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TWENTIETH–CENTURY SCIENCE IN EDINBURGH: A BRIEF PERSONAL SELECTION

AUBREY MANNING

MADAM CHAIRMAN, LADIES and Gentlemen:

It is a cliché, but a meaningful one, to say that it is an honour to contribute to this volume. I have known about the Old Edinburgh Club for a long time and perused some of its volumes, but I have never become a member. That is indeed a shame but there are just too many organisations to belong to!

I believe mine is bound to be a contribution rather different from the others and that is because of the nature of science itself. Clearly it is possible to discuss some aspects of the social history of Edinburgh as a distinct topic; one can talk about Edinburgh law as something having a particular quality. But science is different. It is not possible to characterise anything as being 'Edinburgh science'. What one can describe is science pursued in Edinburgh and because science is such a vast panoply of human knowledge I cannot possibly claim any expertise but for my tiny bit of it. This is (or perhaps *was* is more accurate now) some aspects of animal behaviour. You may understand then why I am very pleased that your President draws attention to the fact that 2008 also marks the centenary of the publication of Kenneth Grahame's *The Wind in the Willows.* A few years ago the University picked on some old cronies – none of us were less than sixty – and asked them to suggest which one book had been particularly influential to them in their lives. The Library then gathered together some nice copies of the works cited. Introduced by Sandy McCall Smith it made for a nice early evening over a glass of wine. There were some worthy selections of serious literature but I was particularly pleased that my friend Owen Dudley Edwards and I together stepped rather out of line. He chose *1066 and All That*, I chose *The Wind in the Willows*. It is with delight now that I recall the then anonymous reviewer in the *Times Literary Supplement* of 1908 (in fact it was E. V. Lucas, usually an excellent and perceptive critic) who predicted that the book would have little appeal either to young or to adult readers, adding in conclusion that '… as a contribution to natural history the work is negligible'. Well … yes!

As I was thinking about what I might say today I concluded that it could only be based around people and not primarily about their science itself. I cannot talk about the science, except superficially. Only for one or two of these people do I really understand the science, although I usually can understand *in principle* what they have achieved and contributed. It can only be a very personal selection and undoubtedly if other scientists read this piece they will deplore my limited vision. Some very great science has come from Edinburgh in the last century. But the history of science does not easily lend itself to reflection like other sorts of history. The history of literature or the history of art or architecture depends so much on the individual inspiration. One can see some kind of progression, certainly some sets of influences there, but also so many delicious side-turns and idiosyncrasies. What would have happened if Picasso had not lived – would we have had any comparable body of art? Somebody else might have come up with cubist ideas but we would never have had Picasso's unique contribution. But if some great scientist had never lived, we would eventually have had their contribution. In Edinburgh Joseph Black discovered carbon dioxide in 1756 but, if he had not existed, this vital gas would not have remained undiscovered for long, somebody else would have got there. There are temporary losses and false starts, but it is certainly true that scientific advances have a certain kind of inevitability.

I suppose every century has said that the progress has been enormous. But really, if one looks at science in the twentieth century, what can one say? Professor MacQueen describes how that pioneer motor car S1

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was just beginning to move around the Edinburgh streets at the beginning of the twentieth century (see Hector MacQueen, 'Lawyers' Edinburgh', elsewhere in this volume). Now we have visited the moon! As the century began James Clerk Maxwell had recently completed his great unification of electricity and magnetism, his field theories from which so much of modern physics has been developed. Now we have quantum mechanics and the internet. The rate of change has been extraordinary and is accelerating.

My personal selection of Edinburgh's science is bound to be biased towards the biological sciences. But I want to make one general point first. There is now much excellent popular scientific literature and much attention to the public understanding of science. Nevertheless I fear that C. P. Snow's denoting of 'the two cultures' more than fifty years ago is still relevant. It is still the case that an educated person may admit publicly and, if not with pride, at least with little embarrassment, that they know absolutely nothing of mathematics or chemistry, and indeed find them distasteful. Who would dare refer to Shakespeare or Matisse in the same way? I am reminded of Jacob Bronowski who tried in his great television series, *The Ascent of Man,* to break down the barriers between science and the arts. He himself had never accepted them. Arriving in Britain as a boy and speaking no English, he grew up as he says 'to be indifferent to the distinction between literature and science, which in my terms were simply two languages for experience that I learned together'. Bronowski saw science as part of culture and understood that great science involves all the human emotions and is creative in the best sense. As he writes elsewhere: 'Those who say that science is objective, confuse the findings of science, which are, with the practice of science, which is not'. Regarding the last point, we have to recognise that certain sorts of science are promoted above others because they may yield useful results. Acceptable for much of medical science, and Edinburgh has recorded many splendid examples, but less so in other areas of science. None of this reflects on science itself – the findings of science. Thus I find it deeply sad that we hear of a flight from science by young people, who seem to regard it as lacking in humanity, unconcerned with human qualities.

As mentioned, Edinburgh was home to one of the scientific giants of the nineteenth century – James Clerk Maxwell, whose excellent statue now graces George Street. Another great theoretical physicist is currently with us in Edinburgh – Peter Higgs – and we all know that the search is on for the Higgs boson (fig. 1). The immense tube of the Hadron Great Collider will be working again soon. The interesting point is that Higgs's key paper was written over forty years ago at a time when there was no possibility of demonstrating these conjectured particles experimentally. People had been trying various approaches, but the amount of energy needed to generate the necessary collisions is so gigantic that hitherto it was just impossible. Now we can produce enough liquid helium to make use of the superconductivity which it can induce in the coils of huge electro-magnets, thus bringing the amounts of energy required to within possible limits. Sometimes great scientific discoveries must await technical advances and here may be an example. But Higgs generated the concept entirely from his intellect. It may be a crucial element in our understanding of the whole nature of matter and of the universe's existence – an extraordinary achievement. Higgs is a very retiring person but I understand he does have a bottle of champagne somewhere around which will be opened on the appropriate day!

Fig. 1. Peter Higgs.

Higgs's ideas may be said to have their first origins in the work of Ernest Rutherford and J. J. Thomson, who early in the century began – as it were – to dissect the atom. The achievements of another of Edinburgh's scientific giants also evolved from Rutherford's work. It was Rutherford who by his discoveries of radioactivity in rocks first unlocked the way to measuring the age of the Earth. Arthur Holmes was Professor of Geology here during the 1950s. Alas, I never quite overlapped with him. He was a pioneer in some of the great enterprises of twentieth-century earth science. Firstly, the development of a fuller understanding of Earth's history, a true 'Theory of the Earth', to borrow James Hutton's title, which could for the first time explain effectively how our planet 'works.' Now every primary school child learns about continental drift and plate tectonics but until the 1960s these ideas, proposed in particular by Alfred Wegener in the 1920s, were still regarded as heretical, even by many serious and established earth scientists. It is all so modern, but Holmes was an advanced radical in this regard and accepted continental drift long before most of his colleagues. In addition he was assiduous in compiling from diverse sources information relating to the age of the Earth. In practice this involved collecting data from research workers all over the world, which enabled him to put ages to the different successive periods of the familiar geological table. Eventually Holmes could include datings from the very oldest parts of the Earth's crust and also from meteorites, fragments of the cosmic dust from which all the solar system was formed. Holmes's date of 4.567 billion years, plus or minus a few million, is now the standard. It is worth reflecting that at the opening of the twentieth century, the age given by Lord Kelvin – 30 million years – was still commonly cited. Decades before, the idea of such a young Earth had given huge problems to Charles Darwin, who knew that he needed much more time for evolution to have occurred. Holmes was one of those who provided it.

Turning to biology, I choose first one of my predecessors in the chair of Natural History, James Cossar Ewart (fig. 2). He was appointed to follow Wyville Thomson, the great marine biologist and leader of the *Challenger* expedition. Cossar Ewart held the chair through the early years of the century up to the 1920s. In my view he has been a neglected figure; he was important for the progress of Edinburgh biological science, though not perhaps in the most obvious ways. He was often publicly overshadowed by his more obviously powerful colleague, James Ashworth, who must receive credit for raising money for the building in 1929 of our great Lorimer Zoology building at King's Buildings.

Cossar Ewart certainly faced one problem in that he was not a good lecturer – he could not hold an audience's attention and in the 1920s student audiences, particularly first year medical students, were a pretty wild lot. I started lecturing here in the 1950s and I can remember there was quite a lot of hissing and the occasional paper dart, but in Cossar Ewart's time it was far worse. Maurice Yonge, a marvellous zoologist himself, was taught by Cossar Ewart when Zoology was located in the Old College (you may know that the Georgian Gallery in the Talbot Rice Art Gallery was in fact part of our Natural History Museum). Yonge told me that such was the pandemonium in some of Cossar Ewart's lectures that you could only tell that he was still speaking because his luxurious walrus moustache continued to move up and down! So perhaps he was regarded as something of a figure of fun. But as a younger man he made extensive breeding experiments with horses and zebras trying to discover whether telegony existed. Telegony is the idea which is still held by some cat and dog breeders that if you have a pedigree breeding bitch or a queen cat which escapes during her oestrus period and mates with a mongrel her womb or uterus is in some way affected – contaminated they would say – and you can never breed pedigree offspring from her again. Traces of the male's characters will continue to appear. Cossar Ewart was interested in genetics and development and believed this might be the case. He owned land at Penicuik where he bred horses and zebras, using them to test for telegony in what became

Fig. 2. James Cossar Ewart, 1851–1933.

known as the 'Penycuik experiments'. He mated female horses with male zebras and then checked for the appearance of stripes on the subsequent foals of the same mares mating with other horses. He found some traces of stripes but he was too good a scientist not to recognise that this was not unknown with normal matings. A tendency towards striping in foals 'hangs around' as it were in the horse lineage. So he abandoned ideas of telegony and moved on. However it became well known that Cossar Ewart was interested in animal breeding and, for example, he did a lot of work on the improvement of merino sheep going to Australia. He had appointed a lecturer in genetics as early as 1911. As a result when the Ministry of Agriculture or its equivalent at the time, was casting around as to whether the newly emerging subject of genetics might be a valuable thing to pioneer in British universities to help with animal breeding, where should they go? Because Cossar Ewart was on the ground, the Institute of Animal Genetics was founded in Edinburgh and that was a crucial move. It has made a huge difference to Edinburgh science.

Fig. 3. C. H. Waddington, 1905–1975.

Francis Crew was the first Director of the Institute and was himself a very influential figure and a pioneering geneticist, attracting key figures such as J. B. S. Haldane, Julian Huxley and Lancelot Hogben to visit and work here. Crew was stolen away from academia to help government during the Second World War and never returned. The new appointment following the war was C. H. Waddington, universally known as 'Wad' to his huge panoply of students and colleagues (fig. 3). Wad was a brilliant man by any standards and something of a polymath like Bronowski. A major contribution of his research was epigenetics, a term that we owe to him, by which is meant the way in which the genes express themselves during development. He likened the developing organism to a ball rolling over a landscape of hills and valleys. As it does so it comes to choice points and sometimes it will have an inherent bias to go down one route or the other, but other times pushes from the environment may push it down one track or another. It may go down here: it may take a detour there. The further down the epigenetic landscape it goes, the deeper are the valleys and therefore the more difficult it is to change path. This model is a very useful one to illustrate the way in which we develop, the influence of our genetics and our environment, our social environment as well as our physical environment. The epigenetic landscape idea has been much applied in my own field of animal behaviour, for example.

Wad's influence here in Edinburgh was very important and it illustrates the way that science often progresses – a brilliant person attracts other brilliant people around, and I could give you a great list of names. Cell biology, genetics and development were all expanding rapidly and Edinburgh was seen as a major centre. The chair of Natural History was vacant and with Wad already here the University appointed a young cell biologist whom Wad knew from Cambridge, Michael Swann. Swann in turn brought up his colleague, Murdoch Mitchison. Swann and Mitchison developed cell biology in the Zoology department, which complemented the new developments in genetics and this burgeoning of the new biology in Edinburgh resulted in two Nobel Prizes. The first, for chemistry, was awarded to Peter Mitchell in 1978 and he was subsequently awarded the Royal Society of London's highest honour, the Copley Medal, in 1981 (fig. 4). Mitchell had worked in the Cambridge Biochemistry labs and was lured up here because of Wad, Swann and Mitchison, to start a School of Chemical Biology, housed in the

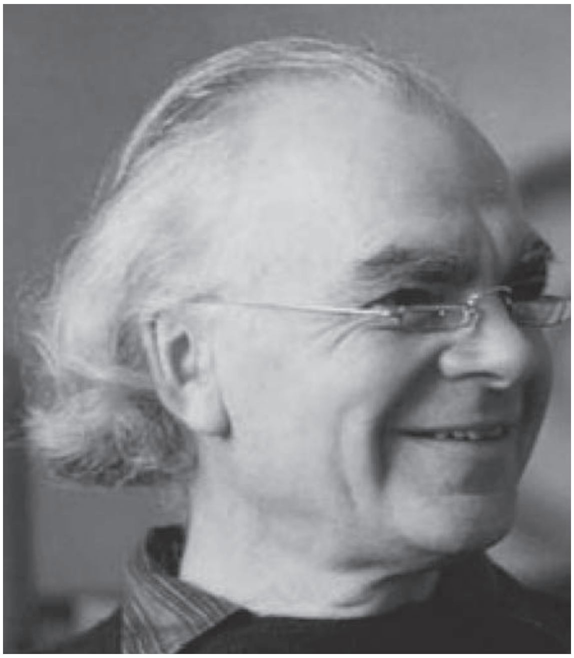

Fig. 4. Peter Mitchell, 1920–1992.

Zoology department, where he worked on one of the most basic aspects of metabolic biochemistry – how energy moves through cells. Mitchell was another polymath. He was a fine pianist, and also a brilliant person with his hands. I remember him sitting at an old foot-operated bellows in his basement lab operating a blow-lamp making his own complicated glassware for certain of his experiments – little vessels which had complex side branches and so on. How many biochemists are making their own glassware today, I wonder? Mitchell was a lover and great collector of glass as well. The theory of energy transfer which began its development here – the chemiosmotic theory – was both radical and heretical at the time and he had considerable trouble convincing other scientists. Eventually more and more evidence began to accumulate but still a few people held out and thought that he was completely wrong. There is a wonderful bit of film of him produced for the archives of the Biochemical Society. He is talking to his long-time colleague and collaborator, Jennifer Moyle, who worked with him here and subsequently at the private laboratory he developed at Glynn in Cornwall. They describe how one of the last conservatives, if I can call them that, came to visit this laboratory in Cornwall. This biochemist did some experiments with them and at last when she left agreed that the chemiosmotic theory must be correct. Then Jennifer says to Peter on the film: 'But then she went back to London, didn't she, and did some other experiments in which she stuck to the old ideas?' 'Yes,' says Peter, 'but it's not very surprising – scientists aren't the most rational people, are they?' We should remember that.

The second Nobel Prize which had its origins in Edinburgh was awarded to Paul Nurse in 2001 for his work on the genetic control of cell division (this was the prize for Medicine, for biologists have no Nobel Prize of their own). Nurse worked for his PhD under Murdoch Mitchison, who got a group working on the control of division in a single-celled yeast, which, being a eukaryote, i.e. an organism whose cells are organised in the same way as ours, was therefore more likely to be relevant for investigation of the same processes in higher animals and plants. Mitchison's group was able to study in great detail the processes of cell growth and division under standard conditions and what were the controlling factors. On leaving Edinburgh, Nurse was soon heading up the Cancer Research Foundation's research programme and his work was soon recognised internationally.

Edinburgh, under the influence of Wad and Swann particularly, was a pioneer in the teaching of molecular biology. This new field grew out of the elucidation of the structure of DNA and the genetic code by Watson and Crick in 1953. From thenceforth some extraordinary new approaches to genetics, cell biology and development suddenly became possible. To me as a complete outsider to this branch of biology it is amazing that you can extract DNA intact very simply from cells. It is not a fragile substance, you can keep it in a test tube and handle it, easily retaining its integrity. You can extract DNA from the tooth pulp of a Neanderthal skull from 60,000 years ago. It is a bit broken up but it is still there and you can see some structure to it.

Swann and Waddington recognised the importance of molecular biology in the 1960s for research and as a subject to be taught to undergraduates. Thus the first department of Molecular Biology in a teaching university was set up here with Martin Pollock as the first holder of a new chair (fig. 5). Pollock came from the Medical

Fig. 5. Martin Pollock, 1914–1999.

Research Council's labs at Mill Hill and had worked there and in Paris on the genetic control of drug resistance in bacteria. He and his budding department moved into a new tower on the King's Buildings site. Now, as you may know, King's Buildings is often called an academic industrial estate and architecturally this title fits very well! Not all is of the greatest aesthetic merit and the new tower is evidence. However it was functional inside and Pollock's lab was opened by Jacques Monod, one of the great French molecular biologists who got the Nobel Prize for elucidating the control of gene expression in cells. I remember him coming to the opening and hearing Pollock's inaugural lecture in which he described certain problems which arose getting mail directed to the new department. Molecular Biology was not a name commonly recognised and the Post Office had to struggle with some rather unusual addresses on the mail. Pollock listed some attempts in his lecture, the Department of Memorable Biology, the Department of Molar Biology, but perhaps the best of all resulted from the fact that his department was located in the upper stories of the tower whose lower stories housed the Department of Natural Resources, concerned with ecology and the management of land. One memorable envelope was addressed to the Department of Supernatural Resources! Martin Pollock was a very influential person and I just want to quote you a comment he made in an autobiographical essay: 'I don't think anyone who has not experienced the tremendous feeling of awe and wonder that accompanies the sensation of having solved a problem that was formerly inexplicable can understand the joy of accomplishment so fulfilled'. This reinforces my earlier citing of Bronowski – that science is a human activity. It is creative, it is not simply cold, hard fact. Of course it contains cold hard fact, but that is not the way that we as scientists pursue our science or how we feel at the good times or, I hasten to add, the bad ones.

Now, molecular biology is perhaps the most reductionist of all the branches of biology, but at the opposite end I must mention a biologist who worked mostly in Scotland and taught here in Edinburgh, Frank Fraser Darling (fig. 6). He was one of the pioneers in the study of wild animals in the field, relating their behaviour to their ecology and to the flow of energy through the environment in which they lived. His now classic study, *A Herd of Red Deer*, of 1937, has recently been republished by Luath Press in Edinburgh. In his Reith Lectures *Wilderness and Plenty* of 1969 he introduced the term 'human ecology'. I have no time to go into his achievements but I will simply say that for all the power and control which reductionist science gives us, if our species is to continue, if you are to have that 200th anniversary which Professor MacQueen drew attention to in his talk, we are going to have to think holistically about our human position here and get into better balance with the planet that supports us. Fraser Darling was a pioneer and I salute him. Waddington certainly did recognise the implications

Fig. 6. Frank Fraser Darling, 1903–1979.

of his work and in his later years here founded 'The School of the Man-made Future' which addressed many of these issues – basically population, resources, environment – in a radical teaching course. The University's Centre for Human Ecology was a successor after Waddington's death but although my colleague Ulrich Loening managed to get an MSc course running here for several years it never received adequate backing. Too many reductionist scientists in the University completely failed to understand the issues and equated a holistic approach with a soft approach. I do assure you that to establish a real human ecology will require all the good hard science and accompanying technology that we can get!

Finally, in closing, I wish to shift emphasis completely. Certainly one of Edinburgh's most remarkable scientists in the last decades was Donald Michie (fig. 7). He worked here for a number of years, a man of great brilliance but one who I think was disappointed and thwarted in Edinburgh – which was partly his own fault. Like many brilliant people, as mentioned earlier, he attracted other brilliant people around him. There was then a period of productive fusion but then the same interacting brilliance began to initiate fission. Michie was an attractive person to come to work with, but possibly not an easy person to work with. At a time when computers were in their absolute infancy, he was one of the pioneers of artificial intelligence. During the Second World War he had worked at Bletchley Park with Alan Turing, probably one of the most transparent intellects in that field of science that had lived up to that time. (Turing and his group solved the Enigma codes of the German military, one of the key contributions to the allied victory. In 1955 he killed himself because he was involved in the aftermath of legal proceedings concerning what was known in those days as 'acts of gross indecency'. Thus the guardians of our society rewarded him for his efforts.) Donald Michie never forgave them and much later he founded the Turing Institute in Glasgow in his memory. Michie was one of the first to see the power and the importance of constructing machines that could learn and that you could communicate and interact with. Two of the people who came to work with him, Rod Birstall and Robin Poppleston, devised the first user-friendly computer language. I see here the foundations of what has now become Microsoft, so much began here in Edinburgh in a few small old buildings just off the Meadows, but it didn't last.

Fig. 7. Anne McLaren and Donald Michie.

Michie first came to Edinburgh as a mammalian geneticist to work on the genetics of the immune system with Michael Woodruff, a pioneer of kidney transplantation at the Western General Hospital. But the questions about machine intelligence which he had discussed with Turing at Bletchley Park began to occupy all his time. Lacking even the simplest of computers he constructed a machine of matchboxes and glass beads which, using the simplest of machine rules, could 'learn' to play noughts and crosses. Soon Stanford University, which did have a large, powerful computer, asked Michie to programme it for them along the same lines.

To their credit both Edward Appleton, then Principal of the University, and Michael Swann, his successor, supported Michie in what he was trying to do, but in the 1970s there was a grave shortage of money and the University Grants Committee was looking for cuts. They knew of artificial intelligence and computerised learning and so on. On their behalf it was examined by a luminary, Sir James Lighthill, who was the Lucasian Professor of Mathematics at Cambridge. (That, in the mathematical world, I understand, means that you are the highest 'heid yin' of the lot. It is the chair now held by Stephen Hawking.) Lighthill came up with a report which, in retrospect, looks incredibly short-sighted, and suggested that there really was not too much future in this – the Japanese were doing quite well on robotics and it was better for British universities to concentrate on something else. Funding was removed, and we lost Donald Michie, although he remained an active and influential figure in the world of robotics and artificial intelligence. If Lighthill had had more vision and if there had been feed money, perhaps Microsoft (under another title) would be based in Edinburgh and all that has flowed from it might have enriched Scotland. Hindsight is of course always 20:20 vision, but speculation is free!

It is impossible to conclude without mentioning another great Edinburgh scientist who was strongly linked with Donald Michie, Anne McLaren, who met him at Oxford when they were both DPhil students working on mouse genetics. They married and lived together in Edinburgh for several years before an amicable separation. McLaren was responsible for much of the original work on the physiology of ovulation, implantation and early embryology of mice. Knowledge of these common mammalian features has become the basis of many modern developments in artificial fertilisation and stem cell research. McLaren was elected to the Royal Society and served on many of the regulatory committees concerned with human fertility. To those of us who knew them it was a huge shock to learn that Donald Michie and Anne McLaren died on the same day in 2007. They were together in a car accident driving from Cambridge to London.

Anne has been the only woman on my selection of scientists – there could certainly have been others and I am happy to say that, at least in biology, women make up over half of new academic appointments here. They will soon catch up! The scientific landscape is changing and for the better and this is a good note on which to end. I need myself to salute change firmly and explicitly here because I confess that otherwise I am much given to nostalgia for the old things. I felt this sweep over me listening to the talks this morning and seeing wonderful images of old Edinburgh, in particular one photograph of the lawyer's office doorway with its old brass plate – now gone. I was reminded that in one of my most curmudgeonly moments, an old architect friend and I were complaining of such things and he remarked: 'All change is bad, and change for the better is worst'.