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Irene Manton: A Biography (1904 – 1988)

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Introduction

Irene Manton was President of the Linnean Society from 1973–1976, during which time I was her Zoological Secretary. In November 1973 we compiled the first of a series of Newsletters to our Fellows which eventually gave rise, in January 1984, to *The Linnean*.

I have many cherished memories from this period, including the fact that Irene always called me BG. I also remember her almost slipping off the Presidential, crocodile skin covered throne and Mrs Holtham embroidering a special cushion to avoid future embarrassing moments.

In March 1973 we founded a hobbies group which later developed into "the Archaeological hobbies group". This allowed Irene to indulge her special passion for ancient works of art with short lectures to us on such diverse subjects as Luristan bronzes and inscribed bricks from the Nebuchanezzar II period, always illustrating these talks with material from her own collections. The culmination of the hobbies group was that, together with a colleague from the Antiquaries, we organised a short symposium on "The Bestiaries and Animals in Art".

During 1974, 1975 and 1976 we arranged field trips/excursions to such places as Bookham Common (with Dr Thorley's help) and Box Hill, where Irene identified the plants and I endeavoured to identify the insects. In March 1975, with my local knowledge, I assisted Irene in the arrangement of a field trip to Westonbirt Arboretum and then, a little later, with an evening meeting on "The Fish Fauna of the River Severn" in which the main fish referred to was the "Food of Kings" – the Lamprey.*

In September 1974 Irene presided over a symposium on "The Biology of Bracken" arranged by the Botanical Secretary, Frank Perring. She later told me how much she had enjoyed the meeting, adding that it was almost as interesting as "The Contribution of Plants to Medicine" (held in March 1976).

In conclusion, I can only add how much I admired Irene Manton and her determination to bring to the Society a fresh outlook, especially through reaching out to the Fellows and informing them of future events.

2004 marks the Centenary of Irene's birth and because of her commitment to women's emancipation, and the fact that it is also 100 years since women were first admitted to The Linnean Society of London, we have included a short postscript to this biography entitled "100 years ago – The Admission of Ladies".

BRIAN GARDINER
Editor of *The Linnean*

*See *The Linnean* 17(4) October 2001:21.

A pen and ink portrait of Irene Manton drawn for her eightieth birthday by Barry Herbert. Reproduced with permission of the artist.

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Foreword

Professor Irene Manton FRS, P-PLS, FRMS, BA, PhD, ScD. Hon. DSc, to cite her name and some of her more important awards, became a legend in her life-time. Even by modest standards it can be said that she had three lives. One life was centred on her fern studies, one on algal ultrastructure and one as a collector of oriental and modern art. It could be argued that she had several other lives as well, for she was a violinist of considerable accomplishment, head of a botany department, an inspiring teacher and an inveterate traveller in connection with her research. As a woman she set several records including being the first female professor and first female head of a department at Leeds University. She was the first (and so far only) woman president of The Linnean Society of London. Also she and her sister Sidnie are the only sisters to date to be elected Fellows of the Royal Society. Yet her life was not without its troubles, her mother suffered from a long debilitating illness and the death of both her parents in December 1945 marked the beginning of a period of estrangement between Irene and her sister that lasted for the rest of their lives.

Although Irene wrote more that 170 scientific papers, one book and many general articles, at no time did she attempt a summary of her life's work. Thus when she died she left a large but scattered literature. Her obituaries sung her praises and acknowledged the importance of her work, but there were no detailed assessments of her achievements.

When in January 2003 I was invited by Professor Michael Melkonian, Editor of *Protist*, a protistological journal, to write an article about Irene Manton for the 'From The Archives' series, I realised that 2004 was the centenary of her birth. This caused me to reflect on the possibility of compiling a more in-depth biography about Irene. It was with some trepidation that I approached the task since I am a protistologist and, apart from possessing a tree-fern in my garden, I had little knowledge of the pteridophytes. However, I felt that the opportunity of celebrating her centenary in this way should not be missed.

I first saw Irene in 1965 when I had just completed my first year as a postgraduate student studying dinoflagellate ultrastructure at Birkbeck College, London. I noticed that she was giving a paper in a session at a meeting at University College, London. The session comprised a medley of subjects, the paper before Irene's being about spiders and their webs. When the time came for Irene to give her talk, the chairman asked someone in the front row if she had arrived, whereupon, much to everybody's surprise, she appeared high up at the back of the lecture theatre. She strode down to the front and took the meeting by storm showing some of her most memorable micrographs of the haptonema and scales in Golgi cisternae. The next time I saw her was in 1967 when she invited me to take up a Fellowship at Leeds University and we met for dinner in a London restaurant. In those two

meetings I experienced the ‘Manton magic’ at first hand. Subsequently I collaborated with her until her death in 1988.

Irene was a ‘woman of her time’. Her life (1904–1988) spanned the better part of the twentieth century. This period was momentous for many reasons. Firstly, there was a major change in the role of women within the professions in general, and science in particular. Secondly, with the advent of electron microscopy, a completely new subject was born and Irene was present at its birth. Thirdly, science was in the process of changing from being a discipline pursued by individuals to becoming an industry. Irene was one of a select group of women pioneers who made their way in what had hitherto been a man’s world.

In compiling this biography, I have not changed my opinion that Irene Manton was an exceptional woman but I have been surprised at the breadth of her intellect and the depth of her humanity. No period of her life is without interest and I hope that the story that follows will give insights into her as a person, into the work that she carried out, and into how and why she managed to make the transition from being a ‘classical’ fern cytologist to being a world leader in a new and technically-sophisticated branch of biology.

BARRY LEADBEATER
Birmingham, August 2004

Acknowledgements

In compiling this biography I have referred to many archives and wish to acknowledge with gratitude the following: The Local Studies Department of the Kensington Central Library (Mrs Isabel Hernandez); Ibstock School (Roehampton) Archive (Mrs Diana Elderton, librarian and archivist), which contains the remaining archive of Colet Gardens Demonstration School; St Paul’s Girls’ School Archive (Dr Howard Bailes, archivist) and the relevant issues of *Paulina*; the Syndics of Cambridge University Library (Ms Jacqueline Cox); Girton College Archive (Dr Kate Perry, archivist); the archives of Manchester (Dr James Peters) and Leeds Universities (Ms Hannah Westall and Dr Chris Sheppard); the archive of the Linnean Society of London (Ms Gina Douglas, Librarian and Archivist); the archive of the Royal Microscopical Society (Ms Judith Lewis). Without exception, I was given full access to documentation. I wish to acknowledge the patience and generosity of the archivists who answered my various questions. Permission has been obtained from the respective archives for direct quotations in the text.

During the preparation of this biography I had discussions or correspondence with many friends and colleagues including: Professor Anne Ashford, Dr Gordon Beakes, Dr Hilary Belcher, Dr Gill Butler, the late Dr Tony Chamberlain, Dr Alison Craft, Professor Elizabeth Cutler, Professor Brian Gardiner, Mrs Mary Gavagan, Dr Mary Gibby, Dr John and Mrs Jane Green, Mrs Kathleen Greenwood, Dr Gareth Jones, Mr Tony Leadbeater, Professor Gordon Leedale, Dr Hilda Canter Lund, Professor Margaret McCully, Dr Erica Swale, Professor Keith Vickerman FRS and Dr Bridget Wallace.

In addition, a number of colleagues and friends allowed me to record in-depth interviews and also provided hospitality, which I acknowledge with gratitude. These interviews have allowed me to obtain first-hand reminiscences dating back to 1929 when Lady Dainton, then as Barbara Wright, was 12 years of age. Dr John Lund FRS, an undergraduate at Manchester University from 1931–35, now 92 years old, kindly discussed his memories of Professors Weiss and Lang and Irene as a lecturer. I also recorded conversations with Mr Adrian Hollowell, a student at Manchester between 1937 and 1940; Mr Bryan Clarke a technical assistant at Manchester and Leeds for the period 1942–1959; Dr Ken and Mrs Margaret Oates at Leeds and Lancaster between 1954–1993; Drs Trevor and Molly Walker, postgraduates and staff at Leeds for the period 1948–1959; Professor David Cutler an undergraduate at Leeds (1957–61); Dr Tony Braithwaite a 'fern' postgraduate student at Leeds (1961–1965); Professor Len Evans, Lecturer and Reader at Leeds University (1966–1991) and one of the executor's of Irene's will; Mr Barry Herbert (previous Head of the Fine Art Department, Leeds University) and his wife Janet; Dr Bill Williams (previous Director of Combined Studies, Leeds University); Dr Peter Evennett (formerly of the Zoology Department, Leeds University and Honorary Archivist of the Royal Microscopical Society); Dr Joan Sutherland (Dundee University) who accompanied Irene on four of her collecting trips, including those to the Arctic and The Galapagos Islands.

I am grateful to Dr Alan Charlton for exchanges of correspondence regarding the Botany Department of Manchester University and for spending a day showing me around the original buildings of the University. I also wish to express my thanks to Ms Charlotta Nygård who provided me with valuable information regarding Stockholm and past botanists in Sweden. She also carried out translations, identified locations and provided me with background information about various Swedish customs. Dr Gill Butler, Dr Alan Charlton, Mr Bryan Clarke, Mrs Mary Gavagan, Ms Lauren Humphries, Ms Charlotta Nygård and Dr Ken Oates read selected draft chapters and made valuable suggestions. Dr Trevor Walker and Dr Bridget Wallace kindly read the entire script and offered many helpful comments. Furthermore Trevor checked the authenticity of the sections dealing with the pteridophytes. I acknowledge with thanks the editorial assistance given by Mrs Mary Morris.

I am especially grateful to Mrs Elizabeth Clifford (daughter of Sidnie Manton and Irene's niece) who offered me unrestricted access to the Family Archive. During the course of preparation of this biography I visited Elizabeth in Sussex three times and she offered me unsparing hospitality. We discussed at length many aspects of Irene's life and career. She also read the entire script and made many helpful suggestions. Without this assistance and her permission to use the extracts from the Family Archive, a complete biography would have been impossible.

I wish to thank my wife, family and friends and colleagues who have assisted in many ways. Finally, I must accept full responsibility for any errors of fact or interpretation.

Nomenclature

According to her birth certificate issued on October 7th 1904, George and Milana Manton named their second daughter Irène. The French version of her name reflected the fact that

her mother, Milana Angèle Thérèse d'Humy, was of French descent. This form of spelling and pronunciation was used throughout Irène's schooldays until she was eighteen years of age after which she adopted the English spelling (Irene) and pronunciation (in the three-syllable form with the final *e* sounded) for the remainder of her life. To comply with this situation, the French form of her name has been used throughout Chapter 1, which deals with her life until the age of 18, but for the remainder of the biography the English form has been used.

Throughout this script, the names of colleagues, friends and students have generally been used without titles to maintain an uninterrupted flow of the text. Familiar names have been used where appropriate. It has been impossible to mention all individuals and events associated with Irene's life. This in no way means that those omitted are unimportant but priority has been given to the continuity of the narrative rather than presenting a catalogue of bibliographical details. Quotations taken from letters and other documents have been reproduced without alteration, which means that occasional misspellings and errors of punctuation have not been corrected.

The references have been divided into two groupings. The first list contains references that are used in the text and that do not refer directly to a publication of which Irene is author. The second list contains all those references of which Irene was an author or joint author. Most of these are referred to in the text but some are not but have been included for the purposes of completion. With such a large and widely distributed bibliography, there are almost certainly other publications of which Irene was an author but which are not listed in the references. Their inclusion in a 'fully comprehensive' list must await a later occasion.

CHAPTER 1

Family, Childhood and School – 'Life as a Paulina'

Irène Manton was born on Sunday April 17th 1904 at 1 Earl's Court Square in the Royal Borough of Kensington, South West London. Her father, George Sidney Frederick Manton, was a practising dental surgeon who had qualified at Guy's Hospital, London in 1893; her mother, Milana Angèle Thérèse (née D'Humy), was an embroideress and designer and was of French aristocratic descent.

There is circumstantial evidence that George Sidney Frederick Manton's family can be traced back to Thomas Manton DD (1620–1677) a nonconformist divine of the seventeenth century. Thomas was born in Lawrence-Lydiat, Somerset; his father and both his grandfathers were ministers of the gospel. When he was fifteen he entered Wadham College, Oxford. At the age of nineteen he was ordained by the Bishop of Exeter and took up his first living in Stoke Newington, Middlesex. Seven years later he moved to St Paul's, Covent Garden and was appointed chaplain to the Lord Protector, Oliver Cromwell. Thomas assisted in the restoration of Charles II to the throne of England and became one of the King's chaplains but in 1662 lost his living under the Act of Uniformity. Along with many other Puritans he was imprisoned but was allowed to preach from prison. He died in 1677 and was buried in the church in Stoke Newington. Thomas Manton was a highly influential and much respected Puritan at a time of great political and religious turmoil. He is now remembered for his writings, including several books of sermons that have entered into theological literature.

Perhaps the most famous members of the family are the brothers John and Joseph Manton, who were two of the greatest gunmakers of all time (Neal and Back, 1967). They were born in Grantham, Lincolnshire; John in 1752 and Joseph in 1766. Both learned their profession in Grantham; Joseph was for a while apprenticed to John. Both then moved to London and set up independent businesses making guns of the highest quality. Whereas John made a variety of guns, including pistols, sporting guns and rifles, Joseph became a specialist of fine sporting guns. Joseph's supreme innovation was to refine the flintlock mechanism so that it fired quickly and efficiently, this required modification to the size and shape of the flints and the mechanism that held them. As a result of this improvement, customers were able to improve the accuracy and reliability of their shot. The innovation was of such great importance that the Manton flintlock for a while became universal and was used extensively in the Battle of Waterloo. The most prized of Joseph's guns were given names such as 'Old Joe' and 'Big Joe' and today they are much sought-after collectors items. Joseph opened a Shooting Gallery in Davies Street, central London that was frequented by British and foreign royalty and aristocracy. Eventually the flintlock mechanism was superseded by the percussion system and from 1820 demand for Joseph's guns declined. In

1826 Joseph was declared bankrupt and for two short periods was sent to the King's Bench Prison in Southwark. John died in 1834 and Joseph in 1845. Joseph was buried in Kensal Green Cemetery, London and on his grave an epitaph written by Colonel Peter Hawker, a distinguished shot of the time, refers to Joseph Manton's "unrivalled genius; the greatest artist in firearms that ever the world produced". Superlative craftsmanship is, undoubtedly, a recurring Manton family trait.

One of Joseph Manton's brothers was an ancestor of George Edward Manton who was Irène's grandfather. George Edward and his wife Emily (née Collins) lived at 1 St Paul's Cottages, in Charlton, South East London. He was a professor of music although no further details of his career are currently available. George Sidney Frederick was born on April 12th 1872 in Charlton but eventually the family moved to 51 Frithville Gardens, Shepherds Bush, West London. It was from here, in 1891, that George embarked upon his training as a dentist at Guy's Hospital, London.

Milana Angèle Thérèse D'Humy's immediate family were of Franco-Scottish descent. Milana's grandmother was descended from the Johnstons of Ayreshire and the Robinsons. Milana's mother, Marianne Robinson Johnston (1850–1933) later known as Angèle Thérèse, was born in Paddington, London. She ran away to marry Paul Raoul de Faucheux D'Humy (1839–1903) who was a Frenchman of noble descent whose ancestry can be traced back to The Battle of Ivry in 1590 where his forebear fought alongside Henri IV who ennobled him for his services. Paul Raoul owned a glassmaking company in France and later in London and used Venetian techniques to produce goblets decorated with flecks of gold, silver and platinum leaf. Samples of his work are currently on display in the British Museum. Marianne bore Paul Raoul six children, the second of which was Milana Angèle Thérèse (b 1871). It seems that Paul Raoul was an unreliable character; the glassmaking company eventually foundered and the family went to New York. Here, in 1890, Paul Raoul deserted his wife for another woman. Marianne returned to France with the children and took up residence with her mother in Boulogne. Paul Raoul refused to come back to France and so, in 1894, Marianne sued for divorce in the French courts and was given custody of the children.

There is no record as to how George Sidney Frederick Manton, Irène's father, came to meet Milana but on June 17th 1896 they were married in the English church, after a civil ceremony, in the VIIIe arrondissement in Paris. Sometime later they took up residence at 1 Earl's Court Square, Kensington (Fig. 1) and settled down to married life. The Earl's Court property was not only their home but also housed the dental surgery in which George and his partner, Mr Maitland, worked. From Earl's Court, Milana pursued her interests in drawing and embroidery and designed patterns for Liberty's of London.

In 1897 Milana gave birth to a son, Sidney. Unfortunately, little is known about Sidney except for several photographs. He died of scarlet fever at the age of four in 1901. This came as a great shock to the family who were devoted to their son and made the parents particularly sensitive to the health and well-being of future children. On May 4th 1902, the first of two daughters was born. In memory of their recently lost son, the parents named her Sidnie Milana. Two years later, on April 17th 1904, a second daughter was born and she was given the name Irène after an aunt on her mother's side of the family.

The Royal Borough of Kensington was, and still is, an upper class inner suburb of London. The majority of properties in the Earl's Court region of the Royal Borough were built in the mid-nineteenth century. Typically they consisted of terraces of grand Italianate-style houses, 3-4 storeys high with Doric-pillared porticoes. Terraces of houses were usually arranged in squares surrounding a well-tended garden that was for the exclusive use of the local residents. Internally, a typical Kensington house might contain 15 or more spacious rooms. Number 1 Earl's Court Square is a large house on the corner of Earl's Court Square and Earl's Court Road. According to the electoral roll of 1900, the Manton household at this address included a cook, housemaid and parlour maid. Other houses in the locality were either owned by individuals, many of who were army officers, or had been subdivided into flats. It was not uncommon for some of the larger houses to function as embassies and consulates.

Figure 1. No. 1 Earl's Court Square in the Royal Borough of Kensington. This is the house in which Sidnie and Irène Manton were born and in which they lived until the early 1920s.

George and Milana Manton were very conscious about the upbringing and education of their daughters. Photographs of the two girls at about the ages of 6 and 4 respectively show them dressed in the typical upper class Edwardian style of the day (Fig. 2). The girls were immaculately attired in embroidered dresses with bows, their hair was curled with ringlets and during the summer they would wear wide-brimmed straw hats (Fig. 3). The parents, themselves, enjoyed a rich variety of leisure time activities. In his spare time George was an expert wood carver and jewellery maker. Milana was gifted at drawing and needlework. George and Milana owned a small residence in Brookwood, Surrey where the girls would spend their summer holidays. Here they were encouraged to observe and enjoy the countryside. Expeditions were undertaken to catch butterflies, which were subsequently drawn and painted. Both children became highly proficient in drawing and painting with watercolours. With this sort of enthusiasm for the natural world it is not surprising that the parents were concerned that their children should receive the type of 'progressive' education that would encourage and strengthen these interests.

Since Kensington was a generally wealthy borough the majority of parents in the region could afford to send their sons and daughters to private schools. Whilst teaching in general concentrated on the education of boys and was disciplinarian with emphasis on the three r's, there were, nevertheless, the first intimations of more liberal styles of education particularly in Kensington. One such style was encapsulated in the 'Froebel movement', named after its founder Frederich Froebel (1782–1852), whose educational principles and values found their embodiment in the *kindergarten* (Weston, 2002). This style of 'child-centred' learning, where children are encouraged to learn by experience and where emphasis is placed on nature study, art, music and play, originated and prospered during the mid-

Figure 2. Photograph of the 'Manton sisters' with their pet dogs at their summer residence in Brookwood, Surrey. Sidnie is on the left and Irène on the right. The date of the photograph is probably about 1909. (Photograph from the Family Archive)

Figure 3. Sidnie (left) and Irène in the early 1910s. Reproduced with permission of Dr Howard Bailes and the St Paul's Girls' School Archive.

nineteenth century in Europe, particularly in Switzerland and Germany. However, in August 1851 the Prussian government passed a repressive decree (the *Kindergartenverbot*) requiring the closure of all kindergartens, fearing that their liberal education system might eventually lead to political revolution. As a result many kindergartens, which had become icons of liberal progressive values, moved abroad to countries such as Britain, Ireland and the USA. One of these kindergartens was established in Kensington. As the *kindergarten* system of education became more popular in Britain, a purpose-built college for the training of teachers, known as the 'Froebel Educational Institute', was opened in 1895 in Colet Gardens, West Kensington. In 1896 a combined kindergarten and school, known as 'Colet Gardens Demonstration School', was built on one side of the College. It was to this school that George and Milana sent their two daughters when they reached the age of four.

Colet Gardens Demonstration School, although dedicated to the Froebellian style of education, was run as a fee-paying, independent school. The headmistress at the time of

Sidnie and Irène's arrival at the school and for most of their time there was Miss Annie Yelland, who had herself been a student at the Froebel Educational Institute. The prospectus explained that: "The School provides a sound, well-balanced education on progressive lines for boys and girls up to 14 years of age. It seeks to develop initiative and thoughtfulness, and an ability to work and play with zest" (Weston, 2002). Children remained in the kindergarten until the age of six after which they entered the school and were taught subjects up to 'Public School standard'. Emphasis was placed on handwork, music and physical training. At the time Irène joined the school, the number of pupils was about 125 but this rose to 160 by the time she left. There were approximately 11 staff and a trainee teacher from the Institute next door was allotted to each class.

Colet Gardens Demonstration School was damaged during the Second World War and subsequently demolished. The limited documentary records that survive are now located at Ibstock Place School in Roehampton. Of particular interest are three diaries painstakingly kept by the headmistress, Miss Yelland, that cover the period 1904 until her death in 1916. These diaries contain details of events, engagements, cricket matches and other information pertinent to the school. The regular appearance of the names of Mr and Mrs Manton in the diaries shows that the parents took a keen interest in the progress of their two daughters. Notable contemporaries of Irène recorded in the diaries include Imogen Holst, daughter of the composer Gustav Holst, and Frank Soskice, who as Sir Frank Soskice became Attorney General and later Home Secretary in the Labour government of Harold Wilson. Miss Yelland died at the untimely age of 50 on April 1st 1916 and on the last page of her diary there is an entry for March 22nd entitled "Mrs Manton and Irène (violin)" (Ibstock School Archive).

From all accounts both daughters progressed well at Colet Gardens School. Sidnie was one of the two girls selected to unveil a memorial plaque to Miss Yelland in the school hall in December 1916. Irène became noted for her violin playing. A programme for a student concert at Kensington Town Hall in 1913 lists 'Irène Manton' as the soloist in a violin concerto by O. Reiding. Whilst at school both girls came under the influence of Miss Rosalie Lulham, a teacher at the Institute and author of a book on lichens, who gave instruction in nature study and took the pupils on fungal forays. Irène felt enough commitment to her old school to become a member of the 'Old Frobelians' and served on the committee until 1923.

Sidnie and Irène left Colet Gardens School in 1916 and 1918 respectively when they were 14 years of age and entered the nearby St Paul's Girls' School on Brook Green, Hammersmith. St Paul's Girls' School, opened in April 1904, is the younger sister to St Paul's Boys' School, which was founded in 1509 by John Colet, Dean of St Paul's Cathedral. Colet requested that when he died his vast fortune should be directed towards founding a boys' school and entrusted the endowment to The Company of Mercers, the oldest City of London Livery Company. The decision to fund a girls' school of 'the highest educational rank' from the Colet Foundation was taken by the Mercers' Company in 1876 but it was not until 1904 that the first pupils were enrolled (Bailes, 2000). By the time that Sidnie and Irène entered the school, it was a thriving girls' public day school with emphasis on academic scholarship. The Manton sisters excelled in this ambience. The recently appointed biology mistress, Miss Nora Caress, a botany graduate of Manchester University, was greatly influential in stimulating their interests in botany and zoology. One of Irène's practical

Figure 4. Hockey team, St Paul's Girls' School about 1922 with Irène second from right in the back row. (Photograph from the Family Archive)

books, now located in Leeds University archive, provides a snapshot of what they studied. There are well drawn and fully labelled illustrations of flowers, fern sori and various insects. The impressive school library with fireplace, large windows and oak tables was well stocked with books and it was here that Irène first encountered E.B. Wilson's book entitled *The Cell in Development and Heredity* (Wilson, 1902). This chance encounter was to have a seminal influence on her subsequent research career.

A great feature of St Paul's was the provision made for extracurricular activities. There were societies or clubs for all interests and regular meetings usually included talks given by outside speakers or 'papers' read by pupils. Summaries of meetings were reported in *Paulina*, the school magazine. For instance at a meeting of the Science Club on March 10th 1921:

> "an unusually well written and attractive paper was read by Irène Manton on "Animal Architecture". The subject was widely dealt with, and Irène brought before us very clearly the advantages of animal buildings . . . from the protozoans to the various groups of vertebrates. Many carefully chosen specimens illustrating the paper made it all the more enjoyable." (*Paulina* December 1922)

Visits were arranged to the Natural History Museum, Kew Gardens and the Zoo. In 1922 Irène was made a prefect and became Treasurer of *Paulina*.

Sporting activities were also well catered for and both Sidnie and Irène were enthusiastic hockey players (Fig. 4). Personal vignettes are recorded in *Paulina*, for instance in 1917 Irène is described as being "a plucky and energetic back, with a reliable hit, but she is rather apt to muddle her half-back". For Irène, music was to be her major extra-curricular interest and St Paul's Girls' School from its inception was a centre of musical excellence. A music wing, consisting of a Singing Hall with immaculate acoustics, a 'retiring chamber' for the Director of Music and soundproof teaching rooms, was added to the school in 1910. The first Director of Music was Gustav Holst (1874–1934), 'Gussy' to the pupils, and it was in the retiring chamber that he composed *The Planets* in its original version for two pianos. Other Holst works immediately associated with the school are *The St Paul's Suite* (Op 29/2) and *Brook Green Suite*. Irène, who in 1917 exchanged for £10 her 7/8-size violin for an old French violin by F. Perin Fils, was an active participant in the school's orchestra. A typical concert contained a wide range of classical repertory, including piano, clarinet, violin and organ solos as well as movements from symphonies by composers such as Haydn, Schubert and Mozart. Imogen Holst, daughter of Gustav, was again a contemporary.

As was customary at the time, both sisters took the matriculation examination of the University of London. In 1921 Irène gained passes in Elementary Mathematics, English History, French (with special credit for the oral examination), English and Botany. The latter two subjects were obtained with honours. Additionally Irène won a St Dunstan's Science Scholarship as a result of taking the London University Open Exhibition examination. In 1921 Sidnie sat the entrance examination to Girton College, Cambridge and was placed first on the list for major scholarships; for this she was awarded the 'Queen' scholarship. She was also awarded a Leaving Exhibition by St Paul's. In 1923 Irène also sat the entrance examination to Girton College and was awarded the Clothworkers' Scholarship, which was to provide her with an annual stipend of £80 per annum for the next three years.

Thus in 1923, George and Milana Manton must have been delighted that both their daughters had started out their careers with such distinguished school records. Letters of congratulation to the parents were received from amongst others, the High Mistress of St Paul's, Miss Gray, and Miss Nora Caress, who by then had left St Paul's School to become headmistress of Wyggeston Grammar School for Girls, Leicester. In her letter she records:

> "And what a monkey Irène was in the Middle School. I hounded her round, day by day, and was absolutely determined she should do some decent work. I am glad you remember I had a high opinion of her ability. That was why I was so unsparing in my use of the whip. Well, she has more than justified our highest hopes. What are her plans for the future?"
> (Family Archive)

The Manton sisters, who rank amongst the most celebrated of a long list of distinguished Paulinas, were to retain a great affection for their old school. In later years Sidnie's daughter, Elizabeth, attended the school and in 1987, just one year before her death, Irène was invited back to present a talk to the sixth form about her research.

CHAPTER 2

Cambridge and Stockholm

It is almost impossible to appreciate now the prejudice against women in higher education at the beginning of the 20th century. In many respects Cambridge University was the last bastion of male chauvinism. Whereas in 1895 women were receiving degrees from the Scottish Universities, Wales, Durham, London and many others, Oxford and Cambridge still refused to confer degrees on women. By 1920 a Statute had been passed by the Oxford Congregation permitting the matriculation and admission of women to degrees. However, Cambridge adamantly refused women full membership of the University even though in 1921 the Senate had voted in favour of women receiving degrees in title. Whilst women could attend lectures and practical classes and took examinations as normal, nevertheless they were barred from attending graduation ceremonies and were not allowed to receive prizes – these would be given to the next nearest man. In addition there were many petty restrictions particularly with respect to use of University facilities, such as libraries (Hunt and Barker, 1998). This was the situation that existed when Sidnie and Irene arrived at Girton College in 1921 and 1923 respectively and remained throughout their student careers.

Girton College, 'that infidel place' (Bradbrook, 1969), was originally founded by Miss Emily Davies in 1869 as a 'College for Women' in Hitchin, Hertfordshire. The move to a 'green-field site' at Girton, a small village about two and a half miles from Cambridge town centre, was achieved in 1873. Miss Davies requested that the new college buildings should be 'as beautiful as the Assize Courts at Manchester'. A small committee decided that the ethos of the new college should be 'Cantabrigian; feminine; moderately Anglican, but with full freedom for dissent' (Bradbrook, 1969). The two matters on which Miss Davies insisted were that young women must follow exactly the same course as was required for Cambridge undergraduates, and that they must not reside in Cambridge itself. By the time Sidnie and Irene arrived in Cambridge, Girton College had been functioning for fifty years and the number of students, known colloquially as 'Girton Girls', had risen to about 200. Bertha Philpotts, who had served in the embassy in Stockholm during the First World War, was Mistress (1922–25) and the College was still small enough to maintain a family atmosphere. Students arriving at Girton for the first time were given a pep talk that ended with the recommendation to put on gloves and hats at Storey's Way, the half-way mark between the College and the centre of town (Bradbrook, 1969).

Irene participated fully in College activities; she joined the Girton College Musical Society and by May 1924 had become leader of the orchestra. She also played for the Cambridge University Musical Club; one programme consisting of the *Overture to the Merry Wives of Windsor* followed by Schubert's *Unfinished Symphony*. Irene continued with her sporting activities and was Secretary of the College Swimming Club, representing the College in diving. Sidnie had already established herself as an outstanding hockey player, for which

she gained a blue, and was a key member of the College swimming and boating teams. In 1926 Irene became Vice-President of the Girton College Debating Society.

The Botany Department at the time of Irene's arrival in Cambridge in 1923 was housed within the 1904 Botany School building. The Head of Department was Professor A.C. Seward FRS (later Sir Albert Seward) who was also Master of Downing College and for the period 1924–25 University Vice-Chancellor (Thomas, 1941). Seward, whose own interests were in palaeobotany and who, in 1886, worked for a year with Professor W.C. Williamson in Manchester (see Chapter 3), gave the elementary lectures for the whole of the first year. They consisted of a survey of the plant kingdom from algae to higher plants and practicals were supplemented with displays of living material from the University Botanic Garden. Seward was much respected and in later years Tom Harris, an older contemporary undergraduate of Irene's, described him as being "clear minded, very hard working, recognisably honest and loyal to anyone he respected" (Challoner, 1985). In the second and third years, lecturers included F.F. Blackman for plant physiology; F.T. Brooks for life-cycles, cytology and elementary genetics; Hugh Hamshaw Thomas for palaeobotany and physiological anatomy and A.G. Tansley for plant ecology. Several of these names were to re-occur in Irene's life, either during her postgraduate studies or later. Contemporary Botany undergraduates who were to reappear in Irene's life included T.S. Bennet-Clark (plant physiologist); Tom Harris (palaeobotanist); A.R. Clapham, T.G. Tutin and C.R. Metcalfe (plant systematists).

Sir Harry Godwin, a postgraduate research student at the time of Irene's arrival in Cambridge, in his book *Cambridge and Clare* (Godwin, 1985), gives a first-hand account of the various characters in the Cambridge Botany School at the time Irene was a student there. He describes in detail some of the practical work carried out by undergraduates. One aspect that impinges greatly on Irene's later work was the training given in cytology; "We now were taught the art of serial sectioning by microtome and the (preparation) room was dominated by a rank of copper ovens containing our tiny plant specimens simmering in molten wax." Sectioning of immature buds of cultivated hyacinth permitted the observation of meiosis, at that time being described by V.H. Blackman of Imperial College. At the end of her second year (1925) Irene spent the summer vacation with Sidnie in Lausanne, Switzerland attending a class given by Prof. Chodat of Geneva. During the Easter vacation of her third year she took part in a class excursion to Southern Spain with H. Gilbert-Carter, the first Scientific Director of the Cambridge Botanic Garden.

Figure 5. Irene, soon after the award of her degree in title in July 1926, wearing the academic robes of a BA Cambridge. (Photograph from the Family Archive)

Irene took Part I of the Natural Science Tripos in 1925 gaining a first class, this was followed by Part II (Botany) in 1926 when again she gained a first class. A 'double first' from Cambridge was a great distinction for any student, but particularly for a woman (Fig. 5). Her achievement was reported in several newspapers including the Daily Chronicle (July 25th 1926) under the headline "Woman's Notable Distinction". The fact that Sidnie had also gained

a double first in zoology (Part I Natural Science Tripos 1924; Part II (Zoology) 1925) was yet another example of the exceptional ability of these two sisters and was again a source of great satisfaction to their parents, George and Milana.

In spite of attending one of the country's premier universities and having been taught by staff of such calibre, Irene has written on numerous occasions that her experience at Cambridge was neither a satisfying nor a happy one. It seems that the standard of lectures at Cambridge left much to be desired. Tom Harris (Challoner, 1985) described the quality of lecturing as appalling: "the courses incoherent, the lecturers ill-prepared, with no real aim, and far too often the lecturer just mumbled at the blackboard. The weekly tutorials, a racket, did help, but they didn't make bad good". In addition, being a woman in Cambridge in the 1920s probably compounded matters for Irene and later experiences may have also coloured her view. Still, having completed her undergraduate studies she now had to give thought to her future career. Sidnie, after a year at Imperial College, London, secured an appointment as a University Demonstrator in comparative anatomy in Cambridge and was back at Girton College as a Staff Fellow.

Reflecting on the inspiration she had experienced whilst reading E.B. Wilson's book *The Cell in Development and Heredity*, at St Paul's, Irene decided that she would like to carry out postgraduate work on cytology. However, since this was not a speciality of the Cambridge department and there wasn't an immediately suitable supervisor, the staff of the Botany School rallied round and made various enquiries. In particular, Hugh Hamshaw Thomas (Cambridge) and Kathleen Blackburn (Newcastle) were consulted. Kathleen Blackburn had recently collaborated with J.W. Heslop Harrison (Blackburn and Harrison, 1921) on a cytological study of the wild rose (genus *Rosa*), which followed on from pioneer work carried out by Otto Rosenberg (1909a) and his student G. Täckholm (1920) in Stockholm. Since there were excellent connections between members of the Cambridge Botany School and botanists in Sweden – Hugh Hamshaw Thomas and Tom Harris at different times had both had first hand experience of working in the Stockholm Museum – the consensus was that Irene should contact Professor Otto Rosenberg at the Botanical Institute in Stockholm. Rosenberg agreed to offer Irene a year's placement provided she could find suitable funding. An application to Girton College secured an Ethel Sargent Research Studentship that provided a stipend of £150 for one year. Dr Thomas Strangeways, founder of the research laboratory in Cambridge that now bears his name, was appointed as her nominal Cambridge supervisor. And so it was that in September 1926, at the age of twenty-two, Irene set off by ferry and rail to Stockholm.

Otto Rosenberg (1872–1948), later known as the 'grand old man' of the Stockholm Laboratory (Fries, 1950), graduated from Uppsala University and studied for his PhD with Eduard Strasburger (1844–1912) in Bonn. For his PhD, which he gained in 1899, Rosenberg had studied the cytological changes that occur in the cells of the Sundew plant (*Drosera*) when irritated. Later he studied meiosis in the hybrid *Drosera longifolia* x *D. rotundifolia*, the first cytologically examined plant hybrid (Fries, 1950). The former species had $2n = 40$, and the latter $2n = 20$; but the hybrid (*D. obovata*) with 30 chromosomes was more-or-less sterile (Rosenberg, 1909b). This so-called '*Drosera* scheme' was probably the first example whereby the parents of a hybrid had been identified by the analysis of chromosome pairing during

meiosis. Otto Rosenberg proved to be a good choice of supervisor for he was a good teacher and was expert at training students (Fries, 1950). Furthermore, he and his family offered friendly and helpful hospitality to a young research student working abroad for the first time.

Irene remained in Stockholm for 9 months, from September 1926 – June 1927, and during this time she wrote letters at weekly intervals to her parents and Sidnie. These letters have been kept in the family archive and they give an intimate and vivid account of her adaptation to life in Sweden and the initiation of her research project. As with many close-knit families affectionate names were used throughout, Sidnie was known as Sid; Irene as Bibs and the family in general were known as 'fambly' or 'bananaskins'. To begin with Irene lodged in a house belonging to a family, the Dicksons, in Djursholm, about seven kilometres from the botany department that was in the centre of Stockholm. In a letter dated October 15th 1926 Irene gives details of a typical day:

> "Cold bath at 7.00am; Breakfast – two eggs, bacon, bread, milk; Catch train at 8.06am; Arrive at Högskola (Department) at 8.45am; Lunch at 1pm – bread, butter, cheese and milk; Train home between 3-5pm; Dinner at 5.30pm; Read German and Swedish; Supper – bread, butter and milk; Bed at 9.00pm. The general inference – very healthy!"

When she dined with the Dicksons, she complained about the complex system of graces before the meal and commented that "in heaven there shall be no grace!" At the end of a meal you stand up and say *"tack för maten"*, which means "thank you for food". In the same letter she also listed the tasks that she had to learn which included:

> "A great deal of cytology; How to get to and from the lab; The Swedish national anthem – sounds like three blind mice; Shoes mended; Swedish words; Drink Kvass – curious drink of fermented bread in sugar solution; How to eat supper without a plate; How to turn on shower – very complicated; How to enjoy cold fried egg."

Work did not go well and a fortnight after having arrived in Sweden Irene complained:

> "All my English material is dud. The mosses I brought are the most difficult things to fix so I haven't got very far. I very much doubt if less than a lifetime will solve my problem – however we toddle along quite cheerfully – very busy getting nowhere at all. I went to a lecture yesterday and understood nothing. A fine life this!"

In a letter to Sidnie, Irene complained:

> "Dash, hang, blow, blast has been a fair sample of my conversation this week. If you want to see the world's worst cytologist come to Sweden."

However, life was not all work, Irene quickly joined the University Orchestra and one of her first engagements was to play for the King (Gustav V) – the national anthem had to be performed standing up. There were boat trips around the islands and opportunities for skiing and tobogganing. Over the Christmas holiday the temperature plunged to –26°C and "we had to put grease on our faces". By now she had adapted to the Swedish way of life and was not going to bed until after midnight.

Christmas 1926 was the first time that Irene had been away from the family for the holiday. On Christmas day she wrote:

> "Christmas in Sverge! Imagine a foot of snow, 5° freezing only. Spruce forest laden white like hordes of decorated Christmas trees. Road indeed defaced by motor cars but all honest

> people driving horse sledges. Locomotion otherwise in snow boots or skis. The wonderful freshness and exhilaration of air that can only be got in the snowy weather and which gives such round red cheeks to the children. . . . Oh perfect Jule! A cloudless sky which is golden at sunrise and sunset, warm bright at mid day and cold clear and starlit at night . . . . Altogether a perfect Christmas setting."

Sidnie joined Irene in Stockholm for the New Year's holiday and they travelled about six hours North to a hostel on the edge of Lake Siljan in the province of Dalarna. On New Year's Eve in late afternoon they visited a church 11 kilometres away travelling in a horse-drawn sledge. Irene gave a graphic description with an illustration (Fig. 6) of this means of transport:

> "The sledge is very funny. You lie flat and pull up the rugs as though you were in bed. The horse has to have a bell because the motion is so silent. When we came home in the evening at about 6 o'clock it was dark and star lit and most lovely to come through the forest with jingling bell in front."

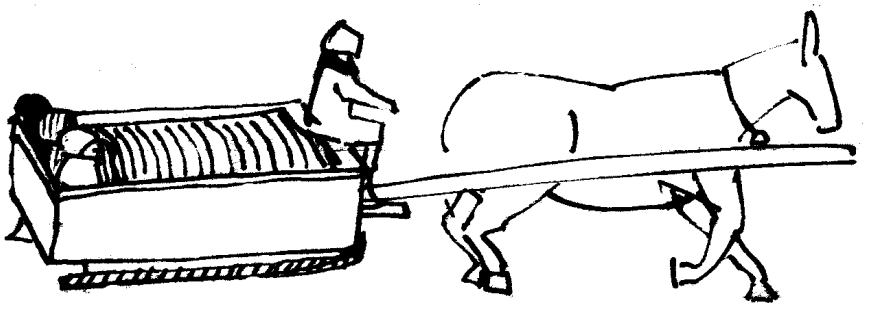

Figure 6. Drawing from a letter written by Irene during her New Year's holiday in Dalarna, Sweden (1925/26). Irene and Sidnie travelled 11 kilometres in a horse-drawn sledge to attend a church service during the late afternoon of December 31st 1925. (Family Archive)

Together Irene and Sidnie skated on the ice, skied in the local hills and fished through holes in the ice. Sidnie recorded in a letter to her father "Bibs talks Swedish with great gusto".

On returning to Stockholm, Irene now moved to new accommodation in Rådmansgatan, a street in the centre of Stockholm next to the Högskola. Although this was more convenient for work, she complained that it was a "rather horrid little room in a nice flat with a nice lady as hostess. I shall eat out". The room contained a stove, a chest of drawers, writing table, washstand and bed. However, she missed being able to take a bath and comments "I loathe washing in a basin". The New Year also saw a change in the direction of her work. She started culturing plant cells in the Medical School under the direction of Dr Hammarsten, a biochemist. However, no sooner had she started this than another crisis was to beset her project when she heard from contacts in Cambridge that Dr Strangeways, her nominal supervisor, had died on December 23rd 1926. In a letter to her father on February 26th 1927 she sums up her situation:

> "The whole trouble is, as perhaps you know, that the man (Dr Strangeways) in Cambridge whom I was coming to is dead. Trouble is perhaps not the word for it for I have now found that the track I had hoped to follow with him is quite dead. I have learned tissue-culturing methods

> here but their application to plant cells is impossible and I have not at present any clue at all. I have by no means chucked Rosenberg. I was dividing myself between him and the tissue culture person for about 6 weeks and still am although I am now mostly back at the Högskola. My trouble is that I cannot get into a good groove of work. . . . Sid was a lucky blighter to have a new spade put into her hand and an undug field set before her! Of course, if she hadn't been so clever she could not dig it even then – but I seem to lack all three qualifications."

On March 1st Irene changed her accommodation again this time to a room in part of a nursing and rest cure home in Drottninggatan just round the corner from Rådmansgatan. In her words she had "a much bigger room with a bathroom attached with shower and geyser. My basin agonies are temporarily over!" And on March 13th 1927 in a letter to Sidnie, she mentions for the first time a project that will ultimately become the subject matter of her PhD:

> "One of my floundering loopholes is developing into a possibility but of Herculean dimensions and will entail investigating the cytology of as many Crucifers as I can get and the family contains 1800. . . . I don't think any more about the research hospital (The Strangeways Laboratory). I shall certainly go to the Botany Schools (Cambridge) if they will have me . . . . I shall quite definitely spend next year in Cambridge and if I don't pull through I shall chuck."

In spite of all the setbacks with her work and social commitments, Irene also spent time reading classical literature and learning Swedish, which at the end of nine months she spoke well. Her letters often contain critiques of literature by classical German authors and poets. Musically she was also perceptive and after attending a concert performance of Beethoven's *Missa Solemnis* she commented:

> "The mass is really inspired in places but Beethoven can say platitudes at times and is often feebly sentimental and extravagant – I think so anyhow. In the *Credo* for the words *ascendit in coelum* to accompany it by furious up arpeggios in the orchestra reduces the musical interpretation to the level of the cinema. One's first impulse is to hoot with laughter at the ascension being put so concretely. . . . Still on the whole I was much uplifted. Nothing appeals to me less than Roman Catholicism as a religion but the latin liturgy is the most marvellous medium for music that I know. But I think that the Bach in B minor is incomparable."

From Easter onwards when the weather improved, Irene's spirits increased accordingly. Before Easter she admitted to being more "a much damaged ninepin than anything intellectual". Now her thoughts are directed towards what she will do when she leaves Sweden in June. Her decision is to travel via Visby on the island of Gotland, to Copenhagen and Berlin and then to spend two months in Jena before returning home to Britain via Ostend. She holds out the possibility of meeting up with her father in Germany and hopes her mother will meet her Grandmère in Belgium so that she can accompany her home. Her desire is to attend the British Association meeting in Leeds in September.

On May 22nd 1927 Irene wrote a letter to Sidnie summing up the experiences of the last nine months and her current situation.

> "I think what has really bitten me is that I have only 3 weeks left. Wanting to come home instead of going to Jena; sorrow at leaving all the people who become nicer every day; wanting really to get at German; wanting to make a better job of Swedish and Sweden; wanting to take the best for work that I can; wanting to prepare properly for next year's work all on top of my native laziness and longing to gaze into the sky and do nothing makes rather a mixed frame of mind. You know it's dreadful to be so many different people all in

> me. I thought I had more or less summed up I.M. but this one is quite different from anything I've seen before and I don't understand it a bit. However, to still the saucepan lid I will go and exercise the microtome until dinner time."

In the second week of June, Irene packed up her possessions including her skis and despatched them to England. Meanwhile, with rucksack and hand luggage she said her farewells and started on her travels to Visby, Copenhagen, Berlin, Weimar, Leipzig and Jena. In Jena she visited Prof Renner and attended courses on German for foreigners and German literature and theatre. It is not clear whether she met up with her father. In one letter she suggests that he should bring his fishing gear and that they might visit the Rhineland. She did travel back via Belgium and took the ferry from Ostend to Hull but, unfortunately, her rail journey to Ostend was delayed and she did not have enough time to meet Grandmère. She wrote a letter on the ferry crossing the North Sea apologising for this omission. After landing at Hull she travelled to Leeds for the British Association meeting and then returned to her parents' home in London. Here she stayed for the remainder of September before returning to Cambridge for her second postgraduate year. Unbeknown to Irene at the time, the British Association meeting in Leeds was to have implications in a year's time for her career.

Whilst Irene was in Sweden, her parents had moved to 18 Ennerdale Road, Kew. This is a suburban house a few minutes walk from Kew Gardens that was to be associated with the Manton family for at least 50 years. There is some uncertainty as to how many houses were owned by the Manton family at any one time. The large house in Earl's Court remained in their name until the mid 1930s. The house in Ennerdale Road is mentioned as early as 1923 as the address of Sidnie and Irene in *The Froebelian*. In several of Irene's letters from Stockholm, 18 Ennerdale Road is mentioned and in a letter in mid-April 1927 she wishes her parents luck with the move. The majority of the Stockholm letters were addressed to 18 Blandford Road, London W4 (Chiswick). However this may have been a temporary address. The upper floors of the Earl's Court property, which still housed the dental practice, had been reorganised into flats.

On return to Cambridge Irene took up residence in Girton College; finance came from the award of an Alfred Yarrow research studentship for the year 1927–28. She quickly re-established her membership with the College Musical Society. On November 20th 1928 the Musical Society was invited to give a concert at King's College where Irene played violin in a *Sonata for two Violins and Piano* by Bach; and in *Two Fantasies for Strings* by Purcell. The same programme was performed at Sydney Sussex College on November 18th.

With respect to her research project, Irene was now committed to studying the cytology of the Cruciferae. In Sweden she had learned the 'Strasburgian' methods of embedding, sectioning and staining, mainly with haematoxylin to observe chromosomes. She later used gentian violet in Cambridge. Plant material was either collected wild or grown from seed and in her thesis she acknowledges contributions from around the world. For this project there was a question as to who would be appropriate to supervise the work in Cambridge. Eventually it was agreed that Mr F.T. Brooks should undertake the task. This decision must have been taken because of his teaching interests, he lectured on cytology, rather than his research interests since he was a mycologist and plant pathologist. Since Irene had not registered for a higher degree before she left for Sweden, she had to apply as she was

leaving Stockholm to the Registry for a 'Course of Research in the University'. This was finally achieved on June 7th 1927 with a year's exemption for the work she had already undertaken in Sweden.

Thus at the end of 1927 it looked as though Irene could enjoy a carefree postgraduate's life in Cambridge with the staff of the Botanic Garden to help with the growing of her plants and good facilities in the Botany School. However, in 1928 this sense of security was shattered. At some point during the first half of 1928, Milana Manton suffered from a debilitating condition. The exact nature of this condition is unknown but it lasted until her death in 1945 by which time she was completely bedridden, slept for most of the day and was oblivious of the world around her. This crisis was fully shared between the father and the two daughters and lead to George's early retirement in 1930 so that he could look after Milana. The effect on Irene was shattering in several respects. She decided to move from Cambridge to live, at least temporarily, with her parents in Kew. To achieve this she had to move her research base from Cambridge to the Jodrell Laboratories at Kew Gardens. Financially, the situation deteriorated for the family and, perhaps for tax purposes, the large house in Earl's Court was transferred into Irene's name with her address given as Girton College Cambridge. For a postgraduate student the nominal possession of such a large property with tenants must have been a major distraction.

A further complication with respect to her PhD studies came with her appointment to an assistant lectureship in the botany department at Manchester University as from December 25th 1928. The unbeknown matter that arose at the 1927 British Association meeting in Leeds was that Tom Harris (by now a Demonstrator in the Cambridge Botany School) met and fell in love with Katharine Massey, an assistant lecturer at Manchester, and they were subsequently married during the Christmas vacation of 1928 (Challoner, 1985). Clearly collusion between the staff of the Cambridge and Manchester departments lead to the recommendation that Irene should be offered the post that was going to be vacated by Katharine's departure to Cambridge. Correspondence between Irene and the Secretary of the Board of Research Studies in Cambridge regarding this situation shows that at the beginning of October 1928 she requested permission to continue her work for a PhD degree away from Cambridge. She wrote:

> "Private circumstances of an entirely exceptional nature make further residence in Cambridge impossible. I have accepted, as from January 1929, the appointment of junior lecturer in the University of Manchester, which is calculated to leave me up to three days per week for research. Until my departure for Manchester, I propose to continue in the Jodrell Laboratory of the Royal Gardens, Kew, where I am at present working. I shall, however, spend frequent periods during the vacations in Cambridge as I have material still being grown in the Botanic Gardens. It would therefore be a great convenience to me if Mr Brooks may be allowed to continue as my supervisor." (Board of Graduate Studies files, Cambridge University Archives)

The letter was passed on to her supervisor Mr F.T. Brooks who wrote on it "Yes, I approve. The circumstances are quite exceptional". On October 28th the Secretary wrote to Irene to say that at a meeting of the Board of Research Studies held on October 16th permission had been granted for these requests. And so with mixed feelings Irene left Cambridge for a future career in Manchester.

CHAPTER 3

Mancunian Idyll – Ferns, Chromosomes and Spirals

Manchester University, like so many of the English 'civic universities', was founded in the 19th century. The University developed out of Owens College, which was founded by the will of John Owens in 1851. This subsequently (1880) was incorporated as a College into The Victoria University, which later included University College Liverpool and Yorkshire College Leeds. In 1903, by charter, the independent Victoria University of Manchester came into being.

When Owens College was founded in 1851, a chair of 'Natural History' was established which comprised 'Vegetable Physiology and Botany, Animal Physiology and Zoology, and Geology' and to this chair was appointed William Crawford Williamson (1816–1895). Two further chairs, one in Geology and one in Zoology, were created in 1874 and 1879 respectively and so, by a process of elimination, in 1879 Williamson became the first Professor of Botany. He published extensively on palaeobotany and one of his important findings was the discovery of cambium in fossil cryptogams – hitherto cambium and secondary tissues were considered to be exclusively features of higher plants (phanerogams) (Andrews, 1980). Williamson retired from the Manchester chair in 1892 to be replaced by Frederick Ernest Weiss (1865–1953), at the age of 26, who remained head of department for 38 years. Weiss, of German Jewish extraction, was also interested in palaeobotany but his outstanding contribution was to convert the Manchester department into a centre of excellence in terms of botanical research and teaching in the North of England (Thomas, 1953). By tireless lobbying and fund raising, he achieved this by an expansion of the facilities from a humble one-roomed laboratory on the first floor of the Beyer building to several larger laboratories acquired from the Main Building and by the departure of Engineering to another site. In 1911, new purpose-built accommodation with rooftop greenhouses was opened and this greatly enlarged the facilities available for botany teaching and research. Weiss also oversaw the establishment of the Botany Experimental Grounds on Whitworth Lane in Fallowfield (Charlton and Cutter, 1998).

The number of staff in the department also increased and in 1909 a Chair of Cryptogamic Botany was instituted as a result of a bequest by Thomas Barker, a previous Professor of Mathematics at the University, who had been a keen amateur bryologist. In 1909 William Henry Lang (1874–1960) became the first Professor of Cryptogamic Botany. William Lang, son of a medical practitioner who died when William was two, was born in Sussex but brought up by his mother in Renfrewshire. He entered Glasgow University when he was 15 and graduated in science and medicine in 1895 at the age of 21. However, he never practised medicine but took up botany as a result of having attended F.O. Bower's lectures. After a brief period at Kew he returned to Glasgow to work for 15 years in the botany department where Bower was head

of department. As might be expected of a Glasgow botanist at this time, his interest was in ferns and palaeobotany. His collaboration with Robert Kidston, a talented amateur, on the famous Rhynie Chert fossils was undoubtedly a landmark in the history of Botany. Lang was an erudite and cultured man; he and his wife enjoyed classical music, collected works of art and he could read four languages, including Swedish. He was also editor of the fourth English version of Eduard Strasburger's *Textbook of Botany* (Salisbury, 1961).

By the time that Irene Manton arrived in Manchester in January 1929, Weiss and Lang were both Fellows of the Royal Society; Weiss was one year from retirement and Lang was 54 years of age. Irene immediately found the Manchester environment convivial in all respects. The University, which was then confined to a small site on the West side of the Oxford Road, had a collegiate feel about it. For her PhD work on crucifers, there were greenhouses on the roof of the new building where she could grow her seedlings. Ernest Ashby, a much-respected technician, helped with growing plants, photography and other tasks. In her own words "I found myself in a uniquely favourable environment" (Manton, 1973a). In terms of colleagues, Irene was particularly friendly with Barbara Colson a mycologist and Kathleen Drew-Baker, a research fellow, who worked on algae.

Frederick Weiss and William Lang became personal friends and through them Irene was introduced to other Manchester people of note. Women academic staff were provided with their own staff room and it was here that Irene met Mrs Mabel Wright of the Geography Department, wife of Dr William Wright of the Geological Survey, and mother of Barbara Wright (now Lady Barbara Dainton) whose life would in the future intertwine with that of Irene's. William Lang was a kindly, patrician, if somewhat aloof man who provided the security and support that Irene required during this period of turmoil within her family. Professor Weiss was able to introduce Irene to local and national societies. He had been President of many societies including: the Manchester Microscopical Society, the Manchester Literary and Philosophical Society, the South Eastern Union of Scientific Societies, the Botany Section of the British Association and he was to become President of the Linnean Society from 1931–34. He served on the Council of the Royal Society from 1924–1925. He was undoubtedly a man of high reputation and enormous energy who played a prominent role in the progress and development of the University, in the expansion of the Manchester Museum and in the intellectual life of the city (Thomas, 1953). Another welcome aspect of Manchester was the more enlightened attitude to women, which was in contrast to what Irene had experienced in Cambridge. By 1897 women could enrol for any course within the University and receive degrees accordingly. Women had featured quite strongly in the Manchester botany department although when they married they were still expected to resign their lectureships. Marie Stopes, the indefatigable promoter of family planning, had been an assistant lecturer and lecturer in palaeobotany in the Manchester Department as early as 1904 (Charlton and Cutter, 1998).

However, whilst things were progressing well in Manchester, where in 1930 Irene was promoted to the permanent post of Lecturer, family matters in London had deteriorated further. Milana now required permanent attention. In a letter to the Cromwell Road (Kensington) tax office dated April 1928 George Manton stated that he had had "to give up the struggle" (Family Archive). On December 17th he gave up his practice in Earl's Court

and saw his last patient on January 31st 1929. His correspondence with the tax office reveals a considerable sense of agitation; he mentions the possibility of moving with Milana to Belgium, possibly to take up residence with Milana's mother who now lived in Coxyde. In the event he stayed in Kew until August 1929 after which he and Milana moved to a house called Castlemead in Polruan-by-Fowey, Cornwall. They lodged in Polruan for a year and then moved to a house on the Esplanade in Plymouth. Eventually, on February 12th 1931, Cheyne Lodge was purchased in Dartmouth and this is where George and Milana lived for the rest of their lives. The house in Ennerdale Road, Kew was let for a while and later acquired by Sidnie and her husband John Harding after their marriage in 1937. This brief summary of events conceals the anguish that the family must have suffered with the uncertainty as to Milana's condition, the constant search for suitable properties and the enormous consequent financial implications. George's situation had changed dramatically; his forced retirement at the age of 58 left him with no income except from the rent of the properties in Earl's Court and Kew. The effects of this turmoil on Irene were also traumatic. Now she was nominally responsible for the Earl's Court property and was investing in the house in Dartmouth. Every vacation she had to return to Dartmouth where she assisted with the care of Milana. This was disruptive to her research although whilst in Devon she was given bench space at the Marine Biological Association in Plymouth. The effect on her personal life was considerable and it is not surprising that for the rest of her life she feared that she, also, might suffer a similar fate to Milana.

Once Irene had settled down in Manchester, the first task facing her was to complete the work for her PhD thesis. As far as plants were concerned, she relied on material from botanical gardens around the world, which were fixed *in situ* or obtained as seeds that were subsequently grown to maturity in the Cambridge Botanic Garden. Some material was also grown in the roof greenhouses of the Manchester department. Identifications of plants were checked against herbarium specimens in Kew Gardens or the Natural History Museum and as a further precaution specimens of the plants used for counts were pressed and deposited in the Manchester Herbarium. Chromosome counts were made from root-tips after fixation with chromo-acetic-formalin. Embedding was in wax and sections were cut with a microtome, stained with iron-alum-haematoxylin or later with gentian violet and viewed with a microscope using a light source modified by yellow and green filters. Drawings were made with the aid of a Zeiss camera-lucida giving a magnification of 2,800. In a later reminiscence Irene states:

> "I cut yards and indeed miles of sections and ultimately completed my PhD on the chromosomes of 250 species of crucifers, all processed in this various laborious manner." (Manton, 1973a)

Much of the thesis was prepared in the Botanical Department, University of Kiel, Germany and Professor Tischler is thanked for generously making available his private library and for criticism of the script.

Irene's PhD thesis entitled *Cytology of the Cruciferae* was duly submitted to the Cambridge Registry in the Spring of 1930. Professor J.W. Heslop Harrison of Armstrong College, Newcastle-upon-Tyne (Durham University) and Mr A.E. Watkins of Cambridge were appointed the examiners. The oral examination was held in Lincoln, a central location between Manchester, Newcastle and Cambridge. When the three parties met at Lincoln

railway station, which was hot and noisy, they climbed the hill to the Cathedral and eventually chose a builder's plank supported by two buckets in the Cathedral precinct as being a suitable location for consideration of the thesis (Manton, 1973a). The reports submitted by the examiners to the Degree Committee of The Faculty of Biology indicate that they were satisfied with the thesis and *viva*. Heslop-Harrison commented in his report that:

> "The thesis is a thoroughly satisfactory piece of work and a real contribution to the literature of the subject. The labour involved is enormous . . . . she has shown herself to possess all the qualifications of a first class worker." (Board of Graduate files, Cambridge University Archives)

Mr Watkins also had favourable things to say but highlighted a limitation of using chromosome numbers alone for evolutionary deductions:

> "The chief defect of the work is that a somewhat artificial outlook has inevitably arisen from the attempt to discuss evolutionary changes from a knowledge of chromosome number alone."

At the next meeting of the Degree Committee of the Faculty of Biology on June 9th 1930, members of the Committee decided that the degree of PhD should be awarded. Those present and voting in favour were Profs Seward, Gardener, Punnett, Dr Appleton, Messrs Nicholas and Brooks.

The thesis is a modest document, looking rather like a school exercise book (Manton, 1930a). The contents of the thesis gave rise to two papers, the first of which is a note on the cytology of the genus *Matthiola* and is published in the *Memoirs and Proceedings of the Manchester Literary and Philosophical Society* (Manton, 1930b). However, it is the second, much more substantial paper in the *Annals of Botany* that summarises the bulk of the contents of the thesis (Manton, 1932a). Since the work only focussed on chromosome counts from root tips (somatic counts), the conclusions are inevitably limited. The stated aims of the work were: 1. To test the applicability of cytology to the solution of taxonomic problems in the Cruciferae and 2. To obtain evidence on the relation between chromosome changes and the natural selection of species and genera. The Family Cruciferae was selected because of the general availability of representatives and because it is a rather uniform group. The large size of the Family (>1900 species) presented problems, nevertheless Irene managed to sample about 250 species representing some 80 genera. During the course of the study two papers on the same topic were published by Jaretsky (1928, 1929) but since he based his counts on meiotic figures the results were more-or-less complementary. The results of Irene's study gave a number of valuable insights into the taxonomy and phylogeny of the Cruciferae. Basic numbers of chromosomes ranged from 5–15. Polyploidy (the increase in the chromosome number of a nucleus by a simple multiple) was common between species – the highest chromosome number being recorded in some species of *Crambe* which reached 120. A number of taxonomic recommendations were made. With respect to phylogeny, Irene compared her cytological results with the current phylogenetic system based on morphology as put forward by von Hayek (1911) and, in general, found a striking agreement between the two sets of results.

The thesis and the *Annals of Botany* paper encapsulate many of the Irene Manton hallmarks, which extend throughout all her papers. These include the prodigious amount of work undertaken; the tireless search for observational proof; the quality and reliability of

the illustrations, even apparent where camera-lucida drawings are given; the clarity of the writing; the cautiousness with which results are discussed, arguments are carefully balanced and the desire to over-interpret is resisted; the confidence with which opinions are expressed; a mastery of the literature. Considering this project was essentially carried out without experienced supervisory input over a period of four years in several different locations on material supplied from around the world and against the troubled family background, the completion of this project was a triumph. Perhaps the most important achievement of this work was that it provided insights into just what could be gained using the cytological techniques available at the time. Clearly chromosome counts alone could only achieve limited objectives; from now on cytology had to be combined with plant hybridising programmes and the analysis of chromosome behaviour during meiosis. From the work on the Cruciferae, two relatively small scale but important programmes emerged, one on *Biscutella laevigata* L. and one on watercress (*Nasturtium officinale* R. Br.). They generated five papers that gave good examples of autopolyploid and allopolyploid series respectively and also cast some light on the biogeography and evolution of the species concerned.

Biscutella laevigata L. is a small crucifer that grows as a rock plant in Central Europe and the Mediterranean. Manton (1934) recognised two cytological types, one with 18 somatic chromosomes (diploid), which was confined to the lowlands of Central Europe, and the other with 36 somatic chromosomes (tetraploid), which was found in the Swiss and Austrian Alps. When the distribution of the two types was mapped out it became apparent that the diploid plants were limited in extent and eminently discontinuous, there were three centres of population around the rivers Rhine, Austrian Danube and Elbe respectively. Manton (1934) recognised these as being relict populations of a once more widespread distribution. In contrast, the tetraploid plants formed a continuous population in the alpine region that had been covered by the ice sheet during the last glaciation. From these facts Irene concluded that the diploid *B. laevigata* was an interglacial if not preglacial relict and that the tetraploid *B. laevigata* was a recent immigrant once the ice-sheet retreated. In a second paper (Manton, 1937) she established a variety of hybrids of *B. laevigata* and studied mutual homologies of the chromosomes by observation of the pairing of chromosomes during meiosis. The results showed that all forms of *Biscutella* in France and Europe belong to closely related stock and that polyploidy, where it has occurred, is indistinguishable from autopolyploidy. The results of this *Biscutella* work have frequently been cited in support of polyploids having greater hardiness and being more opportunistic in colonising recently disturbed habitats (Stebbins, 1971). To some extent the jury is still out on these matters for there are exceptions to the rule.

The work on watercress also derived from the thesis but more especially from the *viva* in Lincoln. Heslop-Harrison had noted that whilst *Nasturtium officinale* was given as having 32 somatic chromosomes, one illustration showed 48. Irene agreed to re-investigate this anomaly after the *viva*. On sampling local populations around Manchester she was surprised to obtain a count of 64 making this the first polyploid series that she had encountered. All three numbers were included in the *Annals of Botany* paper (Manton, 1932a). The follow-up to this showed that meiosis in diploid and tetraploid plants was regular whereas in triploid plants meiosis was irregular throughout with some chromosomes segregating irregularly to the poles; the seed and pollen sterility was an inevitable consequence of the production of unbalanced, non-viable, genetical combinations (Manton, 1935a). In a later paper (Howard

and Manton 1946) the tetraploid was shown to be an allopolyploid, making this system a classic case of two species with an intermediary sterile triploid hybrid. The tetraploid was given the name *Nasturtium uniseriatum* Howard and Manton and the hybrid designated *Nasturtium uniseriatum* x *N. officinale.* Howard, senior author of the 1946 paper, was a Cambridge postgraduate student supervised by Mr A.E. Watkins, one of Irene's PhD examiners.

One other paper that requires mention and that relates to the Cruciferae, involves the study of 'prochromosomes' or 'euchromocentres' in nuclei. These were originally observed by Rosenberg (1904, 1909a) who drew attention to the apparent coincidence between chromosome numbers and the number of chromatic bodies present on the surfaces of interphase nuclei of certain plants. Manton (1935b) in a paper on *Biscutella laevigata* and *Iberis semperflorens* L. confirmed the coincidence in numbers but did not take this work further. Prochromosomes, presently called chromocentres, are now considered to be condensed or heterochromatic regions of chromosomes in interphase nuclei.

Irene might well have continued studying the cytology of flowering plants had it not been for her discussions with William Lang. In 1930 Frederick Weiss had retired from the chair of Botany and been replaced by James Montagu Frank Drummond, known as 'Monty' to staff and students. Although Irene was technically in the Botany Department and therefore not part of the 'cryptogamic group', nevertheless Lang impressed her immensely as both a teacher and research scientist. Many years later she recorded that "Lang taught with authority, an experience that I had never had before. It was my privilege to act as a demonstrator for 12 years and this fact transformed my botanical life" (Manton, 1973a). Lang was interested in both fossil pteriodophytes and extant species. In particular, at that time he was interested in apospory and apogamy. To appreciate what these terms mean it is necessary first to understand the life-cycle of ferns and to do this a quotation from Irene's book (Manton, 1950a) seems in order.

> "The type of life history found in ferns in which sexual and asexual modes of reproduction are separated on different individuals, which succeed each other in regular order, is known as *alternation of generations*. In ferns the complete independence of the two generations for most of their lives makes it necessary to retain the technically correct terminology appropriate to botany or misunderstandings will follow. The conspicuous generation here is a diploid (2*n*) organism reproducing by asexual means (spores) and is known as a sporophyte. The haploid (*n*), sexual plant, which in the case of ferns is the inconspicuous but free-living prothallus, is the gametophyte. Thus sexual fusion occurs between gametes produced by haploid prothalli and meiosis (reduction division) occurs in the developing sporangia (which in many but not all ferns are borne on the underside of the fronds).
> Apogamy and Apospory are two aberrations of the life history by which the regular sequence of sexual and asexual reproduction is modified. Apogamy is the production of a sporophyte from a gametophyte without the intervention of a sexual process. Apospory is the aberration on the part of a sporophyte by which proliferation of gametophytic tissue takes place from it without the intervention of normally constructed spores."

For some time Lang had been interested in the Royal Fern, *Osmunda regalis*. It was already known that the normal chromosome number of the haploid gametophyte was 22 and the diploid sporophyte 44. However, since 1924, Lang (1924) had been cultivating aposporous prothalli of *O. regalis*. He achieved this by placing an *Osmunda* leaf on moist soil; the

prothalli developed from the tips of the veins and were subsequently kept in continuous cultivation by vegetative propagation. The prothalli took on a 'massive liverwort-like habit' although their anatomy was 'normal' and they produced sex organs (antheridia and archegonia) as usual. Self-fertilisation produced sporophyte plants that could then be cultivated to produce specimens of the large fern. The chromosome number in the root tips was 88; clearly a tetraploid had been produced by the fusion of diploid gametes. In addition some plants were triploid, which Irene put down to the fusion between a diploid and a haploid gamete. This, alongside the situation already mentioned in *Biscutella*, was yet another example of an autopolyploid series. Irene published this work in 1932 (Manton, 1932b), at the same time as the major paper from her thesis, and in her own words "I was catapulted into ferns by a force beyond my control" (Manton, 1973a).

As she settled down to life in Manchester, a number of developments took place in terms of her private life and with her work. Now that she was investing in her parents home in Dartmouth she did not attempt to buy a property in Manchester but instead lived in rented accommodation in Withington. Although she could not drive she purchased a car, which was driven by Barbara Colson a good friend in the department. She pursued her interest in music by joining a string quartet and played at regular intervals until she left Manchester in 1946. Unfortunately, there are no details of whether the quartet had a name or who the other members were, although they were probably fellow academics. In the Manchester environment, and probably spurred on by the interest of William Lang and his wife for watercolour painting and their collection of art works, Irene became interested in the visual arts. In 1935 she attended the Exhibition of Chinese Art at the Royal Academy of Arts in London. This stimulated her interest in oriental art and printing. She began to immerse herself in the history of Chinese culture, a topic about which she was to write many years later (Manton, 1971). Within Manchester she mixed widely in academic and intellectual circles; her contacts with Dr Wright and his family have already been mentioned. Barbara Wright (Lady Dainton), as a schoolgirl, had the experience of being tutored by Irene prior to taking her entrance examination to Cambridge. Subsequently Sidnie tutored her at Cambridge. When Dorothy Emmet, the Oxford philosopher, moved to Manchester, she took up residence in the same accommodation as Irene and the two were to remain close friends for the rest of their lives. Irene was one of the characters that Dorothy had in mind when she wrote about 'Vocation' in her book *Function, Purpose and Powers* (Emmet, 1972). Dorothy witnessed at first hand the strength of Irene's character and her determination to achieve her goals no matter what the obstacles – a topic to which we shall return later (Chapter 8).

Within the department, Irene Manton was viewed as being a conscientious and able lecturer who conveyed a sense of enthusiasm to the students and was well respected. John Lund recalls Saturday 'botanical rambles' at which Irene was always present. These were not ecological forays in the normal sense but extensive walks when Irene and other members of staff present would discuss the plants in the field (Fig. 7). John remembers one particular ramble of 14 miles in the Dales of Derbyshire. When he returned home at night he noted in his diary "a most wonderful day". Even at this stage in Irene's career students noted that her clothes were likely to be well-worn; it was not uncommon for her to have one or more holes in her stockings.

Figure 7. Irene discussing a fern with a group of students on one of the Manchester botany department rambles in 1938. The two students on the left are Adrian Hollowell and Leslie Cobley; on the right, with his back to the camera, is Mr T.G. Tutin. Reproduced with permission of Mr Hollowell.

John Lund, who subsequently became a distinguished freshwater phycologist and FRS, recalls his first major encounter with algae. Rather than presenting students with algae that she had collected, Irene asked students to bring in their own water samples for the next practical. John collected water and mud scrapings from several farm ponds in a mild January and when he viewed them in the practical he observed what he described as "utterly beautiful" euglenoids, conjugating *Spirogyra*, *Eudorina* and many other freshwater species. It was Irene's inspiration in this context that led him to choose a career in phycology. Dennis Greenwood, later to work in the Leeds botany department, was another Manchester student who was greatly influenced by Irene. Adrian Hollowell (student 1938–41) recalls that he wanted Irene to act as his hall tutor for botany, which confirms her popularity as a lecturer.

In terms of science, two developments occurred in the mid-1930s that markedly improved her work. The first was the introduction of photography, which she describes in detail in her 1973 article (Manton, 1973a). Lang had introduced photography to the recording of fossil specimens. He used a relatively low power 'dry' lens and the images he obtained were of high quality. However, he did not consider that photography was suitable for application to specimens viewed with oil immersion microscopy. To overcome this 'block' Irene waited for Lang to leave the department for several days and then with Ernest Ashby, the departmental technician, she used the 'simplest of laboratory cameras' to take her first cytological photographs of dividing cells in the root tips of *Biscutella* (Fig. 7). When Lang returned, Irene showed him the pictures and Lang was so thrilled that he took the negatives

home, set up his own enlarger in his study, and made prints at a magnification of x 2700. As Irene noted later "the very great are sometimes like that when they have been proved wrong by a junior". Two of these photographs were included in the Manton (1934) *Biscutella* paper (Fig. 8).

The second technical improvement came about unexpectedly when Irene and Barbara Colson visited Egypt in 1935. Although Professor Weiss had retired from the chair of botany in 1931 he remained active and during the academic year 1934/35 was invited to serve as Acting Professor of Botany at Cairo University. Weiss invited Irene and Barbara Colson to visit Cairo and the Cotton Research Institute in Giza, Barbara Colson was at that stage working as a Research Fellow for the Empire Cotton Research Institute in Manchester. J. Philp was the cytologist at the Giza Institute and it was here that Irene saw for the first time permanent stained slides of pollen mother cells undergoing meiosis prepared according to McClintock's acetocarmine squash method (Manton, 1973a). Irene, who had been brought up on the now outdated 'Strasburgian' methods of serial sectioning, immediately grasped the value of this method for her own work. The advantage of squashing cells and immediately visualising chromosomes overcame at a stroke the laborious process of embedding and sectioning material and also presented an image that could be photographed in one focal plane. From now on Irene would use this technique increasingly in her work. Barbara McClintock, future Nobel laureate, was someone whom Irene held in great respect. Many years later, she tried to persuade the Leeds University authorities to award Barbara an honorary degree (see Chapter 8).

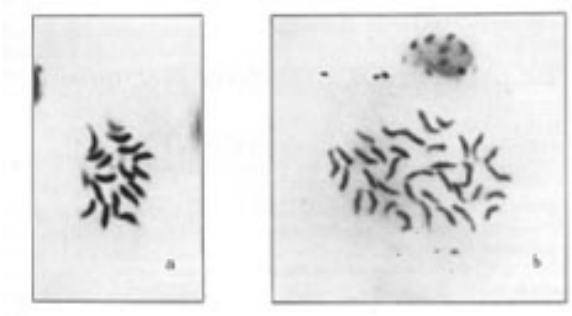

Figure 8. Chromosomes of the two cytological forms of *Biscutella laevigata* L. from root tips. (a) 2*n* = 18 subspecies *subphyla*, (b) 2*n* = 36 subspecies *lucida*. These are the first two photographs of chromosomes that Irene published (Manton, 1934). Reproduced with permission from *Zietschrift für Inducktive Abstammungs und Vererbungslehre*.

The mid-1930s also mark the beginnings of the rift between Irene and Sidnie. In 1935 Sidnie was a Demonstrator in the Cambridge zoology department. She had met John Harding, a Cambridge zoology postgraduate, and they decided to get married in 1937. George Manton vehemently opposed the match. In a letter to Irene dated September 25th 1936 George wrote: "At 5.30 Sid has gone. For the first time in my life I am glad of it as at the moment she is better away" (Family Archive). He went on to explain that John would never be able to earn the necessary salary to maintain Sidnie in the way he would expect. In spite of George's

protestations, Sidnie and John were married on June 19th 1937. George did not attend the wedding, although Irene did, and a week later on June 26th George made his will in which he not only made Irene the sole executor but he also left his entire estate to her. George now actively favoured Irene and she appears to have fallen in line with her father's views. There can be little doubt that this greatly affected the relationship between the two sisters.

Irene's research interests were now completely focussed on the ferns (Fig. 9). Two overlapping aspects were pursued with vigour. One involved an elaborate fern hybridising programme, the other was concerned with the structure and coiling of chromosomes during mitosis and meiosis. Both in their different ways had important implications for the direction of her future research. With respect to the fern hybridising programme, this began with *Dryopteris filix-mas* (L.) Schott that is said to be the "commonest and best known British fern". However, as Irene was to find:

> "It is an assemblage of forms differing in morphology, genetical constitution and life-history, and there seems little doubt that, among the aggregate forms found wild in Great Britain, at least three taxonomic species (*D. abbreviata*, *D. filix-mas* sensu stricto, *D. borreri*) should be separately distinguished, and more may be expected to be found in other parts of the world." (Manton, 1950a)

To unravel this complex situation Irene carried out cytological and other observations on about one hundred plants from the British Isles and from the continent of Europe. One of the species, *D. abbreviata* (Lam. & DC.) Newman, is a sexual diploid with a gametic chromosome number of 41. *D. filix-mas* sensu stricto, is a sexual type with twice this chromosome number (gametic = 82). It can be hybridised with *D abbreviata*, and from the chromosome pairing behaviour in such a hybrid it is deduced that the *D. filix-mas* is itself an allopolyploid with half its chromosomes homologous with those of *D. abbreviata* and the other half of unknown origin. *D. borreri* Newman is exclusively apogamous and diploid, triploid, tetraploid and pentaploid strains are known, the last two being almost certainly hybrids between the first two and *D. filix-mas*.

Collecting trips to continental Europe and the Channel Islands prior to the war made available more fern species for cytological investigation. Other pteridophytes, such as *Equisetum, Lycopodium, Ophioglossum* and *Isoetes*, were collected, grown and a programme of hybridising was carried out. However, with the outbreak of war continuation of observational work became more and more difficult and the programme of inquiry had to be much reduced. Many valuable plants were lost either in air raids or from neglect (Manton, 1950a). Publication was delayed and was only overcome with the completion of a book in 1950.

The second theme that was the focus of Irene's attention was the spiral structure of chromosomes during mitosis and meiosis. Irene first published a short note on this in *Nature* (Manton, 1936). This was expanded in 1939 and from the outset she appreciated that this topic was a minefield. In the introduction to the 1939 paper she says:

> "I am, however, fully conscious of the innumerable pitfalls with which the subject abounds and am prepared to find that some of my observations and deductions may need modification. Nevertheless, since a comparable body of evidence does not appear to exist for any other cytologically worked organism the risk of error is perhaps worth taking." (Manton, 1939a)

Osmunda was again the fern used, as its chromosomes were particularly large. The conclusions of her 1939 paper were that a chromosome is fundamentally a contorted structure that will neither become straight nor untwist except under special circumstances. The contortions were of two orders of size, one a visible spiral of microscopic dimensions, the other a submicroscopic convolution possibly of molecular dimensions. With respect to changes in length of chromosomes Irene concluded that: 1. The chromosome in prophase of meiosis differs from that in mitosis by its length, 2. The extreme elongation is associated with chromosome pairing whenever it occurs and 3. Extreme elongation is followed by supercontraction (Manton, 1939a).

Figure 9. Photograph of Irene in the greenhouse with a potted fern University of Manchester (Photograph from the Family Archive)

The analogy between the behaviour of chromosomes, with respect to their 'contortion' and changes in length by 'supercontraction', and proteins such as keratin was discussed at some length. William Astbury, an eminent X-ray crystallographer at Leeds University, had published widely on spiral structure and supercontraction in proteins, in particular keratin. Irene quoted this work at some length and sought Astbury's advice at first hand. This could have been the beginning of a collaborative relationship between a botanist and a crystallographer who had mutual interests in complex biological structures, especially since in 1946 Irene moved to Leeds. However, this was not to be and in retrospect the reasons for this are clear for on reading J.D. Bernal's (1963) obituary of Astbury, we learn that Astbury was an 'intuitive thinker' and was inclined to be 'rash and lacked self-criticism'. These attributes were diametrically opposed to Irene's temperament, which was analytical, cautious and self-critical. An incident that occurred in 1953 illustrates the point conclusively (see Chapter 4).

Even now the higher-order organization of chromosomes is still not fully understood in spite of the molecular revolution. There are several models none of which fit all the known facts. What was clear in 1939 was that the underlying structure could not be resolved using light microscopy alone and Irene appreciated this whilst working on the problem. This conclusion coincided with the publication of an article entitled "The Electron Microscope" by L.C. Martin (1938) in the December 1938 issue of *Nature*. The article was illustrated by a micrograph of bacteria taken by von Borries, Ruska and Ruska in Berlin "at the unprecedented magnification of x 16,000" – the best magnification that Irene could obtain with her light microscope was x 2000. Armed with a copy of this article in Easter 1939 she visited the National Institute of Medical Research (NIMR) then located in Hampstead and met the Chief Microscopist Dr J.E. Barnard in order to find out whether there was an electron microscope in which she could view her specimens of chromosomes. The reply she received was unexpectedly discouraging, she was told, "No there isn't and it will be one hundred years before there is one" (Manton, 1978c). This reply suggested that she could usefully get on with something else whilst waiting.

On a previous visit to the NIMR Irene had been briefly introduced to ultraviolet microscopy. The Institute owned a 'Beck-Barnard' microscope, so-named because Dr Barnard had designed the instrument and Beck, a firm of microscopists, had manufactured it. In a much later unpublished article written by Irene assisted by Bryan Clarke (see later), five reasons were given, in addition to the extra resolving power of UV light (approximately twice that of visible light), that would favour the use of ultraviolet microscopy for the analysis of the direction of coiling of chromosomes. Perhaps the most important of these was the opportunity of obtaining precise optical sections of specimens – by bringing together a series of optical sections the organisation of a spiral could be re-constructed. Thus the deflection into UV microscopy became a dominating aspect of Irene's research. Throughout the war years she spent approximately three days a month visiting the NIMR laboratory in Hampstead. Two problems relating to the method of preparation had to be overcome. Firstly, it was not possible to squash cells with the brittle quartz coverslips required for UV microscopy. Secondly, stains, such as acetocarmine, which were essential for detecting dividing cells in the preliminary light microscopy emitted undesirable fluorescence when subjected to UV light. To overcome these shortcomings, cells were squashed in acetocarmine on glass slides with glass coverslips and viewed as normal. Dividing cells were subsequently transferred to a quartz slide and covered by a quartz coverslip. The specimen was then decolourised and viewed with UV microscopy. In this way it was possible to gain a greater insight into the coiling and length of chromosomes in *Osmunda*. Both right-handed and left-handed coiling was observed; homologous parts of sister chromatids were coiled in the same or in opposite directions; changes in direction could occur along a chromosome arm and may involve both chromatids at the same point or one only (Manton and Smiles, 1943).

The Second World War affected life in many ways and this was particularly so in a large industrial city such as Manchester. During the 1930s Irene had travelled extensively in Europe and was well aware of the gathering storm clouds. In preparation for war she prepared a series of documents outlining her findings should she or the material be lost during hostilities (Family archive). The 1939 paper on spiral structure of *Osmunda* chromosomes was published in August and Irene took reprints to an international genetics congress in Edinburgh in September 1939. This coincided with the declaration of war on September 3rd whereupon the meeting broke up in disarray before her papers could be distributed (Manton, unpub.). This was a relatively minor matter compared with the fact that some of the American delegates returned to the USA on the ill-fated *Athenia*, a liner torpedoed off the coast of Northern Ireland as the first shipping casualty of the war.

During the war University lecturing was declared a reserved occupation. In Manchester life had to be lived with 'black-out' and the constant fear of air-raids – the worst attacks were in November and December 1940 with a particularly ferocious 'blitz' immediately before Christmas 1940. Fortunately the University escaped comparatively lightly. University staff remaining in Manchester had to perform various duties of national service including fire watching (Rowley and Lees, 2001). Staff and students were deployed on buildings throughout Manchester to put out fires started by incendiary bombs. Irene and her friend Dorothy Emmet were taught how to use stirrup pumps and supplied with long-handled shovels and buckets of sand. Montagu Drummond, Professor of Botany, donned uniform

and became Major Drummond, Officer Commanding the Manchester University Contingent Senior Training Corps (Rowley and Lees, 2001). In 1942, the normal three-year undergraduate degree was reduced to two years and three months and a fourth term was introduced. Irene pursued her monthly visits to the NIMR in London and she also continued her vacation visits to her parents in Dartmouth. George Manton now owned a handloom and was assisting the war effort by weaving woollen blankets and items of clothing. For this he was able to obtain a special licence that allowed him to purchase yarn. Milana was by now bedridden and oblivious to what was happening around her. Dartmouth, although in rural Devon was nevertheless not immune from the war. Plymouth, badly bombed during the war, was only 40 miles away; Dartmouth was home to the Britannia Royal Naval College and the area south of Dartmouth, known as the South Hams, was evacuated to provide practice for the Normandy landings of 1944. In spite of all these distractions and uncertainties, Irene gained her Doctor of Science (ScD) degree from Cambridge University in 1940 and continued with her research on ferns:

> "We did indeed punctiliously pull our weight in civil defence and our research was inevitably reduced in amount. We wrote fewer papers, feeling that some other things were more important, but when it came to the crunch concerning what should be eliminated completely, it was sleep, meals or recreation, but under no circumstances our last fragments of research. Time thus curtailed was nevertheless precious and, with the ever present feeling that death for us or other people might be lurking just around the corner, we, or at least I, became much more selective in the type of research to which we clung. . . . It seemed necessary to concentrate attention on the most difficult type of problem with which one was in contact. For me this meant conquering the Pteridophyta" (Manton, 1974).

In 1940 Lang retired from the Chair of Cryptogamic Botany, and whilst there was some talk of Irene succeeding him in the post in the event Claude Wardlaw from Glasgow was appointed. In 1942 Lang was awarded an Honorary Degree of LL.D. by Manchester University with the citation that he had "the patriarchal presence, the grave dignity, the god-like calm, and serene wisdom appropriate to a great scholar" (Salisbury, 1961). The respect between William Lang and Irene was mutual for Lang made Irene an executor of his will.

A seemingly minor incident occurred in 1944 that was to play an important part in Irene's future research. One day when she was supervising a practical class she heard the sound of a Cambridge rocker microtome in the next laboratory, which was disturbing her class. On going to see what was happening she found Bryan Clarke, an 18 year-old technician, cutting sections of wax-embedded material. With her unfailing ability to spot a good craftsman when she saw one she realised that Bryan had talent beyond his years. After a discussion with Drummond, Bryan became Irene's personal assistant. In this role he prepared the fixatives, stains and reagents for fern cytology, and processed the micrographs. Bryan recalls to this day the smells and noises of the cytology laboratory – the mixture of clove oil, xylene, chloroform and formal-acetic-acid. The collaboration between Bryan and Irene worked so well that when she was appointed to the Leeds Chair of Botany in January 1946, Bryan followed in the summer of 1946 and remained at Leeds until 1959 (see chapter 4). His initial role was to facilitate the installation and operation of a UV microscope in the Leeds department, but his great achievement was to be co-author of the seminal papers on flagellar ultrastructure.

In 1945, following the Normandy landings and the advance of Soviet troops in the East, it became clear that the Second World War was nearing its end. A period of unprecedented change was about to occur. At the end of October 1944 Joseph Priestley, Professor of Botany at Leeds University, had unexpectedly died. It is not clear how many candidates were considered for his replacement, but Irene was interviewed for the post in June 1945, soon after VE day, and she was duly appointed to the chair with the caveat that she had to negotiate the date of her transfer from Manchester. After consultation with the Manchester authorities it was agreed that she should take up her appointment starting January 1st 1946. The remainder of 1945 was to be another period of stress in Irene's life for on December 1st her mother Milana died. Her father was deeply saddened by this experience and then, unexpectedly, on December 30th he himself died. These traumatic experiences led to the final estrangement between Irene and Sidnie. At first sight the reasons for this appear to be trivial. Irene, the sole recipient of her father's estate, was anxious to empty and sell Cheyne Lodge as quickly as possible so that she could buy another property in Leeds. Sidnie, who was not scheduled to receive anything from the will, nevertheless wanted to inherit some small items of sentimental importance, such as the tools her father had used for his jewellery and carpentry. In the event these were packaged up and taken to Leeds. Finally an exchange of furious letters took place between the sisters who did not communicate again, unless by accident or of necessity, for the rest of their lives.

CHAPTER 4

Yorkshire Grit – First Electron Micrographs

On July 18th 1945 the Acting Registrar of Leeds University wrote to Irene: "I have the honour to inform you that the Council to-day confirmed your appointment to the Chair of Botany in the University, at a commencing salary of £1,100 a year". And so Irene became the first woman professor and first woman Head of a Department at Leeds University. One day later Irene replied to thank the Assistant Registrar for his letter and said that "I have had an interview with our Registrar (of Manchester University) who informs me that after consultation with the Vice-Chancellor and Professor Drummond he wishes to retain my services until December 25th".

Following her interview for the post, Irene was asked to provide a summary of her career so that it could be released to the general press. This she did on July 2nd 1945 and, maybe pointedly, she finished by emphasising the excellent working facilities and relationships she had enjoyed in Manchester:

> "Whilst it is obvious that I owe a great deal to Girton College and others for the excellent start which they made possible, especially in my early postgraduate years, it would be ungracious if I did not specifically acknowledge my indebtedness to Manchester. From the day I first went there under Professor F.E. Weiss (now emeritus professor) until now I have enjoyed working conditions and research facilities that could hardly have been improved upon and which few other botanical departments in Great Britain could have provided. In particular I have for fifteen years had the privilege and pleasure of a close working relationship both in teaching and in research with Professor W.H. Lang until 1941 professor of Cryptogamic Botany in Manchester now emeritus professor. This has been a scientific education which in my opinion far exceeds in value every other qualification I possess." (Leeds University Archive)

During the interview for the chair of botany, Irene pressed the panel to make any appointment dependent on the provision of experimental garden facilities, for the cultivation of plants, and a technical appointment for Bryan Clarke. The University authorities agreed to both these requests. Hidden behind these pleasantries, Irene had a clear vision of the challenge ahead, which was to raise the standard of the Botany Department in Leeds to that Weiss and others had built up in Manchester. The success of this challenge was to involve many clashes of will between Irene and the University authorities.

The University in Leeds, like that in Manchester, was founded in the nineteenth century. The generally accepted date for its origin is 1874, the year in which Yorkshire College of Science was founded, which places Leeds amongst the second generation of nineteenth century English Universities. For a short period (1887–1904) the Yorkshire College, along with Owens

College Manchester and University College Liverpool, comprised the Victoria University (Taylor, 1975). However, with the dissolution of Victoria University in 1904, the Yorkshire College became the University of Leeds. Like Owens College Manchester, the Yorkshire College was non-sectarian and looked no further than the local middle-class for its supply of students. However, whereas Owens College from its outset embraced a broad curriculum by appointing five professors and one assistant with responsibilities in the teaching of Greek, Latin, Hebrew, English, History, French, German, Mathematics, Physics, Chemistry, Zoology and Geology, the Yorkshire College made no attempt to match this breadth of commitment. Instead it placed emphasis on more applied scientific studies, such as Engineering, Manufacturing, Agriculture, Textiles, Mining, and Metallurgy, which the older Universities had long neglected. In two other important respects Manchester differed from Leeds; Owens College was better endowed than the Yorkshire College and life was more cosmopolitan in Manchester. The cotton industry in its nineteenth century heyday brought both wealth and people of many nationalities to Lancashire and induced the growth of a vigorous social and cultural life among the industrial and mercantile middle class (Taylor, 1975).

Following the dissolution of the Victoria University, of the three constituent colleges, Yorkshire College was judged to be the least satisfactory in most respects (Taylor, 1975). This feeling of inferiority remained for many years, although there were occasional respites such as the appointment of William Bragg to the Cavendish Chair of Physics in Leeds in 1909, which matched the appointment of Ernest Rutherford, Nobel laureate, to the Chair of Physics in Manchester. Whereas Owens College had been founded by a gift of £100,000 by John Owens, the Yorkshire College could only draw on donations amounting to £20,000. In terms of buildings, differences were also apparent. Until 1945, Manchester University was housed in predominantly well-appointed Victorian gothic-style buildings giving a collegiate feel to the University. Leeds, on the other hand, had to purchase large houses, which were either demolished to make way for new buildings or incorporated into the University. Some of the houses, now listed buildings, and adjacent streets remain to this day. Over-crowding and poor accommodation was a constant problem in Leeds and from the founding of the University "morale was more than once brought low in departments to whom new premises had to be denied year after year, sometimes decade after decade" (Beresford, 1975). The Leeds botany department, at the time of Irene's arrival in 1946, was housed in two buildings – the East wing of the Baines Building that was built in 1907 as 'temporary' and two houses (Botany House) dating from the 1820s in Beech Grove Terrace. Description of the buildings makes for macabre reading, the basement of Botany House was ridden by cockroaches that ran in all directions when disturbed by a visitor.

Compared with the botany department in Manchester, the department in Leeds was in decline. Joseph Hubert Priestley had been Professor of Botany in Leeds for 35 years when he died at the untimely age of 61 years on October 31st 1944. Prior to this appointment he had for six years been Professor of Botany at University College, Bristol. His father had been headmaster of Tewkesbury Grammar School and his brother, R.E. Priestley, was Secretary of the Board of Research Studies at Cambridge University and was the administrator with whom Irene had corresponded throughout her postgraduate years. Joseph Priestley's specialities were plant physiology, in particular carbon fixation in photosynthesis, fat metabolism and tree growth. In the latter he was interested in cambial behaviour and the

deposition of secondary tissues. He is probably best remembered for the widely used textbook *An Introduction to Botany* (Priestley and Scott, 1938). Judging from the obituaries at the time of Priestley's death, he was a highly regarded senior professor who had served on many committees within the University and had been Pro-Vice-Chancellor for four years. He was described as being outstanding as a teacher and in stimulating research. Other members of staff in the botany department at the time of Priestley's death included Lorna Scott, co-author of the textbook; Arthur Sledge, a taxonomist, and Reginald Dawson Preston (1909–2000). Since Irene did not take up her post until January 1st 1946, staff within the department experienced an interregnum of almost 18 months during which time Lorna Scott oversaw the running of the department.

The second half of 1945 was a difficult time for Irene. She had to complete her teaching duties in Manchester, she paid several visits to Leeds and in November she had a spell in hospital. In December both her parents died. On January 1st 1946 Irene wrote to the Vice-Chancellor to explain the situation: and said

> "I may need to call upon the forbearance and kindness of you and my other future colleagues to quite an unusual degree before I am effectively launched as your 'first woman professor'."

After clearing out Cheyne Lodge in Dartmouth she placed the house on the market and set about looking for a property in Leeds, which immediately after the war was no easy task. Eventually she found 15 Harrowby Crescent in West Park, just north of Headingley and within easy reach of the University by bus. The cost of the house, £3,500, was exactly what she obtained for Cheyne Lodge and as part of the move she brought with her Miss Edith Pay, her parents' housekeeper. Edith lived in 15 Harrowby Crescent for 23 years until Irene's retirement in 1969. The house was semi-detached with spacious rooms and a small garden. Some of the furniture that she brought with her had been carved by George Manton and is still owned by the family. The loom that George had used during the war went to friends in Babbacombe, and some of the woven items were hung on the walls rather like small tapestries.

Now Irene had to concentrate her thoughts on the department, her research and devising new teaching programmes for the flood of students that was to descend on the University after the war. The student population in 1946 was just over two thousand. The senior administration had been reorganised in 1946 and the position of Registrar was re-defined as being "a man fully able to appreciate the ultimate objects for which the University exists and able to understand the work and point of view of the teaching staff." (Mattison, 1975). The Registrar was to be an "officer of substantial status" who would be responsible for the business of Faculties, Boards and Senate, and also for mixed academic business affairs involving University development, halls of residence and departments. Dr John Vaughan Loach, a biochemist by training, was appointed to this post in 1945 and remained Registrar until 1971. Thus for the whole of the period Irene was head of the botany department she had to carry out business with Dr Loach.

The tenor of the relationship between senior members of the administration and Irene was cautious, it varied between grudging mutual respect, to exasperation and annoyance on both sides. If the Vice-Chancellor and his colleagues thought they had taken on a Lady Scientist, they were quickly disabused. Irene applied the same sort of direct logic and

immediacy to administrative matters as she did to her research, her desire for rigour meant that dissimulation, even in a benign form, was not part of her character.

Over the years Irene produced several lengthy documents, mostly for the Vice-Chancellor or Registrar, drawing attention to important matters of departmental concern. They are written with a clarity and logic that leaves nothing to the imagination. The first of these is entitled 'Memorandum on the Botany Department Buildings' written in July 1947 (Leeds University Archive) and is of particular interest because it gives a vivid picture of the department she inherited and her thinking at the time. Two extracts from the introduction indicate the seriousness of the situation:

> "In September 1945 I had been so appalled by my first close view of things as a prospective head that I wrote to the Vice-Chancellor pointing out among other things the grotesque costliness to the University of inefficiency on the scale which must have prevailed here for many years and expressing doubts whether the task for which I had been appointed could be carried out unless the basic structure of the building to contain the department could somehow be provided. Later, after my arrival in 1946, I informed the Bursar that, in addition to all of this, almost everything in my so called Department was on a verge of collapse (much of it indeed since collapsed) and that without very powerful support I might be unable to prevent a second-rate department from sinking to a third-rate department in the very near future.
>
> Staff, research students and equipment are housed in rooms which do not keep out the weather and which, as recent experience has shown, are liable to fall down physically at any moment. Botany House is so decrepit that every part of the building shakes when simple things like the front door are opened or shut and the vibration caused by passing footsteps in the building is so great that for critical work we are forced to use dank cellars."

This is followed by a statement of Irene's determination not to allow the situation to deter her research indefinitely:

> "Unless *there is* some reasonable prospect of attaining stability . . . *in* the next twelve months, I for one will find it unbearable. As it is I have laid aside the most important research programme of my life and given unstinted service for two years at the request of Leeds. I am prepared to do the same for one more year. I am <u>not</u> however prepared to devote my whole creative life to what at present looks like a bottomless pit and the progress or otherwise of effective planning in the next twelve months will absolutely determine the length and quality of the service that Leeds may expect of me."

She then outlined the present difficulties with the department, the fact that rooms of the department are separated into four areas, three within the Baines Building and the rest in Botany House on the other side of University Road. She makes a number of suggested remedies in the short and long terms respectively. Finally she ends up by stating:

> "I am told that the contents of Botany House have actually been removed no less than three times in the life of the existing staff, a fact in which (*sic*) itself can explain the low scientific vitality and chronic disorder which characterised it at the time of my arrival . . . *The interruption of my research* for any purpose other than that of providing relatively permanent and ample accommodation in a unified relation to the rest of the department might well be quite fatal and merely result in a general dispersal of all the more creative members of the staff to less difficult conditions elsewhere."

However, in spite of these difficulties, matters were beginning to improve and Irene

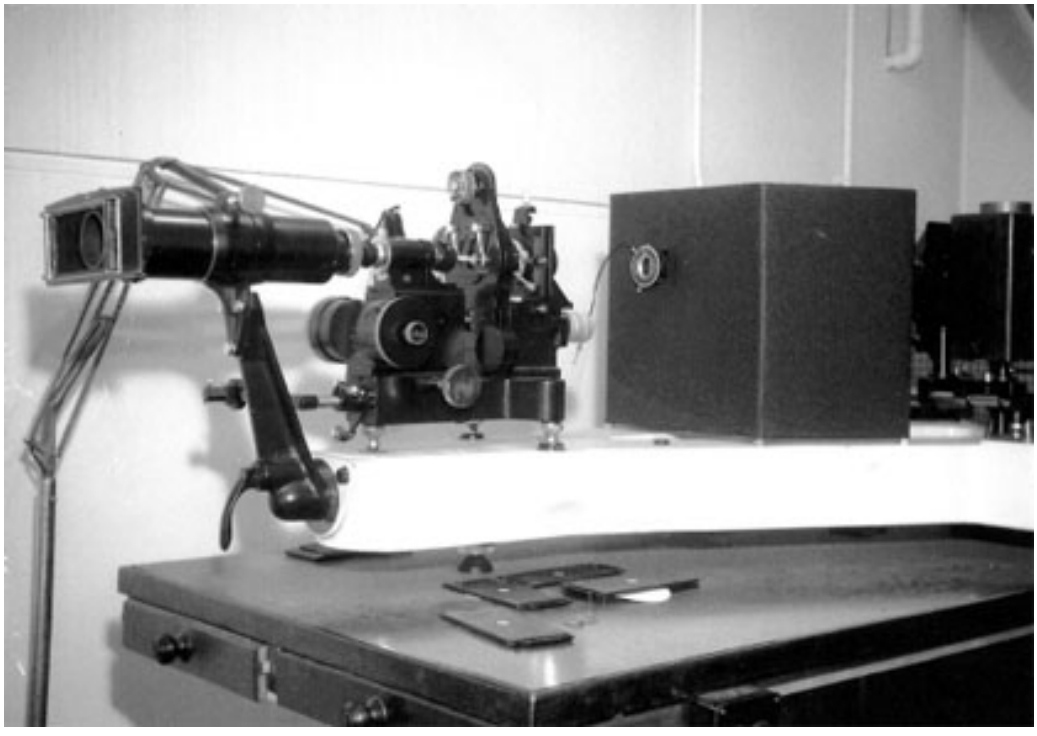

Figure 10. The Cooke Troughton and Sims UV microscope in the basement laboratory of Botany House, Leeds University (1962). Reproduced with permission of Dr Ken Oates.

was once again establishing her own research programme. In July 1946 Bryan Clarke moved from Manchester to Leeds and also in 1946 an experimental garden was purchased about one mile from the University campus. This was part of the original walled garden of Grove House. The former stables were converted into laboratories and glasshouses were erected. Ferns were transferred from Manchester and by the end of 1946 a programme of plant hybridising was re-established.

Ultraviolet microscopy, which Irene had pursued throughout the war years at the NIMR in Hampstead, now became a reality in Leeds. At the beginning of the war Irene had been offered a set of Zeiss quartz lenses for £250, which she had deposited in a bank in Manchester. Now she required a microscope to go with them. Although the instrument at the NIMR was made by Beck, this company was no longer interested in UV microscopy and she was advised to approach Cooke, Troughton and Sims in York. This well-established company had no previous experience of manufacturing UV microscopes so they sent their representative to Hampstead to view the Beck-Barnard instrument. Irene and Bryan made several visits to York and were able to influence the design of the microscope, in particular they recommended the incorporation of facilities for 'normal' light microscopy into the system which meant that the instrument could be used with great precision as a 'horizontal' light microscope. Irene managed to secure a grant of £800 from the Royal Society and an order was duly placed with the York Company. This was accompanied by a Government order for five other microscopes. Eventually, in 1948, the new microscope was completed and, after exhibition in London, delivered to Leeds where it was housed in the basement of Botany

House (Fig. 10). When finally assembled with the lenses from Manchester, and after some initial problems, it could be used for serious work. In the excitement of the moment Irene, with the assistance of Bryan Clarke, took the simplest material she could lay her hands on which consisted of the spermatozoids of *Dryopteris* prothalli fixed with iodine available from a recent teaching practical. Immediately they were able to resolve the flagella and decided to make further preparations but this time taking greater care over fixation by using osmium tetroxide vapour. To their amazement they observed the disintegration of each flagellum into approximately ten longitudinal fibres. One of the photographs taken from this experiment was used as the frontispiece of Irene's book (Manton, 1950a). The same photograph was also used in the first (and only) publication based entirely upon results from the Leeds instrument. In this paper Manton (1950b) clearly shows that the longitudinal splitting of the flagella only occurred in liquid preparations of spermatozoids fixed with osmium tetroxide vapour and then mounted in iodine solution. In specimens dried between the application of osmium tetroxide fixation and staining with iodine this disintegration did not occur. Irene reckoned that "the number of threads composing each bundle can be roughly assessed as of the order of ten". She expressed her indebtedness to Mr Bryan Clarke for the photography and "for help in many other ways".

Although the use of UV microscopy turned out to be a relatively transitory phase of Irene's work – it was rapidly surpassed by electron microscopy – nevertheless it was a crucial stage in the development of her research and marked the beginnings of her transition from being a classical botanist to becoming a world leader in botanical ultrastructure. Till her dying day she remained dedicated to the Cooke, Troughton and Sims microscope, it was a magnificent piece of engineering and when working well gave exquisite results. Bryan Clarke recalls with affection the enormity of the apparatus with its 'horrendous power supply' involving ex-Admiralty electrical equipment. This was not an instrument for the faint hearted – the noise was so great that it could be heard throughout the building; the odorous fumes produced had to be removed by an extractor fan; and a shield was required to protect the operator. Nevertheless Irene felt great attachment to this instrument and cherished the photographs taken (blind) with the microscope.

Another development was now becoming a reality. As part of the lease-lend scheme for wartime equipment, five commercially made American RCA electron microscopes were shipped to Britain, one of which went to Astbury's department in Leeds. This coincided with a visit Irene made in 1946 to a meeting in Utrecht, Holland. Following the meeting she visited Mrs van Iterson, a microbiologist, in Delft and was shown the le Poole electron microscope in the department of Applied Physics. This homemade instrument was about to be used by the Dutch firm of Philips as the prototype for the first commercially produced electron microscope, the future EM 100. Irene was so impressed by the results Mrs van Iterson had achieved on bacteria that she decided that this was the microscope that she wanted. But how could she, a lowly fern cytologist, get hold of one?

One of the younger members of staff that Irene had inherited from Priestley's botany department was Reginald Preston, a biophysicist. Preston had been interested in the physical properties of plant cell walls and as part of his PhD had worked under the supervision of Astbury on the X-ray crystallography of algal cell walls. He had also had access to Astbury's

lease-lend instrument. Irene quickly realised that both she and Preston had a mutual interest in acquiring an electron microscope for the botany department and seeing that he was a physicist, Preston's name on an application would carry more weight that that of a fern cytologist. Preston drew up an application for £14,500, including £5,500, which was the estimated cost of a Philips EM 100 not yet on the market. In 1948, this was a large sum of money and only the Department of Scientific and Industrial Research (DSIR) could afford this sort of figure, and then only for top priority research. This, again, was where Preston's unique position of combining physics with biology was essential. Irene and Preston were invited to meet the DSIR Awards Committee and as a result of their presentation were awarded 90% of what they had asked for, the total sum (£13,500) explicitly including the cost of the Philips microscope. This news came just in time for Irene to clinch the deal for one of the first EM 100s from Philips. The story that has now passed into folklore is that Irene was so determined to purchase the Philips microscope that she offered to mortgage her house to provide surety for the purchase. In later years Irene liked to recall this story, particularly in the context of Sir Bernard Lovell, another Manchester lecturer, who faced possible imprisonment due to over-expenditure during the construction of the radio telescope at Jodrell Bank (Lovell, 1968).

In 1950 the new Philips EM 100 was located within the Baines wing of the Botany Department and was nominally under Preston's jurisdiction. Irene had the foresight to appreciate that to operate a novel microscope like this would require expert technical assistance both at the operational and scientific level. For the former she managed to negotiate the secondment to Leeds of a member of the Philips technical staff, Mr Kuyper, to establish and service the microscope and train a successor, For the scientific side Bryan Clarke was given the task of establishing and developing EM techniques in the Leeds laboratory. Time on the instrument was precious and was allocated according to a schedule, which nominally gave Irene half a day a week during the next eight years (the equivalent of one film of 30 exposures per week). Bryan recalls that Irene usually managed to obtain more than this time allocation for herself and that he became adept at de-gassing five films in advance of a session to ensure a rapid changeover between films. Though easy to operate once set up, there were shortcomings with the early instruments. In particular, the 100KV required for operation of the microscope could not be achieved because of problems with the insulation on the voltage cable, which was constantly breaking down at voltages of 40-60KV. In the first year of the guarantee there were no fewer than twelve successive cables. The restriction of time and the breakdowns led to some frustration with the instrument. As Bryan Clarke recalls "the problem for Irene was the cable and Preston, and for Preston the cable and Irene". In spite of these problems Irene sent off a note to *Nature*, which included the first EM photographs of the spermatozoids of *Fucus serratus* (Manton and Clarke, 1950). Even by today's standards the photographs are of superb quality, they clearly showed the proboscis and the bilateral array of hairs on the anterior flagellum (Fig. 11).

The *Nature* 1950 paper marked the beginning of the joint authorship of papers by Irene and Bryan Clarke, which over a decade resulted in a total of 15 publications. Bryan Clarke, whom Irene had known since 1942 when he was 16 years of age and who had moved from Manchester to Leeds with her, proved to be exactly the right person to collaborate in this early work. He was a superlative craftsman and adept at devising and modifying techniques

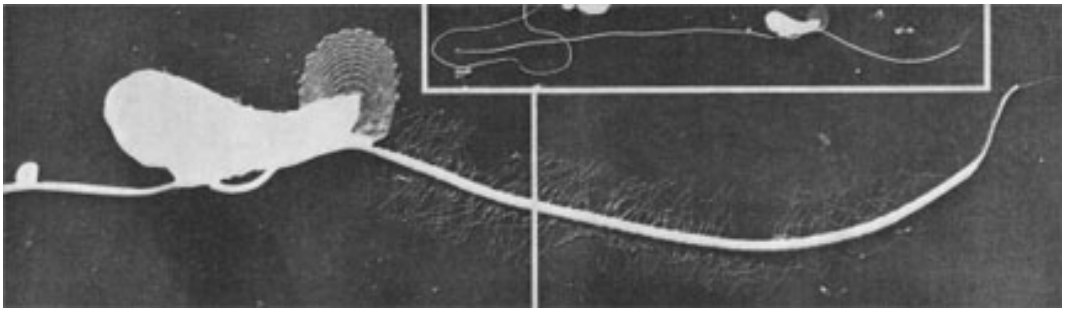

Figure 11. Shadowcast whole mount of a spermatozoid of *Fucus serratus*. x10,000. This is the first electron micrograph published by Manton and Clarke (1950). Reproduced with permission of *Nature*.

to suit the material they were using. Irene and Bryan visited many laboratories and microscopes together in search of novel techniques and improved microscopes. Together they visited the Philips factory in Eindhoven, Holland; in Manchester they used a later Philips model at the research department of Tootal, Broadhurst and Lee. One of the more bizarre visits they made was to use the Philips microscope operated by R.W.G. Wyckov at the American Embassy in London. During the 1940s Wyckov had played a key role in developing the 'heavy-metal shadow-casting' technique for visualising the appendages on dried cells in the electron microscope. After the war Wyckov became scientific advisor to the American Ambassador in London and Philips lent him a microscope that was located in the American Embassy. The security system in the building involved metal grills that isolated individual corridors at the end of the working day. After having seen and used Wyckov's microscope, Bryan and Irene found themselves almost locked in by the metal grills of the security system. As a result of these visits Bryan became a leading expert in handling and manipulating cells for electron microscopy. He developed the 'transfer' (stripping) technique, whereby fixed cells were dried onto slides and photographed with light microscopy. They were subsequently covered by a solution of cellulose nitrate in amyl-actetate which when dried produced a thin plastic film. This film could then be floated off the slide on to a water meniscus carrying with it the cell. By careful manipulation, the film could then be loaded on to a small Philips holder for shadowcasting and subsequent observation in the electron microscope. By using this technique it was possible to view the same cell with both light and electron microscopy. Although in essence straightforward, this was a sophisticated procedure that required a high level of technical skill. Needless to say the Manton and Clarke partnership and co-workers achieved spectacular results from this elaborate procedure (see especially Manton, Clarke, Greenwood and Flint, 1952).

Irene now returned to observing fern spermatozoids that had previously disintegrated to give 'approximately ten longitudinal fibres' when viewed with UV microscopy. Now in shadowcast whole mounts of the spermatozoids of *Dryopteris filix-mas* they were able to obtain a precise count of eleven longitudinal fibres. Two of the strands were "thinner, shorter and more contorted in the dry condition than the others" (Manton and Clarke, 1951a). This paper was followed by a succession of publications on the flagella of a wide range of other organisms including representatives of the algae and fungi (Manton and Clarke, 1951b, c; Manton, Clarke and Greenwood, 1951; Manton, Clarke, Greenwood and Flint, 1952). The most spectacular disintegration was obtained with the moss, *Sphagnum* (*S. acutifolium* agg.)

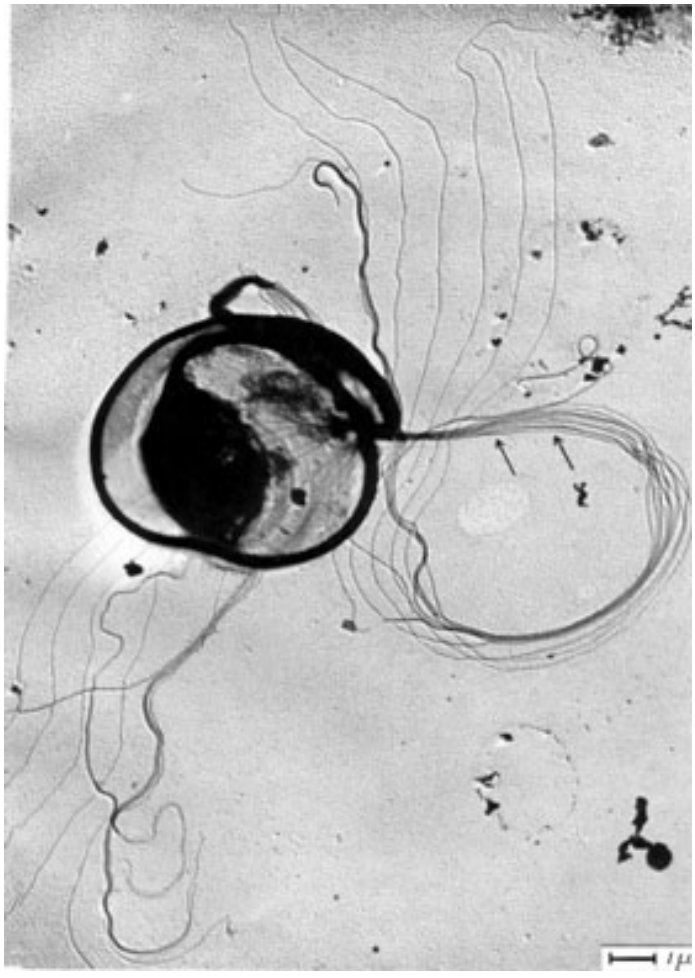

Figure 12. Shadowcast whole mount of a spermatozoid of *Sphagnum acutifolium* agg. after fixation with osmium tetroxide vapour. Note the disintegration of the flagella into longitudinal strands (after Manton and Clarke, 1952). Reproduced with permission of the *Journal of Experimental Botany*.

(Fig. 12). UV photographs were obtained in November 1949 but all the electron micrographs were obtained during 1951. In addition to the eleven longitudinal fibres, Manton and Clarke (1952) were able to ascertain that the nine thicker fibres were ‘double’ and bore intercalary projections. From their micrographs they were able to produce a diagrammatic reconstruction of the 9+2 axoneme (Fig. 13). Although disintegrated flagella, sometimes with the precise count of eleven fibrils, had been known for a long time (Ballowitz, 1888; Dellinger, 1909), and more recently from electron microscopy (Jakus and Hall, 1946; Grigg and Hodge, 1949), this was the first time that a reconstruction of the internal ultrastructure had been attempted. In retrospect the accuracy of their drawing is superlative. We now know that they correctly identified the outer nine doublet ‘tube fibres’ (microtubules) with a spiral lining between the outer doublets and the central sheath (spiral arrangement of radial spoke groups) and the central sheath around the two central microtubules (Satir, 1995). The only mistake of significance is that Manton and Clarke (1952) thought the two central microtubules were

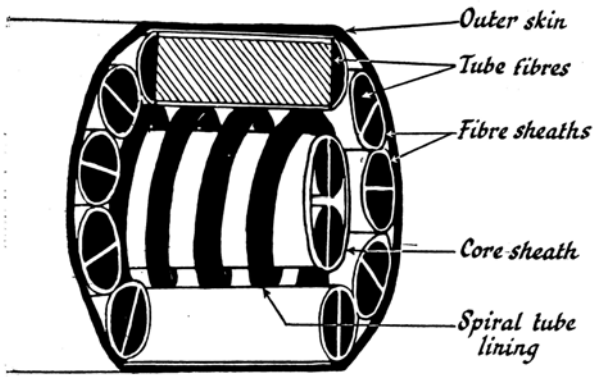

Figure 13. Drawing from Manton and Clarke (1952) showing a reconstruction of the cilium of *Sphagnum acutifolium* agg., based on shadowcast whole mounts of osmium fixed spermatozoids. Reproduced with permission of the *Journal of Experimental Botany*.

also double whereas in fact they are single. In a later note to *Nature* (Manton, 1955b) the plane of bilateral symmetry, which passes between the two central microtubules (not through them), was also determined correctly.

The Manton, Clarke and co-workers' papers (six in two years) demonstrating the consistency of the '9+2 flagellar axoneme' in plant cells took the scientific world by storm. Almost overnight Irene found herself in the vanguard of biological electron microscopy. It is difficult now to appreciate the excitement that was aroused when Irene showed her micrographs at international meetings; it was not uncommon for the audience to break out in applause when she showed her slides. At the 8th International Botanical Congress (July, 1954) in Paris, following her presentation (Manton, 1954d) she said that if anyone would like to know the technical details they should ask Mr Clarke who was in the audience, whereupon the audience applauded Bryan's presence. This was the beginning of a remarkable transformation in that Irene now became a celebrity – the combination of brilliant pictures, her slightly dishevelled mode of dress and her sense of humour made her the 'star attraction' at a meeting. Plant ultrastructure had come of age – she was a good storyteller and with her outstanding photographs, the combination was irresistible.

Within the Leeds department matters were beginning to improve. Slowly Irene was able to build up the staff with the arrival of Robert Brown (plant physiologist) and Dennis Greenwood both of whom she had known at Manchester; John Lovis and Trevor Walker (fern cytologists), Alan Wesley (palaeobotanist), David Bartley (quarternary palynologist). The technical side was also strengthened by the arrival of Ken Oates who became responsible for the new Siemens electron microscope that was acquired in 1956. Buildings were slowly refurbished but not without considerable effort to persuade the University authorities. Celebrity status together with Irene's single-mindedness and determination led to some unsettlement in the department, the details of which reached the ears of the Vice-Chancellor, Sir Charles Morris. As a result Professor Dainton, Head of the Physical Chemistry Department (and husband of Barbara Wright (see Chapter 3)), was asked to "keep an eye on the

Department of Botany" (Dainton, 2001). Dorothy Emmet, who had shared accommodation with Irene in Manchester, and was a personal friend of Sir Charles, was also asked for an opinion. Fortunately, these matters were to blow over as it became more and more apparent that for such an original and creative person there would inevitably be a downside. Irene could be demanding and single-minded but underlying her brusqueness was a caring and affectionate personality that her close colleagues came to recognise. An incident involving Professor Astbury, who was head of the neighbouring Department of Biomolecular Research and a Fellow of the Royal Society, gives an insight into Irene's unbending commitment to scientific rigour no matter how eminent the person involved. Astbury and Saha (1953) independently published a picture in *Nature* of a flagellum of the green alga *Polytomella magna* showing longitudinal splitting into only nine fibrils. Irene was so horrified by this result that she immediately sent a note to *Nature* (Manton, 1953b) in which she said:

> "Readers of *Nature* who may have noticed the simultaneous appearance in the issue of February 14th of two independent communications on plant cilia, one of them an abstract of a paper of our own, could be misled by the accidents of context and wording into the belief that we are trying to use the internal structure as a basis for phyletic conclusions and that there is a fundamental difference between the green algae in which Astbury and Saha have found nine strands and all other plants in which there are eleven."

She went on to point out that there could only be two explanations for this aberration:

> "Where other numbers have been reported this is sometimes, and possibly always, due to imperfect observation or to imperfect material" (Manton, 1953b).

As if her commitments to the department and electron microscopy were not enough, the period between 1946 and 1950 also saw the completion of her book entitled *Problems of Cytology and Evolution in the Pteridophyta* (Manton, 1950a). As noted at the beginning of the Preface to her book, "the publication of this book is one of the more harmless consequences of the Second World War". This book represents most of her fern work, except for aspects of chromosome structure, for the period 1932–1948. The war had delayed publication and the accumulation of so much information made it sensible to publish the work in book form. The book opens with an introduction to 'the method' (Chapter 1), by which is meant polyploidy and the methods by which auto- and allo-polyploids can be recognised cytologically. Chapter 2 sets out the problem, which refers to pteridophyte life-cycles. Chapter 3 presents the *Osmunda* story, much of which had already been published previously. The remainder of the book can be divided into seven sections: Chapters 4 and 5 deal with *Dryopteris filix-mas* and *Dryopteris* in Britain respectively; Chapters 6 and 7 cover the other British ferns including *Polystichum, Athyrium, Asplenium* and *Ceterach*; Chapter 8 is concerned with *Polypodium vulgare*; Chapter 9 adds further information on *Scolopendrium hybridum*, *Woodsia* and *Polystichum illyricum* from species hybrids of non-British origin; Chapters 10 and 11 consider the apogamous ferns; Chapters 13–15 deal with other members of the Pteridophyta (*Equisetum*, the Psilotales, the clubmosses and quillworts); Chapter 16 details the 'ancient' ferns.

By January 1949 the manuscript and illustrations of the book had been completed and were ready to hand to the publisher. Two events then happened. Firstly, the UV photograph of the spermatozoid of *Dryopteris villarsii* illustrating disintegrated flagella was added as the frontispiece for decorative purposes. The second event, equally prescient, was that Irene

Figure 14. Gabor Vida, a visiting pteridologist from Hungary, and Irene Manton in Botany House in the early 1960s. Reproduced with permission of Professor Anne Ashford.

together with two departmental colleagues, Arthur Sledge and Herbert Baker, visited Madeira for 'recreational purposes'. As Irene says "observational habits die hard" and in three weeks they had an almost complete collection of fern species from the island, many of which were fixed and examined in the field (Manton, 1974). These were brought back to Leeds, established in cultivation, and examined cytologically. Thus at the last moment comparisons between ferns of the British and Madeira floras could be made in the book. Complete publication of the cytology of the fern flora of Madeira would have to wait another 37 years (Manton, Lovis, Vida and Gibby, 1986) and was the last fern publication Irene was to complete.

The discussion and conclusions that emerge from the book are of broad interest. The relationship between the frequency of polyploidy and latitude was considered in detail – at the time, mostly from European data, the frequency of polyploidy in plants appeared to increase proportionally with latitude. It seemed that polyploidy might be an adaptation to cold conditions. This to some extent seemed to be borne out by Irene's data. The percentage of polyploidy in the fern floras of Britain and Madeira respectively was 53% and 42%. However, Irene concluded that polyploidy itself was not an adaptation to cold or any other single climatic or ecological factor but that it correlated with climatic or geographical upheavals however caused. A second conclusion was that the pteridophytes, whilst employing many of the same evolutionary mechanisms as those of flowering plants, have in some respects proceeded further than flowering plants, as their longer history had led us to suspect. These preliminary conclusions have had to be modified as more data have become available. However, the book, the only one Irene was to write, became a classic (Walker, 1983) and established "an entire field of current research" (Lovis, 1977). It was the beginning of a story that is still being worked on today and that generated future projects for a distinguished group of research students in Leeds and elsewhere.

CHAPTER 5

The Golden Years – Ultrastructure of the Algae

The electron microscope transformed Irene's life and research. It is still difficult to appreciate how it came about that a classical fern cytologist should make this leap into an *avant garde* branch of microscopy. As with UV microscopy, the connecting thread – to resolve chromosome structure more thoroughly – was not achievable with the techniques available at the time. In fact she did not attempt to view chromosomes or ferns, other than their spermatozoids, with the electron microscope. She moved with speed and impeccable timing into a much more productive line of research, namely the ultrastructure of algal flagellates and for this she owes a debt of gratitude to Mary Parke of the Marine Biological Association, Plymouth.

Figure 15. Photograph of Irene Manton (right) and Mary Parke (left) inspecting photographs of *Pyramimonas* sp. Photograph taken in the late 1950s. Reproduced with permission of Mr Bryan Clarke.

Mary Parke (1908–1989), Mamie to her family and friends, was born in Bootle, Liverpool of Anglo-Irish Roman Catholic parentage. She showed promise in biology and music as a young girl but decided to study honours botany at Liverpool University from

where she graduated in 1929. Her PhD also at Liverpool was carried out under the supervision of Dr Margery Knight on the systematics, growth and distribution of seaweeds, particularly brown algae, around the South East corner of the Isle of Man. She remained as the resident algologist in Port Erin and turned her attention to the cultivation of oyster larvae for which she required cultures of planktonic nanoflagellates (flagellates <20μm diameter) as food organisms. She quickly became adept at single cell isolations, using the micropipette technique, and their subsequent growth in various media. Her earliest cultures date back to the mid 1930s and several species, such as *Isochrysis galbana*, were particularly successful and are used extensively in oyster hatcheries today. At the time of isolation the taxonomy of these flagellates was poorly understood and so cultures were given letters or numbers. In 1941 she moved to the Marine Biological Association (MBA), Plymouth where, after the war, she returned to her work on flagellates and started a culture collection, which eventually built up to over a hundred different strains. In an attempt to classify and describe these isolates, Mamie produced the first paper in a series entitled *Studies on Marine Flagellates* (Parke, 1949). However, the task in front of her was formidable, maintenance of the culture collection was a full-time task and description of the flagellates was difficult because of the lack of satisfactory characters when viewed with light microscopy alone. With these problems in mind she turned to Irene for assistance. In retrospect, this was the best decision that Mamie could have made for Irene, with the assistance of Bryan Clarke, had independently developed exactly the right techniques for handling minute swimming cells. The collaboration of two such talented but temperamentally different women resulted in an outpouring of publications that was to secure their names for posterity (Fig. 15).

Marine nanophytoplankton comprise photosynthetic flagellates and suspended cells from a variety of taxonomic groups, in particular the ‘golden-brown’ algae (tentatively Chrysophyceae), the ‘green’ algae (Chlorophyceae and Prasinophyceae), ‘pink’ algae (Cryptophyceae), diatoms (Bacillariophyceae) and the blue-green algae (Cyanophyceae). Although small planktonic species (nanoplankton) had been recognised at the end of the nineteenth century (in fact some species were described from the Challenger Expedition (1872–76)), descriptions were generally limited because specific details that might be used for identification were just too small to be resolved by standard light microscopy. The literature relating to these organisms was also scattered in journals and monographs, many of the descriptions being in French, German, Russian and the Scandinavian languages. Here, fortuitously, were rich hunting grounds for Irene – the talents required to unscramble this subject were exactly those that she had. The Leeds EM techniques could not have been better tailored to resolve the necessary detail; her ability to read and write most of the languages comprising the literature and her contacts with the major libraries in London (NHM, the Linnean Society, the Royal Society) and elsewhere as well as the MBA meant that she could quickly track down and interpret obscure descriptions. However, what neither she nor Mary Parke could have known at the outset of their collaboration was that these flagellates contained a splendid range of structures of cell biological interest.

The first flagellates to be studied by them were described as golden-brown “with three rather long filiform appendages, two of which are flagella” (Fig. 16) (Parke, Manton and Clarke, 1955). There was little doubt that they belonged to the genus *Chrysochromulina* Lackey that in 1955 was placed in the Class Chrysophyceae. Shadowcast whole mounts for

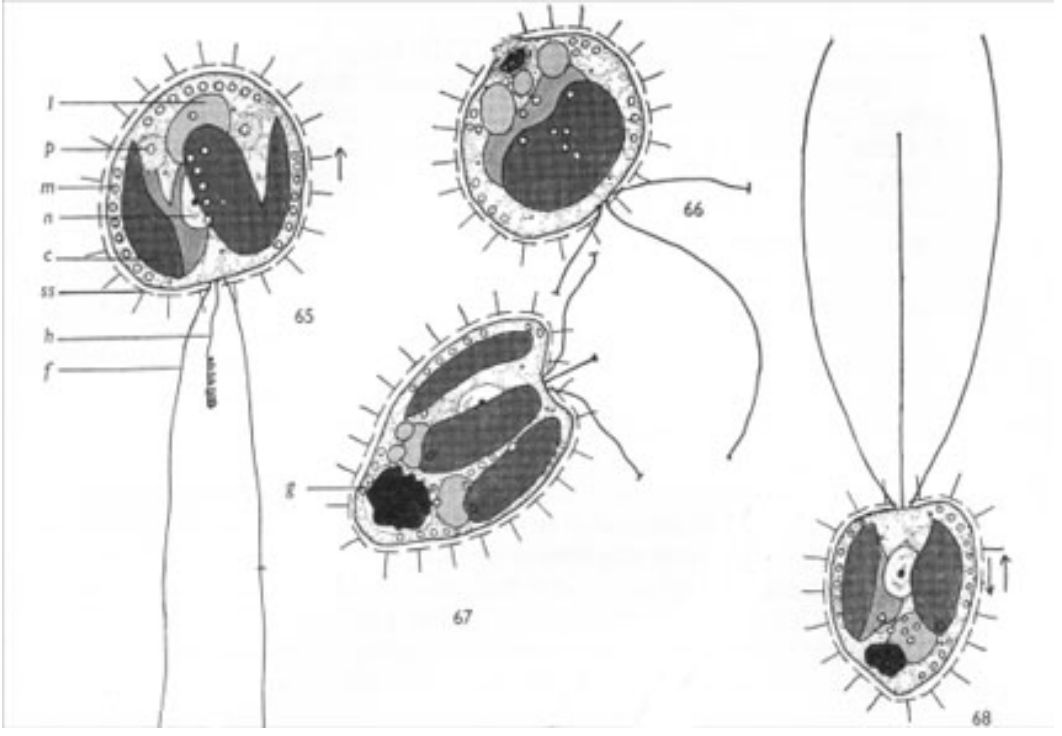

Figure 16. Drawings of *Chrysochromulina brevifilum* accompanying the description of this species (Parke, Manton and Clarke, 1955). The cell is covered by spined scales and between the two flagella is the haptonema which in 'fig. 65' is partly coiled. *c*, chromatophore; *f*, flagellum; *h*, haptonema; *l*, leucosin; *m*, muciferous vesicle; *n* nucleus; *p*, pyrenoid-like body; *ss*, spined scales. Reproduced with permission from the *Journal of the Marine Biological Association of the UK*.

EM quickly showed that the 'third filiform appendage' was not a flagellum at all and so they called it the *haptonema* (*hapto* = sticky; *nema* = thread) because of its tendency to attach to surfaces. They also observed thin, plate-like, patterned 'scales' covering the surface. Details of the morphology and fibrillar patterning of these scales became the major features for taxonomic identification, these characters could be recognised from shadowcast whole mounts (Parke, Manton and Clarke, 1956; 1958; 1959). However, the ability to probe these cells further would require the development of a facility for ultrasectioning.

In November 1952, Irene had received a letter from Don Fawcett, then at the Harvard Medical School, enclosing some original prints of sections of cilia from a frog, a mollusc and a human each showing the 9+2 structure (Fawcett and Porter, 1952, 1954) similar to the reconstruction that Irene had published earlier in the year (Manton and Clarke, 1952c). The sections had been cut in Keith Porter's laboratory at the Rockefeller Institute, New York. In February 1954 Irene visited the Rockefeller Institute with the intention of learning how to section plant flagella (Manton, 1978c). Using a culture of the green alga *Pandorina*, she fixed and methacrylate embedded colonies and obtained sections of the 9+2 axoneme, photographs of which were published in the proceedings of the 1954 EM Congress held in London. The 'Porter-Blum' microtome, named after Keith Porter and J. Blum, the chief mechanic at the Rockefeller Institute, was eventually manufactured commercially by Ivan

Sorvall Inc. Irene brought a Sorvall-produced Porter-Blum microtome back with her from New York in 1954 and this opened up the possibility of observing the internal contents of cells. The first paper she published incorporating sectioned material was on the freshwater colonial chrysophyte alga *Synura petersenii* (Manton, 1955c). In 1956 Irene again returned to the Rockefeller Institute, this time over the Christmas break, and viewed sections of *Chrysochromulina chiton* in which she saw for the first time a section of the haptonema consisting of three membranes surrounding a group of seven microtubules, unequivocally confirming the difference of this appendage to a flagellum. These findings formed the fourth publication in the series *Studies on Marine Flagellates* (Parke, Manton and Clarke, 1958). Although the majority of *Chrysochromulina* species are marine, the type species *C. parva* Lackey is freshwater, having been described from a river in Ohio, USA. *C. parva* also appeared regularly in Windermere and in 1962 John Lund obtained a wild sample of *C. parva* which was subsequently obtained in culture. The very long haptonema, which coiled so spectacularly, provided excellent material for sectioning – a coil of at least 16 gyres provided many profiles showing clearly the arrangement of three membranes with a core of 7 microtubules (Parke, Lund and Manton, 1962). Other publications on haptonema ultrastructure include Manton and Leedale (1963a) and Manton (Fig. 17) (1968a).

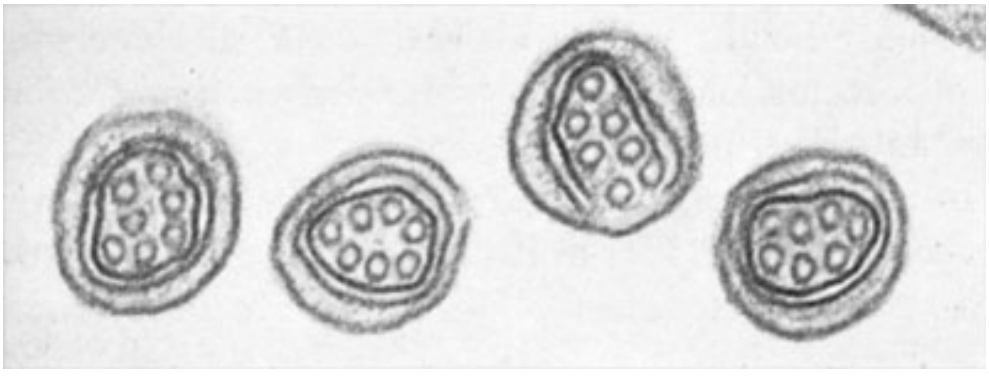

Figure 17. Section through a coiled haptonema of *Chrysochromulina chiton* showing transverse sections of four successive gyres. The seven microtubules are surrounded by a cisterna within the haptonema. Magn. x160,000 (Manton, 1968a). Reproduced with permission of *Protoplasma*.

Starting in 1950, with the Manton and Clarke 9+2 flagellar papers, Irene adopted a style of authorship and writing that she generally applied for the rest of her life. Where technical staff made a significant contribution to a publication, she included their names as second or third authors. Where academic colleagues were collaborators, it became the usual practice to put their names first. This procedure applied to the Parke, Manton and Clarke papers. In nearly all cases Irene was the author who coordinated the publication and it was not unusual for her to write the draft of the paper, discussion would then take place over the draft. Colleagues had to get used to meeting at convenient (and sometime less convenient) locations that could range from hotels, restaurants, railway stations, airport terminals and even cathedrals to discuss the finer points of a script. In Leeds, manuscript writing was generally achieved directly onto a large mechanical typewriter, often with almost exhausted ribbons. Cut and paste, in its literal sense, was the way in which a manuscript was ‘hammered’

into shape. Irene would type out a paragraph and then wrench the script out of the typewriter, raise her glasses on to her forehead and read the text. Words or sentences would be changed with pencil and more major alterations would involve cutting a section out with a large pair of scissors and then re-attaching the pieces with a stapler. When in full flow, tapping of the typewriter could be heard throughout Botany House. The final draft would then be handed to the Secretary who would type up a fair copy, which could be further adjusted before the final copy was typed and sent off for publication.

As a result of Irene's Christmas visits to the Rockefeller Institute in New York, she soon came to appreciate the limitations of the Leeds Philips EM 100 microscope and looked around for a better instrument. The Siemens Emiskop 1 was the instrument she decided upon. An application to the Rockefeller Foundation secured her a grant and in 1958 the new microscope was delivered and located in the basement of Botany House. Ken Oates, who had been trained in a pathology laboratory and was taken on as a technical assistant in 1954, was nominally placed in charge of the maintenance of the new instrument. Now Irene was able to section her own material and had unlimited time on a brand new microscope, research could proceed unhindered. By 1959 Bryan Clarke realised that he had probably given of his best and decided to leave for a more lucrative and responsible job elsewhere. Respect between loyal colleagues remained for all time and many years later Bryan and Irene were to meet again in Manchester.

Unfortunately the quality of early sectioned material suffered from three major drawbacks. 1. Fixation with osmium tetroxide was inadequate, particularly for marine species, 2. The use of n-butyl methacrylate was very destructive to cells because of the damage inflicted during polymerisation and 3. Images were usually faint because of the lack of satisfactory staining. Irene's EM publications between 1956 and 1963 are probably the least satisfactory of her entire output because of the quality of cellular preservation. Fortunately the three problems were overcome coincidentally in 1963. 1. Fixation was improved by the introduction of glutaraldehyde; 2. Embedding was improved by the introduction of epoxy resins and also diamond knives became available for cutting sections and 3. Staining was achieved by the use of aqueous uranyl acetate followed by lead citrate solution. The way was now free for an outpouring of publications of superlative quality.

Whilst the collaboration with Mary Parke continued until Irene's retirement, the team working on the Plymouth cultures was expanded in 1959 to include Gordon Leedale, the first colleague at Leeds to hold a Development Commission Fellowship – he subsequently became a permanent member of the Leeds botany staff. Initially Gordon collaborated on a number of *Chrysochromulina* species and then on a wider range of flagellates (Manton and Leedale, 1961a, b, c; 1963a, b). Research emphasis switched from taxonomy to ultrastructural cell biology. One of the most striking themes that now developed was the function of the Golgi apparatus. Since so many nanoflagellates had a surface covering of scales, the question inevitably arose as to where these scales originated. The first intimation that they were produced intracellularly came from *Micromonas pusilla* (Manton and Parke, 1960; now *Mantoniella squamata*) although there was some doubt as to whether scales within vesicles might have been ingested. *Paraphysomonas vestita* (Chrysophyceae) was the second species in which intracellular scales were observed but, again, fixation and embedding left much to be desired

(Manton and Leedale, 1961a). It was not until 1962, when Manton and Parke (1962) published their description of *Chrysochromulina polylepis*, that unequivocal evidence for the intracellular production of scales in haptophytes was obtained. With the technical improvements noted above Irene went on to show many times that scales originated within Golgi cisternae thereby validating the function of the Golgi apparatus in a secretory role (Manton, 1966b; 1967b, c; Manton, Rayns, Ettl and Parke, 1965). The existence and possible role of the Golgi apparatus had been a source of dispute in the 1920s and 1930s – did it exist and was its role one of secretion? Now there was no doubt that it both existed and could function in secretion. Other flagellates studied at this time included the green flagellate *Mesostigma viride* and the golden-brown flagellate *Sphaleromantis tetragona* (Manton and Ettl, 1965; Manton and Harris, 1966). Both had a spectacular surface covering of scales and in both the scales were produced intracellularly within membrane-bounded vesicles (Figs. 18 and 19).

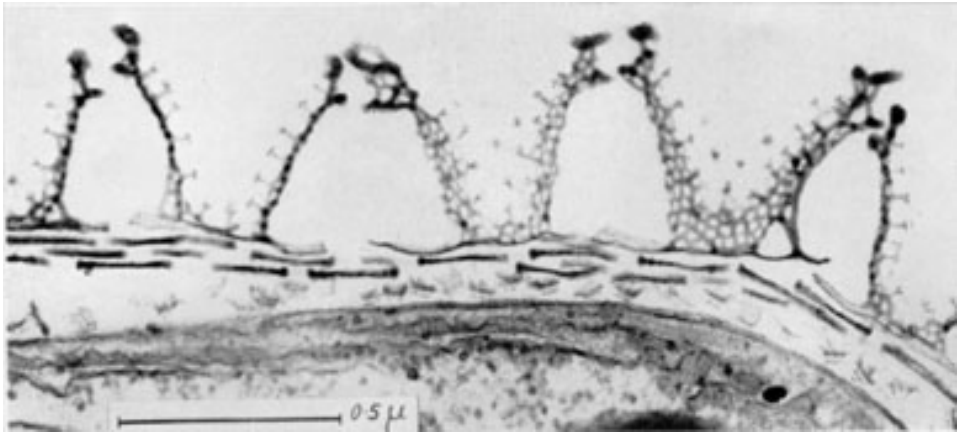

Figure 18. Vertical section through cell of *Mesostigma viride* showing the arrangement of goblet shaped scales on the cell surface. (after Manton and Ettl, 1965). Reproduced by permission of the *Journal of the Linnean Society (Botany)*.

Another important group of nanoflagellates that Mary Parke had in culture in Plymouth was known collectively as the 'green' flagellates. Most of these were attributable to the Class Prasinophyceae and once again they displayed unexpected novelty, particularly with respect to the covering of the cell body and flagella. In 1963, Manton, Oates and Parke (1963) demonstrated in *Pyramimonas* spp. at least two types of scale on the cell body and three on the flagella. In subsequent publications on *Pyramimonas, Platymonas* and *Prasinocladus* (the latter two now *Tetraselmis*) the scales were shown to be of Golgi origin (Manton, 1966c; Manton and Parke, 1965; Parke and Manton, 1965). Although all types of scale were produced within Golgi cisternae, the cell discerned with great precision between the different categories. Those destined for the cell wall were transported directly to the plasmalemma, whereas those destined for the flagella were stored within a large reservoir at the base of the flagellar pit until they were required. The precision with which thousands of scales could be targeted to specific locations outside the plasmalemma is of great interest and has been the basis of subsequent biochemical scrutiny (Becker *et al*., 1994). In *Prasinocladus* and *Platymonas* (both now *Tetraselmis*) the minute 'stellate' scales destined

for the body surface coalesce, once they have been exocytosed, to form a continuous covering, the 'theca' (Manton and Parke, 1965; Parke and Manton, 1965). Thus the apparently continuous theca of *Tetraselmis* is homologous with the scale-covering of *Pyramimonas*. In addition to these results, Irene accumulated much incidental information of other cell organelles, in particular on the chloroplasts (Manton, 1966a, d) and flagellar bases and roots (Manton, 1965).

Cell division and meiosis, a hark-back to her earlier days of cytology, also fascinated her and details of mitosis in *Prymnesium parvum* were published in 1964 (Manton, 1964d); and meiosis in the centric diatom *Lithodesmium undulatum* in 1969–70. The latter work was carried out in collaboration with Hans von Stosch and Klaus Kowallik of the University of Marburg, Germany. This was another example of collaboration between Irene and a classical phycologist (von Stosch) of the first rank. von Stosch had isolated *L. undulatum* and was growing it in clonal culture; addition of fresh medium and minor changes to the temperature and light regime induced vegetative cells to undergo gametogenesis. For cells destined to form male gametes, each vegetative cell undergoes a succession of mitoses, usually four, to give sixteen small spherical spermatocytes. Each spermatocyte then undergoes meiosis to produce four male gametes. In a series of four papers, containing detailed numerical analyses of spindle microtubules, Manton and her co-workers presented for the first time the most detailed insights into the logistics of mitosis and meiosis (Manton, Kowallik and von Stosch, 1969a, 1969b, 1970a, 1970b).

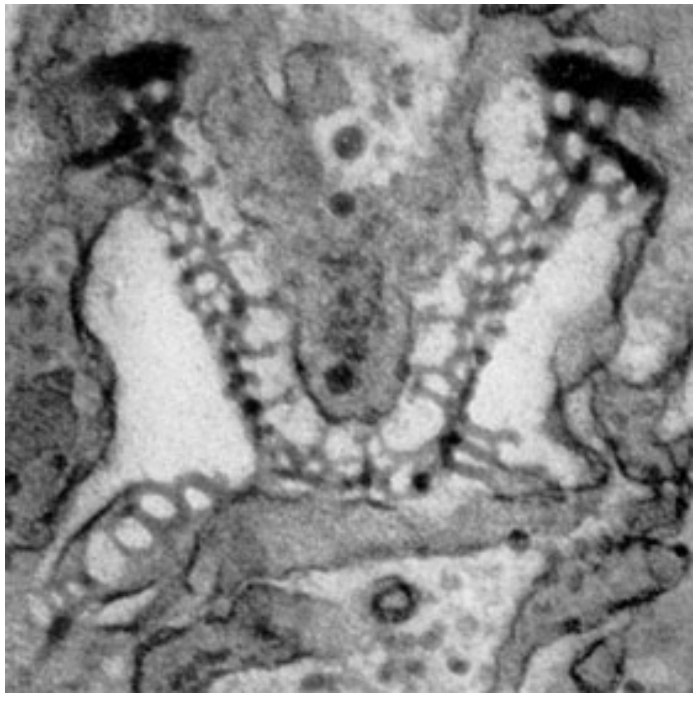

Figure 19. Section of *Mesostigma viride* showing the intracellular production of a goblet scale. Magn. x140,000 (after Manton and Ettl, 1965). Reproduced with permission of the *Journal of the Linnean Society (Botany)*.

Apart from isolating nanoflagellates, Mary Parke was also working on their life-cycles. In particular she was the first to find in the same life-cycle the combination of a heterococcolithophorid (e.g. *Coccolithus pelagicus* with large plate-like calcicified coccoliths) and a holococcolithophorid (e.g. *Crystallolithus pelagicus* with plate-like scales bearing a pattern of rhombohedral, calcite crystals). Manton and Leedale (1963b, 1969), using Mary Parke's material, demonstrated the homology between coccoliths in these two phases of the life-cycle and the unmineralised scales on *Chrysochromulina chiton*.

The period 1961–1969 saw the production of at least 50 publications; at her peak Irene was producing almost one publication every two months. This phenomenal output, superimposed on a continuing programme of work on the ferns and all the other duties involved in the headship of a department, required a tight and unremitting schedule. All the more so because so much of the work, such as fixing and embedding, sectioning, observation and preparation of publications, was carried out by Irene herself. A typical day would start about 9.00am with the opening of her mail and dictation of outgoing letters into a small tape recorder for typing by the secretary. Irene was always prompt in responding to letters. During term time lectures would be given, these were usually delivered without notes but liberally illustrated with glass 'lantern slides' which would be selected immediately prior to the presentation. Undergraduates recall holding Irene in awe; her authoritative command of the subject could be quite intimidating to the newly enlisted undergraduate. Whilst students found Irene's lectures inspiring (they contained all the Manton logic and much humour as well), nevertheless they were performances rather than lectures for note taking. Practicals were well organised with fresh material wherever possible and release of gametes and spores was achieved by standard 'Mantonian' techniques. It was not infrequent for Ken Oates and others to have to rush class specimens back to Botany House for fixation for electron microscopy. From personal experience Irene knew when different species would be fertile; some species of *Equisetum* undergo meiosis in autumn, others in spring or summer (Manton, 1950a). Almost to a week Irene could predict the onset of meiosis in *Osmunda*. Male students, in particular, recall that in practicals she could be critical of their work and could be disheartening with her remarks. Thus, undergraduates held her in high esteem but were wary of her ambivalent criticism.

Fieldwork was an integral part of Leeds botany courses. David Cutler recalls that on his first Saturday as an undergraduate in Leeds, the first year class had to meet at the Department ready for departure at 9.00am. In the field Irene would expound about aquatic plants, often standing astride a small stream, bending over to take scrapings wherever appropriate. For teaching and research purposes she maintained good working relationships with the staff at marine and freshwater laboratories. She was a frequent visitor to the marine laboratory at Menai Bridge and The Ferry House laboratory (Freshwater Biological Association) at Far Sawrey, Cumbria.

At about 5.00pm most working days Irene would prepare for an evening's work on the electron microscope. This followed a precise routine; Ken Oates would prepare the Siemens microscope for use by checking or replacing the filament, aligning the instrument, correcting the astigmatism and loading the camera with a dozen 6½ x 9cm glass plates. Further batches of plates would be placed in the vacuum chamber for 'de-gassing'. During the course of an

evening Irene might take as many as seventy or more photographs. She would develop each batch of plates herself; this would involve precise manipulation in the developer to obtain the optimal tonal range. Plates would then be fixed, washed and dried overnight. During the course of the evening she would take a break and often look around Botany House for a colleague or research student to keep her company whilst she took coffee. Time would never be wasted and coffee breaks often involved discussion of a work of art or a small ancient artefact that she had recently purchased. The EM session would finally end at about 10.00pm when she would don her well-worn plastic mackintosh, collect her two or three plastic shopping bags and make her way home by bus. The following morning she would 'mark up' the plates with a number and magnification using a mapping pen and Indian ink. Substandard exposures would be discarded, rather as an artist would discard a poor quality print. Everything concerned with the labelling of plates and photographs was immaculately catalogued – in spite of the general untidiness of her room. Any deviation from this established routine could result in a serious problem for the person involved. Ken Oates recalls an incident when she was marking-up a batch of plates and the mapping pen was caked with dry ink which caused it to produce incontrollable blobs of ink on a plate. In a fit of outrage, she snapped the pen in half and tipped the ink over the light box and left the darkroom. Ken had to mop up the ink and clean up the light box. However, once all was done and a new mapping pen put out, she continued as if nothing had happened. No hard feelings were held against trusted colleagues.

With so many new results emerging from the Parke-Manton collaboration, a re-assessment of algal systematics was inevitable. Tyge Christensen, of the Institute of Sporeplanter, University of Copenhagen, was the person to whom this task fell. Tyge, in addition to his talents as a botanist, was also a scholar with a command of the classical languages. He had provided the latin diagnoses for most of the new species described by Irene and Mary Parke. Thus he was kept well informed of the striking results that electron microscopy was providing during the late 1950s and early 1960s. It was now apparent that haptonema-bearing flagellates could no longer be included within the Class Chrysophyceae so he created the Class Haptophyceae for this group that also included the coccolithophorids (Christensen, 1962, 1980, 1994). Tyge, a most self-effacing and erudite man, suddenly found himself being given prime time at phycological meetings to present his revised systematic plan of the algae, which was unfurled on a large roll of paper. The creation of the Haptophyceae together with the class Eustigmatophyceae (Hibberd and Leedale, 1970), and the consequent re-definition of the classes Chrysophyceae and Xanthophyceae, were some of the major contributions that ultrastructural studies by the Leeds group made to algal systematics.

Whilst algal ultrastructure was the focus of Irene's attention she still maintained her interest in ferns. For five weeks at Christmas time 1950/51 she travelled with Arthur Sledge and Herbert Baker to Ceylon (Sri Lanka) to sample and collect ferns from a 'tropical island'. The rationale behind the Ceylon trip was to make a comparison between the fern flora of a tropical island and the two island floras on which she had already worked, namely those of the British Isles and Madeira. Ferns were collected; living specimens were returned by air to Kew Gardens, pressed herbarium specimens were brought back separately by Sledge and root tips and developing sporangia were fixed for cytological investigation back in Leeds. Approximately 160 of the 250 species of the total fern flora were investigated, working at

the rate of one item every three days the cytology was completed for between 220–230 individual plants (Manton, 1953a; Manton and Sledge, 1954). The results showed the frequency of polyploidy was about 60% (compared with 50% for the British Isles and 42% for Madeira). This disposed of the notion that polyploidy represented an adaptation to colder climates. Another important finding was that whereas in Britain polyploidy was usually confined to tetraploids with occasional hexaploids, in Ceylon polyploidy was represented by hexaploids, octoploids, decaploids and dodecaploids. From this Irene concluded that fern evolution was proceeding more rapidly in the tropics, probably because growth in warmer climates was faster and without dormant periods, and because there was a greater occurrence of erosion providing a greater range of 'disturbed' habitats. This pioneering work led to an explosion of interest in fern cytology by workers in many countries around the world embracing all continents. The outcome has been that the pteridophytes are now perhaps the best known cytologically of any large group of plants. Just as there had been an insistence on photography in all Irene's work it was also established as a rule that all the ferns used were of known wild origin – this rule has been followed by all subsequent workers.

Work on the Ceylon flora was followed by collaborative work with Eric Holttum on the Malayan (Malaysian) fern flora (Manton 1954a), where the frequency of polyploidy was only 39%, and subsequently the West Tropical African flora (Manton, 1959a). The factors affecting ploidy levels are obviously complex and may differ from region to region (Walker, 1983). The accumulation of information from many different floras, and work by Irene's research students including Stanley Walker (date of thesis 1953), Gopinath Panigrahi (1954), Molly Walker (née Shivas) (1956), Trevor Walker (1956), John Lovis (1958), Ghatak (1959), Janet Souter (née Emmett) (1963), Tony Braithwaite (1964), Anne Sleep (1966), S.K. Roy and B. Sinha and others, including the chemist and Nobel laureate Tadeus Reichstein, permitted the re-assessment of taxa and other systematic groupings on a worldwide basis. One such grouping was the Family Pteridaceae, which was particularly controversial. Here Irene demonstrated that despite many superficial resemblances, approximately half the family was consistent in having a basic chromosome number of 29 or 30 and could be recognised as a separate group the Adiantaceae. The remaining half consisted of genera with very diverse chromosome numbers and has later been split up into a number of more-or-less unrelated families (Manton, 1958). The finer details of the fern studies carried out by Irene and her co-workers are far beyond the scope of this biography and readers wishing to probe the subject further are referred to excellent reviews by Manton (1961a), John Lovis (1977) and Trevor Walker (1983).

During this period there were several changes to the Botany Department; Professor Preston became head of a sub-department called Biophysics, which at a later stage gained full autonomy. Several staff, including Robert Brown and Trevor Walker moved on to other academic appointments. Edith Harrison and David Jennings, physiologists, and Len Evans, an algal cytologist who in later years was to work on ship fouling algae, joined the staff. In the mid-1960s the house immediately next-door to Botany House in Grove Park Terrace became available and with the necessary re-adjustments provided more space for staff and a walk-in temperature controlled culture room. During the sixties Irene made an attempt to learn how to drive with Miss Denison her long-suffering secretary as the instructor but as Miss Denison recorded in the verse she penned for Irene's eightieth birthday:

"But we plodded on and with aplomb, Prof turned to the Commer van,
I would teach her how to drive and aid her field-collecting plan,
Alas the lessons were too few, so collecting was advanced
With Secretary driving and Prof gathering up the plants." (Family Archive)

For Irene, the 1960s marked the high point of her career. The turning point had been the publication of the 9+2 story and its universality in all plant cilia and flagella. This showed that not only was she an outstanding microscopist but she could also quickly adapt to a wholly new branch of biology and become a world leader. Not only did she show a tireless inquisitiveness about her own field of research but she was able to innovate at just the right time. She demonstrated a remarkable combination of conservatism (if it ain't broke don't fix it) with an ability to recognise when change was necessary. She was tireless in her quest for improved microscopes and techniques – spending her Christmas breaks at the Rockefeller Institute in New York was all part of the fun of the game! Now as she pioneered work on algal ultrastructure, her fame spread throughout the world. Electron microscopists, scientists and engineers, beat a path to her door. She appreciated the need to pass on the techniques that had been developed in Leeds to other workers and so in the late 1950s and 1960s a long line of younger colleagues came to Leeds to learn electron microscopy. Her attitude was that this was not a technique that could be learned in a week or two; why not come for three months, six months, a year! At the height of her powers, visitors for both ultrastructure and ferns were travelling to Leeds from the USA, Hungary, Romania, Poland, Czechoslovakia, Switzerland, Norway, Denmark, Germany, Israel, India and elsewhere.

This was also the period when she was recognised nationally and internationally with awards, medals and honorary degrees. In 1953 she was awarded honorary membership of the Danish Academy of Sciences and Letters. In 1954 she received the Trail Award of the Linnean Society and its Gold Medal in 1959; in 1972 she received the Schleiden Medal of Leopoldiana. She was awarded honorary doctorates at the Universities of McGill (1959), Oslo (1961) and Durham (1966). In March 1961 she was elected a Fellow of the Royal Society, the ultimate accolade for a scientist in Britain. Sidnie had been elected to a Fellowship in 1948, so this set a record of the only two sisters so far to be so honoured. Fellowship of the Royal Society had been the preserve of men, Sidnie was only the eighth woman to be elected FRS and Irene was the eighteenth (Fig. 20).

The 'golden years' were brought to an abrupt end on September 30th 1969 when Irene had to retire from the headship of the botany department at the age of sixty-five. It is not surprising that this proved to be a time of crisis since her whole life was her work and electron microscopy was not a facility that could easily be taken into retirement. The University authorities (Vice-Chancellor, Registrar and others), having had long experience of Irene decided that they would act early to try and defuse what they anticipated could be a difficult situation. There appeared to be two guiding principles behind their actions; firstly, to try and ensure that Irene would have access to EM facilities somewhere – they reasoned that to deprive her of facilities would be 'fatal'. Secondly, they insisted she must vacate the department to make room for her successor. On the face of it both of these objectives seemed to be reasonable. Bearing in mind these constraints, about eighteen months before the actual date of her retirement they tried to establish from her what she might have in mind and also they looked at some possible alternatives. They were correct in their judgement that this

Figure 20. Photograph of Irene Manton being congratulated by Professor Reginald Preston FRS on being elected as a Fellow of the Royal Society in 1961. Reproduced by permission of Dr Ken Oates.

was going to be a difficult decision because Irene was not in a mood to contemplate her retirement plans so far in advance. It seems that the authorities had three possible alternatives in mind. One was that she might use the electron microscope facilities in another Leeds department, possibly in the Medical School or an associated department. The second was that she might move abroad – she had mentioned moving to the USA or Australia. Thirdly, there was the possibility that a 'centre of excellence' might be created elsewhere in the UK to which she might move. For the latter possibility Lord Dainton, who at this time was Vice-Chancellor of Nottingham University and who, along with his wife Barbara, was a long-term friend of Irene's, was enlisted to help. He had good contacts with colleagues in the Agricultural and Medical Research Councils.

All these plans came to nought for one reason or another. Most colleagues involved felt that Irene was too powerful a character to move to another department in Leeds or elsewhere. This was a most stressful time for Irene for her housekeeper of 23 years, Miss Edith Pay, who was now seventy-four, decided that she would retire to live with her sister in Kent. So suddenly Irene had to face up to the loss of her department, electron microscope and housekeeper. Negotiations with the University were further complicated because some of the equipment in Botany House, including the two electron microscopes, had been purchased with grant money awarded to her personally. This unhappy chapter ended with the University offering Irene three rooms in the basement of the Physics and Administration building. The largest room served as her office and the two smaller rooms housed her collection of photographic plates and provided a small darkroom respectively.

Could this unhappy experience have been avoided? Probably not, because to cut off such a creative and energetic person in mid-stream was always going to be brutal. Did it do long term damage? Probably not, because Irene quickly rose above the storm and in typical 'Mantonian' spirit carved out a new life for herself .

CHAPTER 6

To the Ends of the Earth – Nanoplankton from the Sea

The summer of 1969 was a difficult time for Irene – retirement was not something for which she had planned and she found it impossible to gain any pleasure in having to give up everything she had spent the past 23 years working for. Physically it meant clearing out her large office in Botany House. Her desks and bookcases were full of letters, reprints, books and photographs dating back over the past twenty years. The large collection of photographic plates, 40,000 or more, all meticulously labelled and in boxes, was a dead weight. She decided that she would have to reduce the number of plates to manageable proportions and threw out those that were substandard. The crashing of glass went on for days, until the collection was slimmed down for its new location. Ken Oates was particularly involved with assisting in the removal of everything to her new premises, which she defiantly called 'the dungeon' (Fig. 25). Adjustments also had to be made to her house because of the retirement of Edith. Life had been so busy during the past twenty-three years that the house had been neglected, there was a lack of quite basic facilities such as a refrigerator, and the heating and lighting systems were in need of refurbishment. Stories are legendary of colleagues visiting the house and having to sit in deck chairs!

At the beginning of July 1969 she attended the First International Symposium on Comparative Spermatology in Siena and witnessed the Palio during which horses charged around the Campo. On July 20th 1969 the USA landed a 'man on the moon' and she commemorated this event by the purchase of a Miró print entitled *Fusée* that was reminiscent of a rocket in orbit. During August she attended a course on the viola da gamba. Violin playing, which she had given up in the 1950s, might have been something that she would take up again. When the final break with Botany House came she made sure that she was fully occupied with papers to complete. Quickly she took to a peripatetic way of life, visiting colleagues and laboratories in succession. In particular, she was welcomed at the botany department in Nottingham by Professor Ted Cocking and Martin Willison, at Imperial College by Dennis Greenwood, at Westfield College by Professor Tony Fogg, at the MBA Plymouth by John Green and Mamie Parke. Later she would visit Graham Bremer at Portsmouth University and Ken Oates who, within months of her retirement, moved to Lancaster University. Suddenly the situation seemed to improve, the itinerant life became more attractive for now she could arrive at a location, use the microscope, develop the negatives, and move on. On leaving Botany House, she took with her to the 'dungeon' an enlarger, photographic facilities and an ultramicrotome so, apart from an electron microscope, she was more-or-less self-sufficient. Small sums of money from the Science Research Council and the Royal Society paid for travel and equipment.

Initially there were papers to be finished on haptophycean flagellates, in particular *Pavlova* and *Phaeocystis*, with Mary Parke and John Green of the MBA, Plymouth (Manton and Green, 1970; Parke, Green and Manton, 1971). As part of a study on haptophycean flagellates, the present author visited Bergen and Oslo, Norway in 1970 and made whole mount preparations of nanoplankton collected directly from the wild. These collections indicated that the number of undescribed species was considerable. In particular, Leadbeater (1972) was able to name new species of *Chrysochromulina* and choanoflagellates with silicified loricae. This work lead to a second collecting trip in 1971 when Irene accompanied the author to Frederikshavn on the North coast of Jutland, Denmark and made further collections. During this trip material was also fixed and embedded and ultimately details of the internal ultrastructure of those *Chrysochromulina* species identified in Norway were obtained (Manton and Leadbeater, 1974a; Manton, 1972a, b). During the Danish trip Tyge Christensen from Copenhagen visited Frederikshavn for teaching purposes and agreed to make arrangements for Irene to visit Greenland during the summer of 1972. The Danish Arctic Station on Disko Island, West Greenland was administered in collaboration with biologists in Copenhagen. Thus began the third phase of research in Irene's career that involved travelling to marine stations in the arctic, South Africa and the Galapagos Islands for the collection of nanoplankton.

The procedure for preparing nanoplankton directly from the sea for electron microscopy involves collecting seawater samples in suitable containers, usually van Dorn bottles, which can be lowered to a specified depth and closed by release of a spring mechanism. The sample is then returned to the laboratory in a cooled container. To remove the larger plankton the sample must be filtered through a 20μm plankton net and the resulting suspension of nanoplankton cells are concentrated by allowing the sample to pass through a membrane filter, usually of 0.45μm pore size, until a concentrate of cells is retained in about 10-20ml of water. The final concentrating process can be achieved in a bench top centrifuge. For whole mounts, small drops of the concentrate are placed on ionised, Formvar and carbon coated EM grids and placed in a Petri dish where they are exposed to osmium tetroxide vapour for a minute or two to kill the cells. The drops are then allowed to dry and the grids washed in distilled water to remove crystalline salt. Whilst essentially a straightforward technique, there are a number of difficulties that make this a tedious and sometimes difficult procedure. Often remote field stations do not have the requisite equipment, such as a bench-top centrifuge. Unless a suitable pump is available, the filtration process depends on the suction created by a natural head of water; in these circumstances filtration can be a long and tedious procedure. Added to this the uncertainty as to whether the final preparations will be of any use makes the whole procedure stressful.

The first of the arctic visits was to Greenland in June/July 1972 when Irene was accompanied by Joan Sutherland, who at the time was a research assistant with Margaret McCully at Carleton University in Ontario, Canada. In addition, Miss Ira Werth, a zoologist from Leeds University, accompanied the party to carry out bird watching and photography. The party left Copenhagen for Godhavn, the capital town of Greenland on the west coast, and then travelled on to Disko Island. The Danish Arctic Station was situated on a bay and as Joan Sutherland recalls the view from the laboratory was 'beautiful' in an arctic context. A nearby glacier periodically calved enormous icebergs that travelled slowly past the island,

some would beach and in the warm air melting produced cascading waterfalls. Colours of the ice varied from white to deep ultramarine. Locally the Greenland population was dependent on fishing; the occasional whale was landed and people would gather around to watch and share pieces of *matak* (whale hide), particularly relished by children. In June/ July there were 24 hours of light so a daily routine had to be carefully followed. Highlights in this remote part of the world included periodic visits by a helicopter bringing passengers and mail, so everyone, including Irene, milled around to see what was happening. Before returning home Irene bought some locally crafted whale ivory carvings.

The second trip to collect nanoplankton, also in 1972, was to Cape Town, South Africa, this time Irene was accompanied by Ken Oates. On this occasion larger boats were used for collections and divers operated the van Dorn bottles collecting at a depth of 30 metres in some cases. Don Williams and Professor O.A.M. Lewis provided facilities in the Botany Department for processing specimens. On this trip, as with many of the others, time was taken for field botanising.

During the summer of 1973 Irene, accompanied by Joan Sutherland, made her way to Churchill on the west coast of Hudson Bay, Canada. Here they had to set up their equipment in a large hanger. Later that year, in September, Irene and Joan visited Resolute Bay on Cornwallis Island in the Northwest Passage. The pack ice had mostly broken up but conditions were cold and samples had to be processed outside the laboratory to avoid the harmful effects of central heating. In June/July 1975 they visited Homer in South Alaska and Point Barrow in North Alaska. Margaret McCully from Carleton University joined them. They encountered several problems – at Homer the laboratory was perched on a bluff one thousand feet above sea level with no access to the sea. Fortunately an employee, of the Fisheries Department, who was a temporary resident at the laboratory, helped by bringing water back to the laboratory after an initial joint trip to learn the drill. One night whilst at Homer, Joan remembers being woken up by Irene struggling to remove an indigenous mouse that had made its way into her sleeping bag. At Point Barrow the laboratory was part of the American Naval base. In mid-summer the sea ice had begun to break up and an open lead had appeared between the shore and the pack. To negotiate this gulf the local Inuit guide improvised a rather wobbly floating bridge using a wooden dog sled. Once on the sea ice they sought out seal holes through which they could sample the water underneath. The visit to Point Barrow coincided with the July 4th celebrations, which meant that everything shut down for 3 days and the Inuit guide and his sled were not available. However, fortune smiled, the wind changed direction with the result that massive sheets of ice were blown up on to the shore and they were able to sample the rich diatom layer on the under surface (Fig. 21).

The final collecting trip was to the Galapagos Islands in 1977. This time Joan Sutherland, Dennis Greenwood and Margaret McCully accompanied Irene. They flew to Quito in Ecuador where they coincidentally met David Bellamy who was about to lead a scientific holiday cruise around the Galapagos Islands. At the Darwin Research Station on Santa Cruz Island, Irene and her colleagues, watched over by marine iguanas, were able to collect nanoplankton. By this time Irene was seventy-three years of age and yet during a botanising trip to Mount Cotopaxi in Ecuador there was a discussion with Bellamy about whether she might be flown to the North Pole as part of one of his television programmes. Eventually it was

decided that it might be easier to collect a water sample from the Pole, preserve it with fixative and return it to Leeds. Unfortunately, much to Irene's chagrin, the Bellamy team mislaid the collecting equipment during the trip.

After each collecting trip the grids containing cells as well as blocks of embedded material were analysed at the many locations in Britain that she visited. Most of the work was carried out in Nottingham and Lancaster. Hundreds of photographs were taken and they provided rich pickings. The collections showed that: 1. Many nanoplankton species in these widely dispersed localities were already known from the Plymouth culture collection and elsewhere and were therefore likely to be universal in distribution, 2. Nevertheless, there were still many undescribed species and 3. Some of the new species occurred at very low frequencies but were still ubiquitous. There was little evidence of endemism – if one looked hard enough most species could be found everywhere. As Lohmann (1902) had noted in his studies at the beginning of the twentieth century, it was difficult to know whether some of the species observed were, in fact, stages in the life-cycles of other better known organisms. Mary Parke (see Chapter 5) had already demonstrated several heteromorphic life-cycles amongst the coccolithophorids and the Prasinophyceae. Working with mixed 'wild' samples raised many problems in comparison with the use of clonal cultures where all cells were derived from a single cell. Another important feature of these collections was that they allowed comparisons to be made from one region to another.

Relating sections of cells to their equivalents in whole mounts was a time-consuming and laborious process but, nevertheless, further details of interest to the cell biologist were revealed. This work also entailed the use of novel analytical techniques associated with electron microscopy that became available in the 1970s and 80s. In particular Irene published results based on the AEI system of X-ray microanalysis (EMMA) (Manton, Oates and Gooday, 1973; Manton and Leadbeater, 1974b) and the JEOL SEM equipped for X-ray microanalysis in Lancaster operated by Ken Oates (Manton and Oates, 1975; Manton, Sutherland and Oates, 1976, 1977; Manton, Sutherland and McCully, 1976; 1977). An even more elaborate array of analyses (X-ray microanalysis and X-ray diffraction) was used to determine the chemistry of the periplast of *Polycrater galapagensis*, a 'putative' coccolithophorid from the Galapagos Islands (Manton and Oates, 1980). This was shown to have an aragonitic covering rather than a calcitic one. In these later papers the details recorded in the Materials and Methods and the Acknowledgements make almost as interesting reading as the text itself. As a result of her various collecting trips, Irene published a total of 29 papers (see reference list), many of which carried descriptions of rare new species. These publications are a testimony to her resourcefulness, physical and technical, and extend considerably our knowledge of the little known members of the nanoplankton.

During this period of restless travel, Irene would stay with colleagues or in guesthouses as appropriate. She was a regular visitor to Ken Oates and his wife in Lancaster and to Dennis Greenwood and his wife Kathleen in Sutton, Surrey. Dennis would ferry her in and out of London to the Linnean Society and other locations in his van. Kathleen helped with mending her clothes, giving advice about cooking and occasionally cutting her hair. Her dress at this time had settled into a standard format. She would sport a number of layers – usually a yellow aertex shirt, a bright red coloured waistcoat and on top of this a loose fitting brown cardigan.

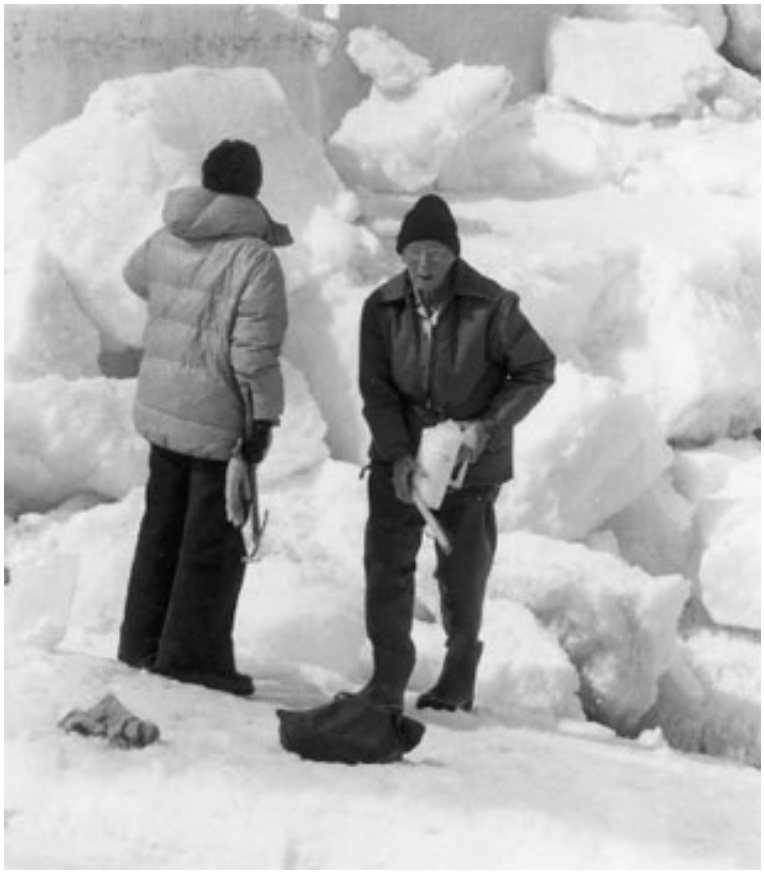

Figure 21. Irene with Joan Sutherland sampling the 'diatom layer' on the pack ice that had been blown ashore at Point Barrow, Alaska at the beginning of July, 1975. Reproduced with permission of Professor Margaret McCully and Prof. Anne Ashford.

These layers accompanied a large brown pleated skirt, lisle stockings, and sandals or shoes. For outdoor wear she would don a large fabric coat and usually carry two or three plastic bags. The latter would contain large re-used brown envelopes containing partly completed typescripts of the next papers. She was well known in Leeds, especially by all University staff. In the vicinity of her home she would always be willing to engage in conversation with local neighbours and had the knack of being able to converse at every level – whether it be about ancient history and art or about the swallows that had just returned to her porch to nest. Barry Herbert, Head of the University Fine Art Department (see Chapter 7), and his wife had a small swimming pool in their front garden and were surprised when one day Irene appeared with her hand-knitted costume ready for a swim (reminiscent of Girton days). She watched television in her retirement and enjoyed children's programmes, detective stories and snooker. Occasionally she would go to a film or attend theatre productions at the Leeds Playhouse. She enjoyed Chinese food and it was not uncommon for her to take visitors or groups of students to her favourite Chinese restaurant. She positively enjoyed company; in retirement her past students, colleagues and friends became an extended family by now dispersed throughout the world. There were few places that she could visit without knowing someone. In spite of her

tireless activity there appeared to be a degree of loneliness in her life. However, her social life was always secondary to her work.

In 1972 Irene became President of the British Pteridological Society and in 1973 she was elected President of the Linnean Society, the first (and so far only) woman to be elected to this post since the Society was formed in 1788. In response to the letter inviting her to become President, she said:

> "Thank you for your very nice letter. I am afraid I am too old to feel any emotions except minor apprehension about the prospect of a thing like the Linn. Soc. On the whole I dislike being either a figure head or a chairman but couldn't think of a watertight excuse for refusing, not being a complete coward.
> Whether it will be fun or tremendously hard work I don't know. . . . In the mean time any help that you or other wellwishers can concoct for helping the solvency of the Linn. Soc. by encouraging people to join would lighten my labours. They are as usual in a chronic state of threatened insolvency and yet I feel sure that if they could improve publicity and the value of their services to Fellows many more would join if only for the usefulness of having a working base in London. Merely to concentrate on doing what they do more cheaply wont get round their difficulties. So any bright ideas that I could follow up would be most welcome." (Girton College Archive)

This was a perceptive analysis of what might be done to improve the state of the Linnean Society's finances. With this situation in mind she instigated the Newsletter, which was subsequently transformed into *The Linnean*, and together with Brian Gardiner (then Zoological Secretary) she initiated the 'Hobbies Group'. In the latter context she was an active participant, convening meetings on a range of subjects including 'Animals in Art'. On receiving a copy of the first issue of *The Linnean* in January 1984 she wrote a letter to the editor and erstwhile Zoological Secretary, Brian Gardiner, in which she reminisced:

> "I was much pleased by the appearance and contents of your new Newsletter, that I have been stimulated to do the unusual, namely write an un-necessary letter. You will remember however that the very first Newsletter (supposedly 1973) had been my personal brainchild, with you as a major aider and abetter. (If I have remembered wrong please put me wise).
> You will remember the so-called Hobbies Group, to which you ministered so nobly until it ceased to be active following removal of both of us. It occurred to me now that, after this lapse of time, it might interest Fellows to be reminded of it.
> It was intended, as you will remember, to bring together interested persons round a table, for conversation, rather than for an audience in a lecture room. This enabled us to handle and discuss objects and even to conduct experiments, as when we tried a method of manufacturing a wick from a pealed green rush, to test out "Lighting in Antiquity" without risk of burning down Burlington House." (Archive, Brian Gardiner and The Linnean Society of London)

The Linnean, still edited by Brian Gardiner, has now celebrated its twentieth birthday, and the Hobbies Group has spawned a number of specialist groups concerned with subjects such as Evolution; London Freshwater; Palaeobotany; Palynology and Plant Anatomy.

Irene was a lifetime Fellow of the Linnean Society and used the library regularly. Frequently she would take a day return journey by train from Leeds to Kings Cross, call in at the Linnean Society and present the librarian with a list of references, visit one or two of

Figure 22. Photograph of Irene Manton taken after she received an honorary degree of Doctor of Science at the University of Lancaster (1979). Reproduced with permission of Dr Ken Oates.

her favourite galleries in the vicinity, take lunch in the Royal Society and then call back for the photocopied references before returning to Leeds on the evening train. In 1984 the Linnean Society sponsored a gathering to celebrate her eightieth birthday. After her death in 1988, the Society commissioned Roger Remington to produce a posthumous painting of Irene in which she is shown holding a frond of *Osmunda*. In her will she left the ultimate residue of her estate, which amounted to approximately £24,000, to the Linnean Society. In addition she made a bequest to fund a prize for the best PhD thesis on a botanical subject. The requirements were that the thesis had to be submitted within two years of completion and the prize was to consist of a small piece of sculpture or other work of fine art.

Honours continued to be bestowed on her well into her retirement, she was awarded honorary degrees at the Universities of Lancaster (1979) (Fig. 22) and Leeds (1984), honorary

Fellowships of the Royal Microscopical Society, the Department of Biology at Lancaster University and, significantly, by Girton College Cambridge in 1984. With respect to Girton College, Mrs J.A. Jollowicz wrote to say:

> "It is with very much pleasure that I write to tell you that at the meeting of the Governing Body of Girton College last Friday, 3 May, the Governing Body unanimously elected you into an Honorary Fellowship of the College. There are absolutely no duties whatsoever attached to the Honorary Fellowship, but on our part we hope that you will sometimes have time to visit the College."

Irene responded to this:

> "I am naturally astonished to receive your very kind letter yesterday evening. I can think of no circumstances, which would justify anybody in refusing such a noble offer. I therefore accept with the utmost alacrity and pleasure." (Archive, Girton College)

In 1979, after Sidnie's death, Irene's niece Elizabeth, encouraged by her father, made contact with her. There was much to catch up on and the subsequent exchange of visits seems to have gone some way toward making up for the estrangement that had existed between the two sisters for more than thirty years. In 1984 Irene and Bryan Clarke made contact again after 20 years. In 1986, after 37 years in gestation, the mammoth paper on the *Cytology of the fern flora of Madeira* was published (Manton, Lovis, Vida and Gibby, 1986). In the spring of 1987 Irene was invited by the High Mistress of St Paul's Girls' School, Hammersmith to address sixth form pupils about her research. Now there was a sense in which things had moved full circle.

CHAPTER 7

Other Ways of Looking at Nature – Oriental and Modern Art

In addition to being a distinguished scientist, Irene had a wide range of artistic and literary interests. From an early age she played the violin and music was an important part of her life until she moved to Leeds. She had played the violin at school, at Cambridge, in Stockholm and she played regularly in a quartet in Manchester. She also played in the University Orchestra in Manchester and Bryan Clarke remembers hearing her playing at a concert during the war where, at short notice, she substituted her violin for a viola. Possibly because of pressure on her time, she gave up quartet playing in the 1950s. Nevertheless, she continued to attend University lunchtime concerts. She took an interest in members of the botany staff who played instruments and occasionally she could be persuaded to attend a public concert or listen to recorded music. Gordon Leedale recalls a time when she was moved to tears on hearing a recording of Kathleen Ferrier singing Brahms's *Four Serious Songs* (Op. 121). Occasionally, when visiting colleagues abroad, if she saw a violin she would ask someone to accompany her in playing a chamber work. This happened whilst visiting Tadeus Reichstein in Basel and Mrs von Stosch in Marburg, Germany. She bequeathed her two viols (tenor and bass) to the Department of Music in Leeds. The eighteenth century Aletzie bass viol was a particularly fine instrument and in acknowledgement of this gift, six musicians with University connections who played English consort music on viols called themselves the 'Manton Consort'.

Irene's command of languages was also considerable; she could read and write French and German and during her nine-month visit in Stockholm mastered conversational Swedish. She often translated articles written in these languages into English directly on the typewriter and was prepared to have a go at other languages as well. Bryan Clarke recalls that during an international meeting in Paris Irene was asked to move to the front of the lecture room so that she could translate the discussion from French to English and German. Her interest in Chinese Prints and Printing also broadened her repertoire to include an appreciation of oriental languages (Manton, 1971).

History, both ancient and modern, particularly of science and microscopy, was also something that Irene wrote about. In a number of publications for the Royal Microscopical Society she wrote authoritatively on the history of microscopy (Manton, 1981, 1983b). She was particularly fascinated by Leeuwenhoek's microscopes, which she had seen in Delft when visiting Mrs van Iterson in 1946, and kept a replica of one of his microscopes in Botany House. She visited the Royal Society to view the original correspondence between Leeuwenhoek and the Secretary of the Royal Society and was able to see and use Robert Brown's microscope at the Linnean Society.

However, it was the viewing and collection of oriental and modern art that was the most abiding non-scientific interest in her life. The seeds of this interest appear to have been sown in Manchester. Professor Lang and his wife and friends pursued a wide variety of cultural activities. In the Royal Society obituary, William Lang was described as having "a keen artistic appreciation and was no mean artist himself. His holiday sketchbooks contain numerous watercolour landscapes and pen-and-ink sketches with a fresh vigour of style suggesting rapid execution". Irene had clearly been persuaded by what she saw because when she visited Egypt in 1935 she had also kept a holiday sketchbook with some excellent sketches and watercolour paintings. Lang also collected art, particularly works by Aubrey Beardsley and Theophile Steinlen, and this may have been the stimulus for Irene to start her own collection. She attended the Exhibition of Chinese Art at the Royal Academy of Arts in 1935 and was greatly inspired by what she saw. She was fascinated by the difference in perspective adopted by oriental artists. In an article entitled *The Origins of the Collection* (Leeds University Archive) she refers to her use of slides and prints to illustrate to students "the oriental concern with the natural world of plants and animals which differed both in kind and intensity from any modern scientific approach to comparable biological entities in the west". This was a theme encapsulated in the phrase *Other Ways of Looking at Nature* that she developed over the years. In 1953 she was given a Chinese painting of an insect hanging from a branch of a Ginkgo tree and soon afterwards learned that the artist of this painting was coming to London. Irene invited him to Leeds to exhibit in the University and during his visit he gave a public demonstration of how Chinese painting was carried out. As a result of this she bought several of his works. On visits to Paris and elsewhere she bought further works, usually for small sums of money (£5 or less). She took to juxtaposing Chinese paintings, for instance a fish swimming in sunlit water, with western pictures, such as a colour print by S.W. Hayter called *Poisson Rouge* depicting sunlit water and movement but implying the fish. She found the result challenging – "it also provided a good conversation topic for 'nervous' students" (Manton – *The Origins of the Collection*).

The turning point, which prompted collection on a more serious scale, came with an exhibition of paintings by Terry Frost (Gregory Fellow, Leeds University 1954–1958) in the University Parkinson Building in the mid-1950s. Irene was immediately impressed by his "superb colour sense, visible form and distance". She enquired about the artist and on meeting him she was horrified to find that the public and University authorities had ignored the Leeds exhibition (Knowles, 2000). She decided to right the wrong by buying a large picture, which was hung in Tetley Hall, and a series of smaller ones for herself. She explicitly did not only choose the ones she liked because she felt that "you like what you understand and you understand what you know". Terry Frost (later Sir Terry Frost (1915–2003)) became a personal friend, he was invited to Botany House to discuss his paintings, and subsequently she followed his career as he went on to become a leading abstract painter with world-wide reputation. Terry Frost paintings, which could be purchased in the 1960s for tens of pounds, now exchange hands for many thousands of pounds.

The meeting with Terry Frost had now introduced her to the world of modern art. On the way she had purchased several Lowry pencil drawings and a painting that combined the perspective she admired in oriental art with a Mancunian industrial scene, which she knew so well. From now on most of her purchases would be of modern abstract art. Irene had a

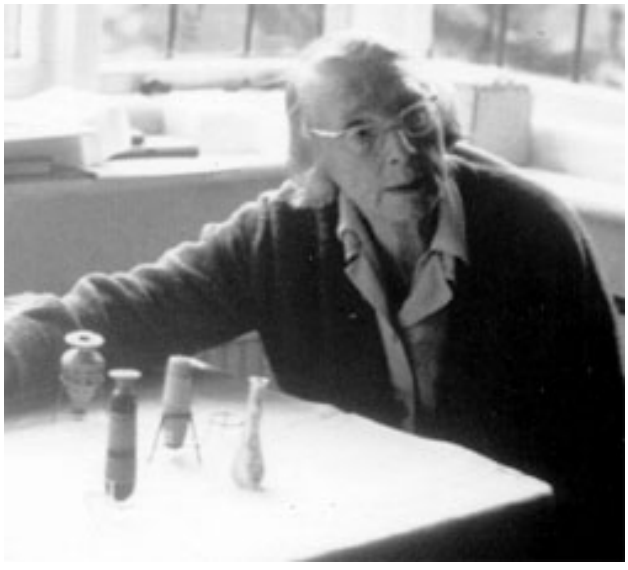

Figure 23. Irene with a selection of ancient artefacts.
Reproduced with permision of Mrs Kathleen Greenwood.

desire to communicate her own interest in art and so displayed her purchases, including the famous Lowry painting, around Botany House. This caused a considerable amount of amusement and incomprehension amongst onlookers but in retrospect was a marvellous way of familiarising people with this art form. To assist visitors in understanding the collection she produced a document entitled *Botany House made Easy* (Leeds University Archive). In this she goes some way to explaining the policy behind the selection of pictures, which "has been to illustrate the more important trends which have made mid-twentieth century painting so different from previous centuries". She goes on to explain:

> "It is however necessary to remember that almost every square inch of Botany House is part of a working environment in which it is essential to avoid inserting discordant influences which might interrupt people's thoughts. 'The human predicament' in particular has been almost entirely excluded since we have found by experience that such pictures disturb. The more abstract art forms on the other hand do enliven colourfully a previously drab environment without this disturbing effect."

Irene's interest in art took her to many London galleries, in particular the Redfern Gallery in Cork Street, near Piccadilly; Gimpel Fils in Davies Street, The Crane Kalman Gallery in Brompton Road and Charles Ede of Brook Street. Over the years she accumulated works by an impressive list of artists including Arp, Ernst, Feininger, Frost, Hayter, Kandinsky, Klee, Kupka, Kwok, Matisse, Miró, Winifred Nicholson, Pasmore, Picasso, Shahn and Vasarely. Some of the works were original paintings, which were purchased privately from the artist either in Leeds or through some non-profit-making organisation such as the Commonwealth Institute or the Arts Council. Most artists were represented by colour prints. Where possible she obtained signed etchings, woodcuts or lithographs – this was the best way of obtaining authentic first examples of an artist's work on a budget income. In a few cases, as for example Picasso, Irene purchased a lithograph with the signature

on the block since anything else would have been too costly. In general she paid a few pounds per item and only rarely as much as £20.

The overall collection was much larger than was on display in Botany House and elsewhere. Many of the unframed pictures she kept in old brown suitcases under a bed in her front bedroom. After her retirement, Barry Herbert, Head of the Department of Fine Art in Leeds, and his wife recall Irene telephoning and inviting them over to her house to view some of the unframed pictures kept in the suitcases. On other occasions she would show them Roman glass articles and ancient seals. Many of these had been purchased in London Galleries for a few pounds at a time. In Leeds, Irene became well known amongst local artists, exhibitors, and gallery owners, in particular she became a friend of Mrs Gilchrist who owned a gallery in Park Square.

From the very outset of electron microscopy, Irene had been fascinated by the interface between art and science. Following the publication of her first electron micrograph of a shadowcast spermatozoid of *Fucus serratus* (Manton and Clarke, 1950), Lord Rothschild, then at Cambridge University, had asked Irene for a picture for his collection. An unlikely coincidence followed her publication of the fine structure on the spermatozoids of bracken (*Pteridium aquilinum*) (Manton, 1959e) when Irene happened to see a painting in New York based on one of her published whole mounts. Irene continued to develop this theme of 'fine art' and 'fine structure' with the sculptor Austin Wright, another Gregory Fellow, who put it into practice in his sculptures. "He was now able to see through and into a surface that to the innocent eye was opaque and a barrier to vision" (Hamilton, 1991).

Following her retirement and with the opening of the University Gallery in Leeds she was persuaded to mount an exhibition of part of her collection from May 19th – July 1st 1970. She chose many of her favourite works including the Lowry pictures, *Poisson Rouge* by Hayter, *Yellow* and *Walking Down the Quays* by Terry Frost, *Fusée* by Miró and *Bouquet* by Picasso. In total there were 43 works on display. This exhibition was popular and appeared to mark a warming between the Leeds authorities and Irene. Following this exhibition discussion took place between Irene and the Leeds authorities as to whether she might make the pictures available to the Leeds Gallery on a more-or-less permanent basis. However, she requested that they should be shown together and that the collection should not be broken up. The University was not able to agree to this presumably because of space considerations. Unfortunately what eventually happened was one of the most publicly controversial episodes that surrounded Irene's life and death.

A year or so before Irene's death a discussion took place between Mrs Mary Gavagan, Director of the Peter Scott Gallery, Lancaster University and Irene regarding a possible exhibition of her pictures in Lancaster. Eventually the exhibition, entitled *Another Way of Looking*, took place in Lancaster from April 25th – June 3rd 1988. About 40 pictures were loaned, and whilst this was only about one tenth of the entire collection those selected were the most prized works (Leeds Reporter, 1990). The overall value of the collection for probate purposes was put at £100,000, of which the forty pictures at Lancaster were valued at £80,000. On May 31st, three days before the exhibition was due to close, Irene died in Chapel Allerton Hospital, Leeds. Lancaster thereupon retained the pictures awaiting a decision from the

executors as to what should be done with them. The executors could not advise return of the pictures to Leeds because of the following clause in Irene's will:

> "Any of my framed or unframed pictures (but not unbound books) on loan to any Institution at a date of my death I GIVE (*sic*) to such Institution or Institutions absolutely if it or they shall wish to keep them."

Leeds University contested Lancaster's right to keep the pictures. Their argument seemed to hinge on interpretation of the word 'loan'. Leeds claimed that 'loan' referred to 'indefinite loan' and not 'short-term loan'. This view was supported by a number of Irene's colleagues and friends, many of whom felt that what had happened at Lancaster was a twist of fate that Irene could not have foreseen. However, when the executors (Professor Len Evans and Lloyds Bank plc) sought Counsel's opinion, that opinion unequivocally argued that the pictures in question belonged to Lancaster. Leeds University could have let the ownership of the pictures be decided by the courts, but the chances of Leeds winning such a case seemed slim and the legal costs would have been high (Leeds Reporter, 1992a). Lancaster for its part made it clear that they would fight any legal moves taken by Leeds

Five months after Irene's death starting October 22nd 1988, Leeds University mounted an exhibition of some of the works remaining in Leeds in the 'Manton Room' within the University Gallery. There was an element of irony in the interest that was now being shown towards Irene's pictures considering that the University of Leeds had been so slow in responding to her various offers during her lifetime. When the news was announced that Lancaster could retain the pictures, Leeds University finally decided to forward the remainder of her collection to Lancaster. The Peter Scott Gallery at Lancaster University now possesses 545 items bequeathed by Irene, including modern abstract works, Japanese and Chinese paintings and prints and a small collection of antiquities. Maybe this whole episode reflected the ambivalence with which Irene had viewed the ultimate destination of her collection. Leaving aside the important caveat about what would happen if the pictures were on loan, Irene had left her collection to Leeds but had stipulated that if they could not guarantee that the pictures would be maintained as a collection for teaching and display in a gallery or museum, then they were to be donated to the University of Manchester so that they could select which pictures they wanted for exhibition in the Whitworth Gallery.

Figure 24. Botany House, University of Leeds as seen from Beech Grove Terrace in 2004. A third house, to the right of the buildings shown here, was demolished in the late 1970s.

Figure 25. ‘The dungeon’. Three rooms in the basement of the Physics and Administration Building used by Irene after her retirement from Botany House in 1969.

CHAPTER 8

The End of an Era

During 1986 and 1987 Irene suffered from a chronic cough that seemed to be resistant to treatment by antibiotics. By Christmas 1987, for the first time in her life, she seemed to have lost the enthusiasm for completing the two papers still on the stocks. The first months of 1988 saw her slowly weaken, she had one or two short spells in hospital, but the cough remained. In May she made one final visit with Bill and Joyce Williams to Lancaster University to see the exhibition of her pictures but was keen to return to Leeds as soon as possible. Finally she was admitted to hospital where she died several days later on Tuesday May 31st 1988. Obituaries appeared extensively in the national press and throughout the following months in learned journals (Christensen, 1988; Gilchrist, 1988; van Iterson, 1988; Reichstein, 1988; Sleep, 1988; Walker, 1988; Leedale, 1989; Preston 1989).

The funeral was held at Lawnswood Crematorium on Tuesday June 14th and was attended by over a hundred mourners. Her colleagues, friends and students ranging over many years and from many walks of life, as well as representatives from the many societies and organizations of which she had been member, were present. The service took place in a small chapel and consisted of short perorations interspersed by musical recordings including the Adagio from Beethoven's *String Quartet No. 14* (Op. 131), the third of Brahms's *Four Serious Songs* (Op. 121) and the Adagio from Schubert's *String Quintet in C major* (D. 956). Afterwards the University hosted a buffet reception in University House. Irene held no particular religious beliefs and it is certain that she would not have wanted anyone to dwell unduly on her passing.

Irene's death coincided with the end of an era in many different respects, but particularly in biology, in the financing and administration of Universities, and in the role of women in the professions. Irene was very much a 'woman of her time' and part of the assessment of her life and career requires an appreciation of the period during which she was brought up. When one reflects on the situation in the 1920s and 30s at Cambridge, it is almost impossible to appreciate that women, who achieved similar (if not better) results in education as men, were still not allowed to graduate or win prizes. Similarly in Manchester, women members of academic staff were not allowed to use the Staff Common Room but had to use a smaller room set aside for them. Customs have changed a lot since those days.

So what drove Irene to become such a commanding force in biology and to what extent did her upbringing prepare her for the long and arduous life ahead? The time in which she lived could still be called the 'heroic' age when it was possible for individuals, by a lifetime of committed work, to shape the subject on which they worked. Irene was not alone in this respect, she was contemporary with many other strong-willed, ambitious and multi-talented women, mostly from the middle and upper classes, who made remarkable contributions to

their specialities, whether they be in academia, medicine, engineering, astronomy, archaeology, the arts or music (Kass-Simon and Farnes, 1990, Shils and Blacker, 1996). And nor was it only women who forged ahead, there were many examples of men who also made similar contributions, but men had been longer in the field. The twentieth century saw the emergence of women in the professions; this was undoubtedly due to the broadening and liberalising of late nineteenth century education. In Irene's case the Froebel Educational Institute, St Paul's Girls' School and Girton College Cambridge were the immediate beneficiaries of the changes that were taking place more generally in education. When Irene started at Colet Gardens Demonstration School it had only been in existence for 12 years, when she entered St Paul's it was 14 years old and when she arrived in Cambridge as an undergraduate Girton College was just celebrating its 50th anniversary. Compared with the respective ages of the equivalent boys' institutions the difference is stark.

Sidnie and Irene were born into a middle class family to parents who had inherited a wide range of talents. George, their father, was a dentist and so he had a professional interest in medicine and science. His hobbies were highly practical, including carpentry, making jewellery and weaving woollen and cotton fabrics. He was articulate, as witnessed by his letters in the family archive, and from all accounts he held strong opinions, as demonstrated by his treatment of Sidnie with respect to her marriage and his persistent argumentative correspondence with the tax office. There is less information about Milana, but she was artistic in temperament, being noted for her designs and embroidery and she played the piano. Both Sidnie and Irene seem to have inherited a mix of these talents; both were academically able, both were good artists and had an appreciation of the arts, both were articulate and both were strong-willed and single-minded. Thus setting out on their educational careers early in the twentieth century they were well equipped to make their way in a man's world. They were fortunate that both the schools they attended and Girton College provided the background and support necessary to help women enter the professions. Both sisters had sporting abilities and these, no doubt, reinforced their sense of confidence and competitiveness. Nevertheless, the sisters suffered a troubled family background with Milana's long debilitating illness. Irene, in particular, found herself at a relatively young age having to provide support for her parents.

Irene's letters to her parents and Sidnie during her stay in Stockholm give a good indication of her character and personality in her early twenties. In stylistic terms, her writing is confident and mature, many of the phrases that she used in these letters, in her thesis (Manton, 1930a) and her first major paper (Manton, 1932a) occur repeatedly in her writings throughout her life. Her struggle to find a suitable research project in Stockholm, her independence of thought and her youthful exuberance provide an insight into someone who is struggling to come to terms with herself but is, nevertheless, fully aware of the wider world. Her sense of 'fun' is a personal trait that existed throughout her life, her scientific inquisitiveness was always combined with a sense of enjoyment. She frequently uses the word 'fun' in her writing and she wrote an article entitled *Microscopy for Fun* (Manton, 1975b). As most colleagues and friends will admit she had a mischievous sense of humour.

There is no indication from the family archive or from contemporary reminiscences that Irene ever had a romantic attachment. On more than one occasion Irene expressed the

opinion that she did not want to marry because of the possibility of her mother's debility being hereditable. In this regard Irene differed from Sidnie who, in 1937, married John Harding a Cambridge postgraduate. With Irene's major commitment to work it is difficult to see how a family might have fitted into her busy schedule. However, she enjoyed children and was interested in the families of her colleagues. As her career developed her extensive circle of colleagues, friends and past students formed a widely dispersed surrogate family.

As a person Irene was forthright and direct, which had its advantages and disadvantages. Most colleagues and friends at some time experienced the sharpness of her tongue, and on some occasions she could be rude and inconsiderate. One character trait she shared with her father and Sidnie was a tendency to overstate her case. It was not uncommon for her to have running battles with editors of journals who had the temerity to request changes to her papers. One such contretemps involved William Pearsall who in the 1950s was editor of the *Annals of Botany*. Pearsall requested changes to a paper that Irene had submitted for publication and she was so annoyed that she vowed never to use the journal again. Some years later (1966) John Lund wrote to Jack Heslop-Harrison, then editor of the journal, explaining the situation and asking him to consider offering an olive branch to Irene. Heslop-Harrison responded to John Lund's letter:

> "I am also fully aware of her idiosyncrasies over matters of publication . . . However, as you say her work is usually so good that one can accept a lot of difficulties for the sake of getting it published in the way she wants." (Archive, John Lund)

Some of her most acrimonious battles were with the authorities in Leeds, which can be caricatured as an irate woman professor battling against a staid and slow-moving group of male administrators. Dorothy Emmet, who for a while shared accommodation with her in Manchester, used Irene as a role model in her book entitled *Function, Purpose and Powers* (Emmet, 1972) in which she explored the accommodation of 'a creative and original person' in a 'conservative and hierarchical society'. Emmet (1972, page 258) states:

> "And if we turn to societies of other kinds, even in universities where, if anywhere, it should be possible to have a functional organization supporting a number of vocational characters, there is a danger that committees may be tempted to appoint nice people who will be easy to work with, 'good common-room types', rather than people with an original flair, if it is suspected that the latter may be 'difficult'.
> For people of strong individual character are often said to be 'difficult'. Sometimes this may be because they have had to live in a society in which they have had to struggle to do what they see as important, and where they may want to go faster than the administrative machine is prepared to take them."

An incident in 1983, when Irene was an Emeritus Professor and had been officially retired for 14 years, exemplifies the gulf between Irene's flair and the unimaginative nature of the University authorities. When Barbara McClintock, the internationally famous American maize geneticist and long time contemporary of Irene's, was awarded the Nobel Prize for physiology and medicine on October 10th 1983, Irene wrote one day later to the Leeds authorities asking them if they would award Barbara an honorary degree if she could persuade her to break her journey from the USA to Stockholm to collect the prize. Barbara McClintock, then eighty-one years old, was a woman of similar mould to Irene who herself had experienced many difficulties in the USA but had eventually been lauded for her discovery of 'mobile

genetic elements' (transposons) (Keller, 1983). The Leeds University authorities turned down Irene's request because Barbara hadn't had sufficient connection with the University.

The euphemism of 'not suffering fools gladly' used in her obituaries was the flip side to a person who was remarkably caring and affectionate. The stories of Irene's personal generosity are legion. Generosity took all forms, she would write a cheque on the spot to help someone who might be in financial difficulty. She was supportive of Terry Frost and other struggling artists. She went to great lengths to help people who fell on hard times. Ken Oates retells the story of when he was in a distant sanatorium suffering from a recurrence of tuberculosis (a result of war service) just after his appointment in 1954, Irene made sure that his post was kept open until his return and she visited him on several occasions taking fruit and other gifts. She went out of her way to obtain financial support for Anne Sleep, one of her previous research students, when she was badly afflicted with illness in the 1980s. Irene was greatly moved to learn of the death of Stanley Walker in 1987, one of her early 'fern' research students in Leeds. She wrote in the Acknowledgements of the Madeira fern flora paper (Manton, Lovis, Vida and Gibby, 1986):

> "Special Acknowledgement must be made to Stanley Walker, formerly Head of the Cytogenetics Unit in Liverpool. . . . His untimely and sudden death occurred during the finalization of the last plate and the three focal levels of one cell of an exceptionally difficult species (*Anogramma leptophylla*) were actually taken by him on his last day of apparently normal health before he fell painlessly into a coma from which he did not wake up. His intimate contacts with each one of us (Manton, Vida, Lovis, Gibby) be it as student, colleague, friend or teacher, make it singularly appropriate for us to re-dedicate to his memory the completion of this project in fern cytology, begun while he was still a student in Leeds, and ended in the week of his death. We are grateful that he was with us for so long."

There was nothing sentimental in Irene's help, she felt compelled to do what she could in whatever way possible to assist. This inner warmth created a sense of extended 'family' between Irene and past students, colleagues and friends on a worldwide basis.

Most of the story so far has concentrated on Irene as a scientist but she was, of course, also a teacher. Her teaching commitments took preference to research, which she viewed as a reward for teaching. Past students, graduate and postgraduate, of the Manchester and Leeds botany departments are now scattered throughout the world, many in positions of responsibility. To them Irene set an example of what could be achieved by commitment, determination and working to the highest standards. Irene also sat on numerous committees in the University and elsewhere. She took these commitments seriously and by all reports she was constructive, often getting directly to the point. She sat on appointment panels, including posts to the Departments of Fine Art and Music. In a wider context, she sat on the committee that oversaw the Culture Collection of Algae and Protozoa when it was based in Cambridge. There is no doubt that Irene possessed leadership qualities of a high order and that she lead by example.

With respect to her long research career, from the very outset it bears a number of unmistakeable traits. She was exceptionally hard working and was tireless in her search for observational proof. No stone was left unturned. She was demanding of everybody and anybody no matter what their status. The craftsmanship of her work was of the first rank;

instinctively she set and maintained the highest standards. She would go to great lengths and distances to incorporate new techniques. She had a 'sixth' sense of when it was necessary to innovate; critical examples of this include her desire to expand her work to UV microscopy and then to electron microscopy. Her colleagues at the time did not sense these changes in the same way. Once into electron microscopy she quickly mastered the techniques with superlative skill. No matter how much the subject has now moved on, the papers she published on disintegrated flagella and later those containing the sections of glutaraldehyde-fixed and epon-embedded material are superlative and will stand the test of time. She exerted an artist's eye with respect to the photographic aspects of the subject. She knew that to get one good photograph required taking dozens of negatives. It is highly relevant that technicians feature as much in her life as academics, in particular Ernest Ashby in Manchester, Bryan Clarke and Ken Oates in Leeds and many others who at one time or another passed through these departments. She managed to collaborate with many academic colleagues, pre-eminently with Mary Parke of the MBA Plymouth, to great effect. She was keen to nurture the younger generation and throughout her time in Leeds many young scientists visited Botany House. She was intensely loyal to those whom she respected and there are many examples of how she helped people at critical stages in their careers.

As far as publication was concerned, Irene was prolific. It is almost impossible to count the number of papers and articles she wrote, 170 is a conservative estimate. She maintained an analytical-descriptive approach to her writing and was cautious and self-critical in interpretation. Only rarely did she take a more subjective-philosophical approach and then she was on less secure ground. She was able to modify interpretations in the light of new results – for instance when she obtained the result that polyploidy was higher amongst the ferns of Ceylon than amongst those of Madeira and the British Isles, she had no difficulty in accepting that the frequency of polyploidy could not be interpreted as an adaptation to cold. Sometimes she was averse to hearing results, such as the presence of cellulose in the scales of haptophytes, which conflicted with her understanding; nevertheless she did not refuse to accept the evidence when it was accompanied by a full explanation.

Of the three areas of research she pursued – ferns, algal ultrastructural and nanoplankton distribution it is easiest to comment on her contribution to the study of nanoplankton first. The information she reported from the various collections she made has greatly expanded our general appreciation of the distribution of these small organisms. The results broadly conform to the thesis that 'everything occurs everywhere'. More detailed analysis points to local variations in frequencies with some species being extremely uncommon, at least in the water bodies she sampled. There are, of course, many questions that remain unanswered, for instance the possibility of some species being stages in the life-cycles of other apparently unrelated species. Nevertheless, this body of work represents a valuable contribution to a study still in its infancy. Its detail is unlikely to be repeated in the near future.

With regards to fern cytology, Irene was essentially the founder of this subject. The methodology involved in the fern programme had an important and lasting effect. Thus the modification of the squash method by the application of heavy pressure enabled the completely accurate determination of the high chromosome numbers found in ferns which was previously impossible to achieve. Hand-in-hand with this was (a) the insistence on

photography to validate the count and (b) the use of simple silhouettes, which illustrated frond morphology in a most effective way. The exclusive use of material of known wild origin obviated much of the confusion in the interpretation of chromosome data that bedevilled some of the early work by many authors on flowering plants. The use of synthetic hybrids in interpreting inter-relationships between species was also a key feature and enabled conclusions to be reached sometimes on an intercontinental basis e.g. *Polypodium, Dryopteris* and *Asplenium* where natural intercontinental hybrids could not be expected to form. One of the most striking features of the results was the very high basic chromosome numbers reached in the homosporous ferns mainly falling in the range $b = 22–69$ which could only be interpreted on the basis of a very ancient polyploidy followed after diploidisation by aneuploidy which characterised individual genera in contrast to the flowering plants and heterosporous pteridophytes where aneuploidy preceded polyploidy in sequence. It was possible, therefore, to use the basic chromosome numbers to group genera with their individual numbers into families and to indicate where past groupings were at fault. The case of the Pteridaceae has been noted. More familiarly the superficially similar appearing genera in the Thelypteridaceae could be confidently placed at some distance from Dryopteridaceae. A 'glass ceiling' on wider interpretation of interrelationships was hit by the limitations of the techniques then available and it is only now that due to the development of biochemical methods, such as nucleotide sequencing, that it has been possible to break through this barrier and to attempt a detailed picture of the evolutionary relations of the many families of pteridophytes to one another.

With respect to algal ultrastructure, the direction of this research was determined to a large extent by outside forces. Once electron microscopy became available, Irene was opportunistic in what she chose to work on. Thus she worked on marine flagellates with Mary Parke, and freshwater flagellates with a large number of colleagues who could supply the appropriate organisms. The deflection into diatoms came through an incidental meeting with Hans von Stosch. The fact that the algal work adds up to a coherent story is somewhat fortuitous. The important aspects to have emerged are:

1. Flagellar Ultrastructure (i) Details of the 9+2 structure were a valuable starting point for work by Peter Satir and co-workers who, in a splendid set of publications, showed that flagellar movement was achieved by sliding of the doublet microtubules. (ii) The early Manton papers on flagellar root structure and the first attempts to show that there might be a phyletic pattern laid the foundations to the large amount of work that has been carried out subsequently (Moestrup, 2000).

2. Cell Wall Structure. The results here have greatly extended our knowledge of cell wall structure in a wide range of flagellates from many systematic groupings. The different morphological scale types and the variations in the way in which they combine to form a cell wall are of interest. It seems certain that scales have evolved on a number of occasions and presumably are serving similar functions in the different groups.

3. The Golgi Apparatus. Revelations relating to the Golgi apparatus must rank amongst the most spectacular finds to have emerged from Irene's ultrastructural work. The consistent appearance of the Golgi apparatus and its function in scale secretion unequivocally confirmed the secretory role of this organelle.

4. Mitosis and Meiosis. The studies on *Prymnesium* and the diatom *Lithodesmium* provided the beginnings of descriptions that have now been taken much further by many other workers, in particular by Jeremy Pickett-Heaps.
5. Systematic implications. Irene's output of ultrastructural papers has made a substantial contribution to the systematics of algae. The Class Haptophyceae was created for haptonema-bearing species. The authenticity of the Prasinophyceae as a separate class of 'green' algae has been confirmed.

When it comes to placing Irene's research output within the pantheon of scientific achievement, her major contribution must be the enormous body of work that she has donated to the literature which will form the bedrock of information for generations to come. There are individual achievements that one could select which were of seminal importance – amongst these must range the universality of the 9+2 substructure of plant flagella and the structure and function of the Golgi apparatus. However, she did not have a completely novel find in the way that Barbara McClintock did which, of course, won her the Nobel Prize. However, Irene's achievement most certainly warrants her inclusion on the roll of honour alongside many other eminent Fellows of the Royal Society. The joint names of Sidnie and Irene Manton have now extended beyond the confines of this planet to a 20 kilometre crater on Venus (location: latitude 9.3º north, longitude 26.9º west). Designation of the 'Manton Crater' on Venus, in line with naming features on Venus after famous women, was announced by the US Geological Survey during the summer of 1992 (Leeds Reporter, 1992b).

When colleagues were asked to name the character traits that distinguished Irene, there was almost unanimity in their responses. Firstly, she had an insatiable inquisitiveness into the world around her. Secondly, she was a prodigious worker and applied the highest standards of rigour to both her research and writing. Thirdly she possessed great 'humanity' and unshakeable integrity. When Irene was appointed as 'first woman professor' at Leeds University, she saw it as her challenge to raise the standard of the botany department in Leeds to that which she had experienced in Manchester. Did she succeed? Emphatically yes, she brought great distinction to a University emerging from the shadow of its northern rival and it is most appropriate that her name should now be emblazoned on its buildings and computer clusters. Recognition in the after-life would also appeal to her mischievous sense of fun!

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POSTSCRIPT

One Hundred Years Ago – the admission of ladies.

At the Anniversary meeting held on 24th May 1904, the Treasurer (Mr. Frank Crisp) 'laid on the Table the Supplemental Charter, dated 8th April 1904, the result of the Special General Meeting held on 15th January 1903.

The Charter having been formally read over, the President (Prof. Sydney H. Vines FRS) moved a special vote of thanks to the Treasurer for the labour expended and his generous gift of the Charter to the Society, which was supported by Mr. W. Carruthers (former Council Member), and carried by acclamation.

In his 1904 Presidential address, Prof. Vines noted that he had begun his 1903 address

> "with an allusion to the probability that that Anniversary meeting would be the last meeting of the kind "for men only"; and I ventured to add that it would fall to my lot to admit the first Lady-Fellow. At the same time I was cautious enough to hint that the process of obtaining a Supplemental Charter would require time and patience. Owing to the realisation of the last of these three anticipations, the two others remain unfulfilled: so the Fellows are meeting today as of yore, and my term of office is not to be rendered memorable by the gracious event to which I have alluded. However I am to-day in a position to announce that the Supplemental Charter has at last been granted. I cannot make this gratifying announcement without adding that the Society is deeply indebted for the successful conduct of this business to the Treasurer, who has borne single-handed the not inconsiderable labour and, with characteristic generosity, the still less inconsiderable expense that it has involved.
> In order that the Supplemental Charter may become operative with as little delay as possible, the Council has been engaged for some time past in preparing a revision of the Bye-Laws. This will be submitted in due course to the Fellows for approval; and when this formality has been completed, the new order of things will have been officially inaugurated."

The President went on to note that in the expectation of

> "an appreciable increase in the average number of Fellows, it will be reassuring to know that, should this prove to be the case, the requisite accommodation will be forthcoming" and would be met by the Assistant-Secretary vacating rooms on the upper floor and "quite recently the Society had received official intimation that the rooms in this building at present used by the Post Office will shortly be handed over to us."

Some indication of the generosity of the Treasurer in paying for the Supplemental Charter can be gleaned from present-day costs in excess of £20K for this task.

Bye-Law revisions were read at General Meetings held on 2nd and 16th June 1904, when the Presidency had been assumed by Prof. William A. Herdman FRS, a marine biologist. The revised Bye-Laws were eventually passed at a General Meeting on 3rd November 1904

with 72 in favour and 4 against. "…. whereupon the President declared the new Bye-Laws to be confirmed by a large majority."

At a General Meeting on 17th November 1904, the following were proposed as Fellows: Her Grace Mary du Caurroy Russell, Duchess of Bedford, Miss Margaret Benson, D.Sc. Lond., Mr. Stafford Edwin Chandler, B.Sc., Mrs. Catherine Crisp, Miss Alice Laura Embleton, B.Sc., Mrs. Marian Sarah Ogilvie Farquharson, FRMS., of Haughton, Mrs. Grace Coleridge Frankland, FRMS., Mrs. Maria Matilda Ogilvie Gordon, Ph.D. Munich, D.Sc. Lond., Miss Gulielma Lister, Miss Ethel Sargant, Mr. Arthur Everett Shipley, M.A., F.R.S., Miss Sarah Marianne Silver, Mrs. Constance Percy Sladen, Miss Annie Lorrain Smith, Mrs. Mary Anne Stebbing, Miss Emma Louisa Turner, Mr. William James Tutcher, Mrs. Lilian Jane Veley, and Miss Ellen Ann Willmott.

So it was on 15th December 1904 that a General Meeting balloted for Her Grace Mary du Caurroy Russell, Duchess of Bedford, Miss Margaret Benson, D.Sc. Lond., Mr. Stafford Edwin Chandler, B.Sc., Mrs. Catherine Crisp, Miss Alice Laura Embleton, B.Sc., Mrs. Grace Coleridge Frankland, FRMS., Mrs. Maria Matilda Ogilvie Gordon, Ph.D. Munich, D.Sc. Lond., Miss Gulielma Lister, Miss Ethel Sargant, Mr. Arthur Everett Shipley, M.A., F.R.S., Miss Sarah Marianne Silver, Mrs. Constance Percy Sladen, Miss Annie Lorrain Smith, Mrs. Mary Anne Stebbing, Miss Emma Louisa Turner, Mr. William James Tutcher, Mrs. Lilian Jane Veley, and Miss Ellen Ann Willmott. All were elected to Fellowship except Mrs Farquharson. Her nomination was resubmitted on 6th February 1908, recommended by Lord Avebury, J. Reynolds Green, E.M. Holmes, Catherine Crisp, Grace Frankland and Ellen Wilmott. She was finally elected on 5th March 1908. Due to ill health she never signed the Roll for Admission to Fellowship, dying abroad in Nice on 20 April 1912, age 66 and was buried next to her husband in Alford on 21 May 1912.

A General Meeting on 19th January 1905 admitted Mrs. Catherine Crisp, Mrs. Constance Percy Sladen, Miss Ellen Ann Willmott, Miss Emma Louisa Turner, Mrs. Mary Anne Stebbing, Miss Sarah Marianne Silver, Mrs. Lilian Jane Veley, Miss Margaret Benson, Miss Annie Lorrain Smith, Miss Gulielma Lister, and Miss Ethel Sargant. A painting illustrating the event hangs in the Society's rooms in the stairwell just above the Library (see *The Linnean* 18(3): 11).

JOHN MARSDEN FLS

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