed they belly over with a curve, like the ribs of some wrecked vessel from which the planking has been torn away; in another they project in a straight line, like muskets planted slantways on the ground to receive the charge of cavalry; in others the inclination is inwards, like that of ranges of stakes placed in front of a sea dyke, to break the violence of waves; while yet in others they present, as in the eastern portion of the Sguirr, the common vertical direction. The ribbed appearance of every crag and cliff imparts to the scene a peculiar character: every mass of light and shadow is corded with minute stripes;….*", and so on. You can all picture the terrain now.

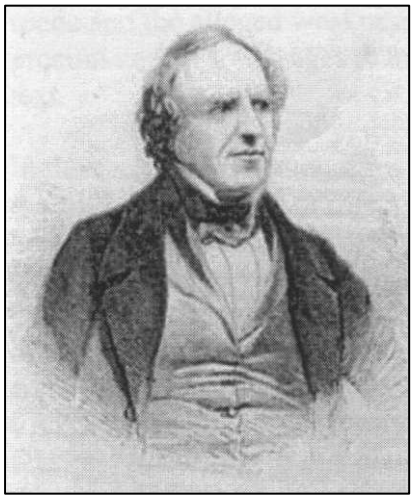
Hugh Miller was not just a good travel writer but a very good geologist, too. His work with fossil fish in the Devonian established this period of many millions of years as the age of the fish. The house Miller was born in Cromarty is owned by the National Trust for Scotland and is open to the public.

There were the technical Scots, too. I'd like to mention one, William Nicol, who was born near Edinburgh about 1771. He made a dual contribution to Geology. In 1829 he published his description of what we call the Nicol prism, a device for producing polarised light that was superior to anything else available. Secondly, he is credited as being a pioneer of the technique of analysing the minerals in rocks by examining thin, transparent slices under a microscope. The two ideas are brought together in the petrological microscope, a key instrument used by geologists since the mid-nineteenth century to identify minerals and some of the history of their formation by examining their appearance in polarised light.

William Nicol earned a living in what many of us might think of as the hard way. He thought otherwise. Nicol was a professional itinerant lecturer in Natural Philosophy, Physics by another name. When he was offered a permanent post in 1818, a university professorship no less, he wrote declining the post saying "*In the first place, I can realize considerably more after defraying every expense than the other would produce.* [i.e., it's badly paid] *Secondly, my present duties are a mere amusement, the other would harass my soul with anxiety.* [i.e. it's highly stressful] *Thirdly, I have become so much habituated to an erratick life which I have led from my infancy that were the pecunary advantages even ten times greater I should scarcely chain myself down to a permanent abode,* [i.e. the constraints of the job are too great] *and lastly that to a man whose life has extended to nearly half a century - who has already the wherewithall to supply his wants - and who feels himself sufficiently happy in his present condition it would doubtless be imprudent to leave the path he has trodden with success…*" and he goes on to add "*I purpose in a fortnight proceeding to Sheffield. I have an audience here amounting to more than a hundred and six weeks does the job.*" [i.e. his course of lectures]. Would that we were all equally at ease with ourselves.

Nicol isn't particularly one of my heroes but beneath the great names there is always a hive of activity, largely unrecorded, that makes real development possible. Nicol's ideas made a big contribution to helping geology become a progressive science. In one sense his ideas illustrate my introductory comment on luck. There's no evidence that he foresaw their impact, let alone developed them for the purpose.

John Playfair's support of James Hutton has diverted me a long way from Dundee. John Playfair has a crater on the moon named after him.



The next stop on my train is Arbroath, the birthplace of a less well-known hero - Neil Arnott. Like the best heroes in modern times, Arnott donated money to us in Aberdeen, and indeed to all 4 Scottish Universities. His wife did the same to promote two London women's colleges, no doubt with the approval of Mary Somerville. Our money is still 'on-the-go', providing scholarships and prizes. Arnott did much more. He was inspired to an interest in science by the enthusiastic Professor Patrick Copland of Marischal College, whose lectures he attended in 1803. He made his career as a medical practitioner in London, rising to become Queen's surgeon, but he made his reputation in the world at large as an educator. It can be done. He published his "*Elements of Physics*" in 1827, which became the portfolio textbook of the times. It was very popular for more than 50 years, and justifiably so. "*Elements of Physics"* was rapidly translated into a clutch of foreign languages. It set out the method of teaching employed by Copland, giving very clear accounts of his subjects in plain language, illustrated by numerous real examples.

If you have a chance, get hold of a copy. It will fascinate almost anyone who teaches science. Even let your pupils browse. 'The Times' said of it in their review of 1827 "*To the most idle schoolboy it will be as entertaining as a treatise on witchcraft or legerdemaine*"; substitute "Dungeons & Dragons or computer games" to bring the quote up-to-date. As I was organising this talk I opened the book genuinely at random and came to the paragraph on

'wetting', which illustrates Arnott's style. Let me read the text. After describing how "*A finger dipped in water comes out wet; dipped in mercury it comes out clean and dry*" and how mercury has a greater attraction for itself than for our skin, he describes wetting as occurring when (I quote) "*the adhesion of the liquid to the solid is greater than the cohesion of the liquid. For example*", he continues "*if we are over-cautious in pouring water from a tumbler or a cup, the liquid may prefer trickling down the inclined side of the vessel to falling vertically. Hence the use of a projecting lip, that the quantity approaching the edge at one time may be a small stream, and the adhesion to the glass is less difficult to overcome than that of a broad sheet of liquid. In pouring clean mercury from a glass, a lip is unnecessary, as the liquid has practically no adhesion for the glass.*" We don't get to play with mercury any more but the paragraph is a wonderful example of how a feature of everyday life, the lip of a pouring vessel, is related to the science of what's going on. There are such examples on every page.

Arnott's book can also claim to be a pioneering text in the teaching of 'medical physics' because he has numerous examples illustrating how the application of physical principles enables us to understand the working of our bodies. The final edition of 1876 has a whole section on 'Animal Physics'. This was over 15 years before 'medical physics' teaching was introduced into our Universities. I could read from Arnott's textbook all evening. Just let me give you a flavour of his medical illustrations. "*In the graceful human step the heel is raised a little before the foot is lifted from the ground, as if the foot were part of a wheel rolling forward; and the weight of the body, thus supported by the muscles of the calf of the leg, rests for a time on the ball of the foot and the toes*". He goes on to describe how English farm labourers' strong wooden shoes prevent them raising their heel as they walk, and hence using their calf muscles. The result, he says, is that farm labourers typically have fine robust bodies and arms but "*legs which are almost spindles, producing a gait which is awkward and unmanly*". To make his point further he relates that formerly in Paris, where the streets had no side pavements, ladies had to walk almost constantly on tiptoe. "*The great action of the muscles of the calf*", he writes, "*gave a conformation of the leg and foot to match which the Parisian belles proudly challenged all the world – not aware, probably, that it was a defect of their city to which this peculiarity was due.*"

You can learn a lot from Arnott's "*Elements*". Outside the world of textbooks, Arnott made a great name for himself in his day by his interest in public health. He wrote about ventilation in houses, factories and schools and the patented the Arnott stove and Arnott ventilator, which were widely used as far as I know. He spread the value of a good Scots education to the capital city, being on the first Senate of London University when it was set up in 1836. He was a 'hero' worthy of being remembered by all of us in Scottish education.

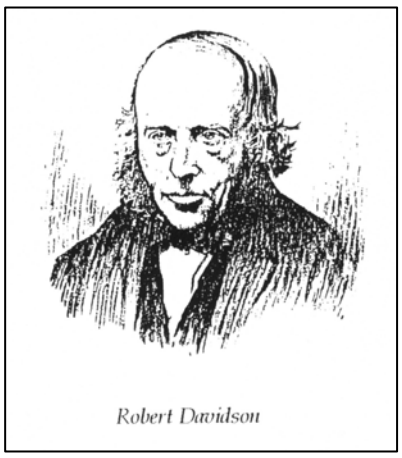
I virtually promised to introduce Robert Brown, son of the Episcopalian Minister at Montrose, born in 1773. He also graduated from Marischal College. Robert Brown was one of the greatest 19th century botanists in Britain. Like Joseph Banks before him and Charles Darwin after him, Brown got his first break by being included as naturalist in one of the great extended expeditions to survey unknown territory. This time it was under Captain Flinders and they were away for four years exploring New Holland. The expedition returned in

1805 with thousands of dried plants, many of which were new to science. Brown was appointed librarian to the Linnean Society and over the next 4 years produced a famous and meticulous account of the new flora of New Holland, which we all know now as Australia. He became librarian to Sir Joseph Banks, who was President of the Royal Society for 41 years. Banks bequeathed his entire library and specimen collection to Brown, as well as a splendid house in central London. Brown continued to make brilliant discoveries in plant science, including the discovery of the nucleus of plant cells and, in 1827 the phenomenon now known universally as 'Brownian motion'.

Brownian motion is the constant movement of minute objects in solution, that can be seen under the microscope. Brown observed the motion in pollen particles suspended in water. You can easily observe it in dilute milk. He found out it was not due to convection currents, evaporation and other possible causes he had under his control. Nor was it due to any motion of organic origin. Brownian motion never goes away. Einstein, no less, built his reputation in 1905 with a theoretical explanation of its origin in random molecular collisions between the particles in suspension and the surrounding water molecules, pointing out that the distance travelled by a particle increases as the square root of the time of observation, unlike normal motion. You can find Brownian motion science cited in three Nobel prizes in the 1920s, that of Einstein for Physics in 1921, that of Robert Millikan for Physics in 1923 and that of Jean Perrin for Chemistry in 1926. Brownian motion was the clinching visible proof that atoms and molecules exist. To this day, Brownian motion is cited as the archetypical random motion in fields as diverse as Stock Exchange fluctuations, medical image analysis, robotic motion across rough terrains, business decision making and other disciplines, yet few know that the quiet and studious Robert Brown from Montrose was the man on whose observations the whole edifice rests.

After Montrose, the train stops briefly at Stonehaven, whose famous son is Robert Thomson. To the dismay of locals, Thomson is seldom given credit on a wider stage for his great invention, that of the pneumatic tyre. His claim is quite genuine, and occurred many years before that of Dunlop. He not only had the idea and patented it, but had pneumatic tyres made. The Thomson preservation society conduct something of a permanent wake for him.

Twenty minutes after Stonehaven, we reach Aberdeen. In Aberdeen, there's certainly a choice of heroes. Some of my personal ones are Patrick Copland, Andrew Mackay, and David Gill, the great 19th century observational astronomer. However, I'm going to introduce you to Robert Davidson, forgotten hero and electrical visionary.



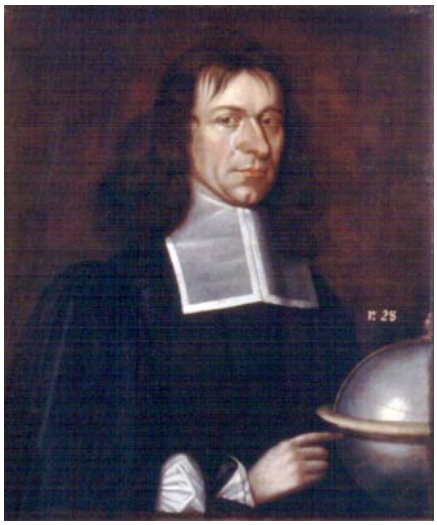
Robert Davidson

Davidson was born in 1804, son of a grocer and wine merchant who had his shop close to Marischal College. Robert Davidson attended the College and passed through the inspirational classes of Patrick Copland. Finding the life of a grocer uncongenial, he set up a yeast brewery, which transformed itself into a manufacturing chemist specialising in dyes. He diversified into growing seeds, sharpening and hardening files and even dentistry at one point. His business made him enough money to build his own large reflecting telescope of the style employed by

Wm Herschel – a large mirror of very long focal length pointing skyward, with a tower made of ladders that was climbed to let him examine the image. You're beginning to see what kind of man Robert Davidson was. He certainly had the instinctive curiosity, independence of spirit, love of finding out the 'go' of things and the passion for making things that I mentioned earlier.

In the 1830's, Faraday showed how to generate mechanical motion from electricity, albeit in a way that was useless for exploitation as a practical electric motor. Davidson became fascinated by the possibilities. He built his own batteries and by 1837 had made his first fair sized electric motor. In 1840 he held a public "Electromagnetic Exhibition" in Aberdeen and thousands paid 1/- entrance to see a working model electric locomotive able to carry two people, a model electric lathe, a small electric printing press and an electro-magnet that could lift 2 tons when supplied by a suitable battery. The motor driving the lathe and printing press had a 5 foot diameter flywheel and the electromagnet had pole pieces 4 inches square. These were not desk-top toys. If Davidson had had this exhibition in 1880, many would have marvelled. This was 1840. The *Aberdeen Banner* prophesised that electromagnetic machinery "*will in no distant date supplant steam*"'. Davidson took his exhibition to Edinburgh in the following year, where the influential Robert Chambers of encyclopaedia fame made similar remarks and the young James Clerk Maxwell aged 10 was taken by his father to see it. In late 1842, Davidson took his exhibition to London in the hope of attracting sponsorship. By then he had added an electrically powered circular saw that cut 1" square planks in about 1 second and a powerful electric arc made by passing the current through two pieces of coke. He broke even in London but didn't attract the sponsorship he'd hoped for.

Between the Aberdeen and London exhibitions, Davidson built a full-sized prototype electric locomotive called *Galvani*. It was 16 feet long and weighed about 6 tons. In 1842 it ran at 4 miles per hour on the Glasgow to Edinburgh line (the railways hadn't reached Aberdeen by then). Unfortunately, *Galvani* was destroyed before Davidson could get it back, by men unknown but suspected of being promoters of steam technology. Davidson's attempts to interest the railway companies failed. He was discouraged and probably couldn't afford to pursue the matter on his own. Electric locomotives didn't appear commercially on the railways in Britain until around 1890. Robert Davison was suddenly found to be still alive and was converted into a media celebrity "*Octogenarian Aberdonian - oldest living electrician*" the press trumpeted, or words to that effect. *The Electrician* magazine reported "*Robert Davidson was undoubtedly the first to demonstrate the possibility of electrical traction in a practical way*". He was, but sadly his foresight fell on the blind eyes and deaf ears of those who could have promoted it. Davidson died 4 years later at the age of 90, old enough to see his vision at last made real.



No student who has come to my Optics lectures will get away without hearing about James Gregory, but I don't really do him the justice he deserves. Gregory was another son of the manse, born at Drumoak, not far from Aberdeen, in 1638. The Gregory family are one of Scotland's intellectual phenomena. James Gregory became Professor of Mathematics at St Andrews and then Edinburgh; his son, became a Professor at Aberdeen, his grandson, his great grandson and his great-great grandson were all professors in Scottish Universities or in Oxford, particularly of medicine or mathematics. In all some 22

related Gregory's were professors over a span of 200 years. Mind you, James' elder brother David, who looked after James education when their father died, gave the family a good start by having 32 children. He too was a notable mathematician, a specialist in exponential growth obviously, whose son became Professor at Oxford.

To return to young James. Why should we remember his contributions to science? For several reasons. In brief, he showed us how to make much better telescopes, using a mirror as the main optical element, rather than a lens. All the big astronomical telescopes these days, from the Hubble telescope to those with their feet on the ground, are reflecting telescopes, for good reasons. Many people, and textbooks, say that Newton invented the reflecting telescope. Not so. It was James Gregory, some 9 years before Isaac Newton's version. Gregory published the design in his first book, *Optica Promota*, in 1663. By then, aged 24, he had gone to London and he attempted to get one of the best optical instrument makers of the day to make the telescope mirror for him, but the maker failed to figure a satisfactory one. Gregory and Newton's telescopes differ from each other somewhat as a flute differs from an oboe. In Gregory's, you look straight through, in Newton's you peer in at the side through a 45° mirror. Gregorian telescopes became the most popular of all in the following century, and very fashionable among the amateur scientists of the aristocracy, of whom there were many. Today, many observatories use a modified Gregorian telescope of the kind devised by Cassegrain.

On one famous occasion, while Professor of Mathematics at St Andrews, James Gregory persuaded the good folk of Aberdeen to hold a church-door collection throughout the town to supply money for astronomical instruments for the observatory at St Andrews. That takes real talent. You can still see the meridian marker, so called, that Gregory set up to the South of St Andrews to mark the exact North-South line to his observatory. I have been shown it by Prof Jack Allen, whose association with St Andrews itself extends to the distant past.

Gregory made the first reasonable estimate, to my knowledge, of how far away the stars are. He compared the amount of light coming from the Sun to that from Sirius. Assuming they were both similar bodies, he deduced from the weakness of Sirius's light that it was about 90,000 times further away than the Sun. In fact, modern measurement by a different technique shows that Sirius is 6 times farther away than even this but Gregory's answer is a pretty good estimate for an astronomically huge distance, and Gregory didn't know that Sirius was an intrinsically much brighter star than the Sun.

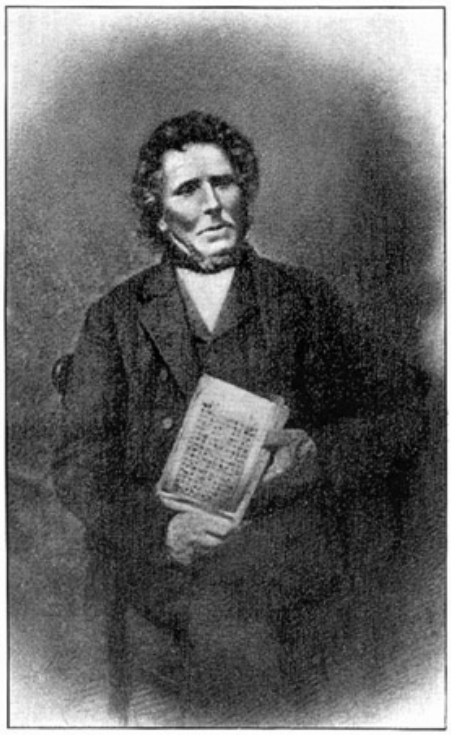
He spelt out how you could find the distance to the Sun itself, which was not known in his day. The method involves watching and timing the transit of Venus across the disk of the Sun from different latitudes on the globe. These transits only occur in pairs about every 120 years and on the following two occasions, in the 18^{th} and 19^{th} centuries the experiments were done and the answers proved the best answers then available. The distance is about 150 million kilometres, a pretty long way to stretch a tape measure. Nowadays, we measure the scale of the Solar system by radar, invented of course by another great Scot, Robert Watson-Watt.

Gregory's greatest talent lay in mathematics, and historically minded mathematicians point out that he not only discovered Taylor's fundamental theorem in calculus 40 years before Brook Taylor did, but achieved so much in advancing the techniques of calculus that he deserves to be credited as a co-inventor of calculus, with Newton and Leibnitz. Some of you might want to put him in the pillory for that. What did St Andrews University make of all this

talent on their doorstep? His students learnt facts in mathematics that made some of the teachings of the other masters seem wrong. These masters gave orders to the servants not to help Gregory with his astronomical observations; they '*kept scholars of the most eminent rank from him, contrary to their own and their parent's wills*', as Gregory put it, persuading them that their brains were not able to endure his mathematics; they even with-held his salary. It is often thus that talent isn't appreciated at home. He left to go to Edinburgh University, at twice the salary.

Gregory's girl was Mary Jamieson, daughter of the great Scottish painter, to whom I suspect we owe the likeness of James. He had only one son by her, also called James, before he died a year into his Edinburgh professorship at the tender age of 37, still mathematically active. Charles II thought sufficiently highly of Gregory to award a pension to his widow and family "*in recognition of his services to science and to Scotland*". Remember James Gregory: inventor of the reflecting telescope, measurer of the heavens and co-inventor of basic calculus. James Gregory has a crater on the Moon named after him.

A lot more of Scotland waits to be covered. Those from the West coast will have their own local heroes such as John Anderson, Thomas Graham, John Macadam, William Ramsey, "Paraffin" Young, and many others too. However it seemed to me fitting to end with Dundee's equivalent of Robert Davidson - a man even more eccentric and even less successful, but certainly no less of a visionary. Locals will have guessed - I'm referring to James Bowman Lindsay. That he, too, could have made it into the big time is hinted at by a little biographical volume I have on him, that has a foreword by Senatore Marconi himself. Yes, Lindsay was another electrical pioneer whose efforts were sparks before their time, tinder to damp kindling.


James Bowman Lindsay

In 1835 he obtained a sufficiently constant electric light to write a letter to the Dundee Advertiser in October, outlining some of his vision of the impact that would be made by electric lighting, electric power and the electric telegraph. Even 50 years later, electric light and power were comparative novelties. 1835 was before Morse had thought of his code that really made local and international telegraphy a viable reality. Penury and an obsession for compiling his "Pentecontaglossal Dictionary" seem to have diverted Lindsay's attention from developing the light any further. His Dictionary, on which he worked devotedly for well over a quarter of a century, gave synonyms in 50 languages found across the globe. The unfinished manuscript was given to Dundee Free Library sometime after his death in 1862.

In 1845 Lindsay made feasible suggestions that a transatlantic telegraph could be constructed using a single copper wire with 'earth' return path through the ocean, some 10 years before serious thought was given to an intercontinental telegraph cable. Lindsay probably made this suggestion without knowing that yet another Scottish electrical pioneer, Alexander Bain from near Wick, dubbed the "*Genius of the North*", had a similar idea about using the Earth in

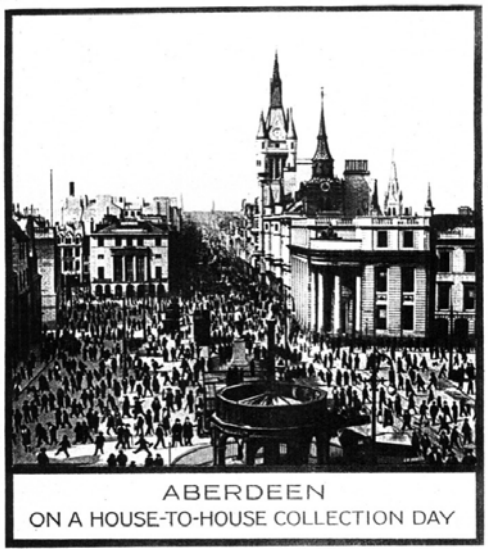
overland telegraphy and was planning to erect a single-wire telegraph between Edinburgh and Glasgow. Bain did so in 1846.

I am reminded of the only two lines I know of the poetic gems of the adopted Dundonian William McGonagall. Writing about the wonders of the telegraph in keeping the outside world informed of the news of the King:

"Along the wire the electric message came,
He was no better, he was much the same."

To return to Lindsay: in succeeding years, Lindsay attempted to develop a wireless telegraphy, using the conductivity of river or sea water to transmit the messages. In 1859 he lectured to the British Association at Aberdeen "*On Telegraphing Without Wires*", which drew commendations from Faraday himself and other leading scientists at the meeting. After the lecture, the audience repaired to the River Dee where they were given a successful demonstration of telegraphy without wires across the river. Although this really was wire-less telegraphy, it was not radio. The world had to wait until the 1890s before Marconi and others demonstrated how electromagnetic waves could be used for communication and James Bowman Lindsay's name slid from public view as developments took their new turn. As far as I know, James Bowman Lindsay hasn't got a crater on the moon named after him.

If you had the patience and I had the time to put them together, there are stories of Scots heroes, sung and unsung, that could keep us here until midnight. I'll temp fate by finishing with another traditional Aberdeen joke about locals and railway journeys to London: Mr Macpherson was a buyer in one of Aberdeen's large drapery stores. He just made the return trip by rail to London. "*And what did you think of the English when you were up in London*" he was asked. "*I didna see ony*", he replied, "*I only met the heids o' Departments*".



This evening was intended to be a look backwards, before we look forward to the new millennium over the weekend. In Scotland we've a great heritage, in science, in engineering, in commerce, and in many walks of life. Our forbears we're perceptive, inventive, industrious and successful. Let's try to keep this up.

JSR