

Noreen Elizabeth Murray, (née Parker)
CBE, FRS, FRSE



image supplied by Jean Beggs

Noreen Murray was recognised internationally as being one of Britain's most distinguished and highly respected molecular geneticists.

In the early 1970s, together with her husband Ken and colleague Bill Brammar, she led the development of recombinant DNA technology, or genetic engineering, as it is commonly called. This was a seismic event, ultimately affecting all areas of biology and making possible much of modern biotechnology. Their pioneering work put the UK at the head of this revolution in research, and the technology and tools that they developed have had lasting impact.

Noreen was born Noreen Elizabeth Parker in Read, near Burnley in Lancashire. She enjoyed a rural upbringing, initially in the village of Read and, from the age of five, in Bolton-le-Sands, on the edge of Morecombe Bay, where her father, John Parker, was headmaster of the local school. The family spent much of their time outdoors, playing tennis, cycling, swimming or rowing on Lake Windermere or on the canal at the bottom of their garden. Their home in Read was close to the cricket ground, and Noreen particularly remembered watching Learie Constantine, the much-admired West Indian cricketer. Noreen said that as a child she was a little tomboy, and she loved climbing trees. She also liked to help her father with gardening, and she had her own section of their garden, which was the beginning of a life-long love of plants. Her father was a strong disciplinarian and she and her older brother had a strict but loving upbringing. He was particularly concerned about punctuality and, as a result, Noreen said she always tried to be on time.

Noreen's brother, Neil, also had a strong influence on her. He was a keen naturalist (he later studied forestry at Edinburgh University) and he encouraged Noreen to collect pressed flowers and birds' feathers. In her 5th form at school, Noreen studied physics and chemistry, biology not being an option available to her at that stage. However, her brother introduced her to the subject, teaching her Mendel's Laws and encouraging her to read biology books. Thus, at the age of 15, Noreen changed from thinking of becoming a domestic science teacher to studying biology.

Noreen won a number of prizes at school and in 1953 was awarded London Intercollegiate and State Scholarships to enter King's College, London, to study botany. She developed an interest in microbial genetics and after graduation moved to the University of Birmingham to work for a PhD under the supervision of David Catcheside, Head of the new Department of Microbiology.

Noreen was very interested in the nature of the gene and whether genes concerned with a particular biochemical pathway were closely linked in eukaryotes, as had been found for some pathways in bacteria. Catcheside used the bread mould *Neurospora crassa* as an experimental organism and Noreen decided to investigate the chromosomal distribution of genes needed for synthesis of the amino acid methionine. This required isolation and genetic mapping of mutants that could not grow without methionine, leading to an interest in the mechanism of recombination, the process that ensures that new combinations of genetic variants are transmitted from one generation to the next. Noreen discovered that recombination does not occur uniformly along chromosomes, but occurs more frequently at hotspots from which it proceeds preferentially in one direction.

Noreen occasionally recalled with amusement that, when she first arrived with her luggage at the large house where she was to stay in Birmingham, she was mistaken for a maid going into service. In Birmingham she met her future husband, Kenneth Murray, who was studying for a PhD in chemistry. In addition to their shared passion for laboratory work, they enjoyed hill walking, camping and climbing, especially in the Scottish Highlands. They married in 1958 and were later to become close scientific collaborators.

After completing their PhDs, Noreen and Ken took up postdoctoral positions at Stanford University. Noreen continued her studies of *Neurospora* during five happy years in David Perkins' laboratory, describing her time there as being outstanding. She found the environment at Stanford intellectually stimulating, meeting many leading microbial geneticists. It was during this time that she first met Frank Stahl, who was interested in her studies of polarised gene conversion and who later collaborated with Noreen during sabbatical visits to the UK.

In 1964, she and Ken returned to the UK, Noreen to work with Harold Whitehouse in the Botany School, Cambridge, and Ken to the MRC Laboratory of Molecular Biology. Noreen was shocked that her degrees were not recognised by Cambridge University. It seemed that she was expected to work for a Cambridge PhD and, during her 6th year as a postdoctoral researcher, she appeared on the photograph of the Cambridge PhD students.

In 1968, Noreen took up a position in Bill Hayes' MRC Unit of Molecular Genetics in the University of Edinburgh, and Ken became a Senior Lecturer in the Department of Molecular Biology. Noreen decided to turn her research to systems that were more accessible to molecular studies. She had become interested in the phenomenon of host-controlled restriction (the ability of bacterial cells to "restrict" foreign DNA) and decided to study this phenomenon in *Escherichia coli*, using bacteriophage lambda and her knowledge of bacteriophage genetics learned from Frank Stahl. Ken, at the end of his time in Fred Sanger's laboratory, had begun to determine short DNA sequences at the ends of the lambda genome, and they became excited by the prospect of combining their genetic and molecular skills to identify the DNA sequences that are cleaved by DNA restriction enzymes within the phage lambda genome.

Noreen and Ken were among the first to realise that the ability to cut DNA with restriction enzymes opened up the possibility of joining together different DNA molecules that had been cut in this way, to produce recombinant DNA molecules, and thereby to clone DNA sequences. Noreen used elegant genetic approaches to modify the chromosome of phage lambda, reducing the number of restriction enzyme cleavage sites, so that it could be used as a DNA cloning vector. Noreen, Ken and their close colleague, Bill Brammar, used these modified bacteriophage to clone defined fragments of DNA from a variety of organisms.

Over the next ten years, Noreen developed a series of increasingly sophisticated lambda vectors, in Edinburgh and at the European Molecular Biology Laboratory in Heidelberg, where she and Ken worked from 1980 to 1982. These were rapidly adopted by researchers throughout the world and are still widely used today. She also realised at an early stage that the protein products of cloned genes could be expressed in bacterial host cells, and her clever use of the quiescent, lysogenic state of phage lambda allowed the expression of proteins that may be toxic to the bacterium. This facilitated the high level production of proteins in bacteria, including enzymes such as T4 DNA ligase, polynucleotide kinase and *E. coli* DNA polymerase that were of major importance for the new recombinant DNA technology.

The practical aspects of Noreen's work were always supported by scholarly exploration of the biochemical and genetic properties of the systems used, and it is notable that many of her publications have only one or a few authors, because she was generally the main instigator and often the sole technical contributor to the work. In the collaborative work with her husband, Noreen's contributions were clearly identifiable; she being the geneticist, he the biochemist.

Noreen was generous with her time, both with her colleagues and by serving on many committees, including the Executive Advisory Board of the Scottish Higher Education Funding Council, the

BBSRC Council, the Council of the Royal Society, the Cabinet Office Science & Technology Honours Committee, as Vice-President of the Royal Society and President of the Genetical Society of Great Britain. She was also a Trustee of the Darwin Trust of Edinburgh, a charitable organisation founded by Ken and Noreen to support research in the natural sciences.

In 1988, Noreen was promoted to a Personal Chair at Edinburgh University, as Professor of Molecular Genetics. Her many contributions to science have been honoured by Fellowships of the Royal Societies of Edinburgh and London, Membership of the European Molecular Biology Organisation and Honorary DScs from the Universities of Birmingham, UMIST, Warwick, Lancaster, Sheffield and Edinburgh. She was awarded the Gabor Medal of the Royal Society, the AstraZeneca Award of the Biochemical Society, the Nexxus award (jointly with Ken) and, in 2011, she received a Royal Medal from the Royal Society of Edinburgh. She was awarded a CBE for services to science in 2002. Despite her eminence as a scientist, Noreen was always very unassuming and quietly spoken. She was also strong minded and very determined.

Noreen's achievements came at a time when it was not always easy for women to make a career in science and it is a measure of her ability, hard work and determination that she reached the very top of her profession, despite occasionally contending with the unconscious prejudice of the scientific establishment. Perhaps because of this, Noreen was particularly attentive to the careers of her female colleagues and delighted in their success. Although she had no children, Noreen thought of her students and postdocs as her family and she earned their admiration and affection.

Noreen loved to work at the bench and continued to do so long after her formal retirement in 2001. She was an exceptional mentor to those who worked with or around her, whether an undergraduate, postgraduate student, technician, postdoctoral research assistant, sabbatical visitor or academic colleague. She was inspirational both by example and through her lectures, which were delivered with clarity and confidence despite her finding public speaking stressful. She was extraordinarily hard-working, and held very high standards not only in her work but also in her personal life. Noreen took pleasure in gardening, fine art and the company of others. The garden at their house in Edinburgh was her favourite place to escape to and it always looked magnificent. Noreen also took a pride in her appearance and dressed elegantly and stylishly. She and Ken were exceptionally hospitable to friends and colleagues, entertaining them at home, where Noreen was an excellent cook, or at the Edinburgh New Club. An invitation to dine was a real treat.

In 2010 Noreen was diagnosed with a form of motor neurone disease. She confronted this affliction with courage and dignity, more concerned for the welfare of those around her than for herself. By the beginning of 2011 she could no longer speak, but she continued to come into her office to deal with correspondence and to converse with colleagues via notes. At the beginning of May she entered the Marie Curie Hospice in Edinburgh, where she died with Ken at her side. Noreen will be remembered with huge affection and admiration by so many, and she will be greatly missed. She is survived by her husband, Professor Sir Kenneth Murray, and her brother, John Neil Parker, who lives in Australia.

Jean Beggs and David Finnegan

Noreen Elizabeth Murray (née Parker), CBE, FRS, BSc (King's College London), PhD (Birmingham); Born 26 February 1935; Elected FRSE 1 March 1989; Died 12 May 2011.