PRESENTATION OF PROFESSOR BENOIT MANDELBROT FOR THE HONORARY DEGREE OF DOCTOR OF SCIENCE BY DR PETER CLARK, SCHOOL OF PHILOSOPHICAL AND ANTHROPOLOGICAL STUDIES.

CHANCELLOR, I have the honour to present for the degree of Doctor of Science Honoris Causa, Benoit Mandelbrot : mathematician, scientist and educator.

Chancellor at the close of a century where the notion of human progress intellectual, political and moral is seen perhaps to be at best ambiguous and equivocal there is one area of human activity at least where the idea of, and achievement of, real progress is unambiguous and pellucidly clear. That is mathematics. In 1900 in a famous address to the International Congress of mathematicians in Paris David Hilbert some listed 25 open problems of outstanding significance. Many of those problems have been definitively solved, or shown to be insoluble, culminating as we all know most recently in the mid-nineties with the discovery of the proof of Fermat's last theorem. The first of Hilbert's problems concerned a thicket of issues about the nature of the continuum or the real line, a major concern of 19th and indeed of 20th century analysis. The problem was both one of geometry concerning the nature of the line thought of as built up of points and of arithmetic thought as the theory of the real numbers. The integration of those two fields was one of the great achievements of 19th century mathematics.

Now lurking about so to speak in the undergrowth of that achievement lay certain very extraordinary geometric objects indeed. To all at the time, they seemed strange, indeed rather pathological monsters. Odd indeed they were, there were curves -one dimensional lines in effect - which filled two dimensional spaces , there were curves which were smooth, that is nice and continuous but which had no slope at any point (Not just some points, ANY points) and they went by strange names, the Peano Space filling curve, the Sierpinski gasket, the Koch curve, the Julia set. Despite their pathological qualities, their extraordinary complexity, especially when viewed in greater and greater detail, they were often very simple to describe in the sense that the rules which generated them were absurdly simple to state. So odd were these objects that mathematicians set about barring these monsters and they were set aside as too strange to be of interest. That is until our honorary graduand created out of them an entirely new science, the theory of fractal geometry: it was his insight and vision which saw in those objects and the many new ones he discovered, some of which now bear his name not mathematical curiosities, but signposts to a new mathematical universe, a new geometry with as much system and generality as that of Euclid and a new physical science.

Benoit Mandeibrot was born in Warsaw, Poland in 1924, the son of a very scholarly family. His father, nevertheless made his living the hard way by making and selling clothing and his mother was a doctor. As a young man he fell under the influence of his two uncles one of whom became his tutor and the second of whom became a Professor at the College De France in Paris as a colleague of Henri-Leon Lebesgue, the founder of measure theory and as successor to the great analyst Jacques Salmon Hadamard. In 1936 the family moved to Paris and when war broke out to Tulle in central France. The war, the constant threat of poverty and the need to survive kept him away from school and college and despite what he recognises as " marvellous" secondary school teachers he was largely self taught. Eventually in 1944 he scored very highly in entrance exams to the prestigious Ecole Polytechnique and thereby gained access Paul Levy who was to have a considerable on his work. After two short visits to the United States to Caltech and to The Institute of Advanced Studies in Princeton where he was the last visitor sponsored by the great Hungarian mathematician John Von Neumann he returned to France in 1955 and there married his wife of 44 years standing, Ailette Kagan. Still deeply concerned with the more exotic forms of statistical mechanics and mathematical linguistics and full of non standard creative ideas he found the huge dominance of the French foundational school of Bourbaki not to his scientific tastes and in 1958 he left for the United States permanently and began his long standing and most fruitful collaboration with IBM as a Research Fellow and Research Professor at their world renowned laboratories in Yorktown Heights in New York State.

I should not Chancellor give the impression that we have here before us a mathematician alone. Let me explain why. The first of his great insights was the discovery that the extraordinarily complex almost pathological structures, which had been long ignored, exhibited certain universal characteristics requiring a new theory of dimension to treat them adequately which he had generalised from earlier work of Hausdoiff and Besicovitch but the second great insight was that the fractal property so discovered, the general theory of which he had provided, was present almost universally in Nature. What he saw was that the overwhelming smoothness paradigm with which mathematical physics had attempted to describe Nature was radically flawed and incomplete. Fractals and pre-fractals once noticed were everywhere. They occur in physics in the description of the extraordinarily complex behaviour of some simple physical systems like the forced pendulum and in the hugely complex behaviour of turbulence and phase transition. They occur as the foundations of what is now known as chaotic systems. They occur in economics with the behaviour of prices and as Poincaré had suspected but never proved in the behaviour of the Bourse or our own Stock exchange in London. They occur in physiology in the growth of mammalian cells. Believe it or not Chancellor they occur in gardens. Note closely and you will see a difference between the flower heads of broccoli and cauliflower, a difference which can be exactly characterised in fractal theory. It is small wonder then that our graduand has been a professor of engineering (Yale), of mathematics (Ecole Polytechnique), of economics (Harvard) and of physiology (Einstein College of Medicine). It is no wonder that a creative mathematician of this calibre, with some eight books and nearly

200 scientific papers to his credit should be awarded many international honours including the very prestigious Wolf for physics in 1993. Chancellor, I have had the great honour of speaking about the work and achievement of a very great mathematician who was not overawed by tradition or authority, I was then amused to find an allusion to the great analytic tradition and to our own institution in a remark of his. Alluding to the work of our own fractal geometer Ken Falconer he says "Falconer's 'Geometry of Fractal Sets' is very welcome, but it is a conventional monograph and the style is dry as usual. It will not be the last monograph on these and related topics". Indeed Professor Mandelbrot was entirely right, Kenneth wrote another!

Chancellor I take the greatest pleasure in inviting you to confer in name of the President and members of the Senate of the University of St Andrews the degree of Doctor of Science, Honoris Causa, on a great mathematician of a great mathematical age.