

Light on a dark lady

Rosalind Franklin was a scientist at a time when the parameters of science were changing fast and there were new ideas and new methodology to be explored; however, this was also a time when there was still considerable prejudice against women scientists.

I have long felt that there is a need for more to be told of Rosalind: more of the woman herself and more of her work. What is generally known of Rosalind has been gleaned from Jim Watson's book *The Double Helix*¹. Actually, she spent only two years of her short life at King's College London working on DNA; she also made a significant contribution to science through her research in other fields. Her fame, however, has been built around the work on DNA that she did at King's.

I was a friend of hers for a number of years and feel that I would like to pay tribute both to her ability and to her courage. This article, which was originally presented as a lecture to the Wimbledon Literary and Scientific Society, is dedicated to her.

As I prepared this article, I became more and more aware of what a very small part I had played in her life, although I probably knew her as long and as well as anyone apart from her close family. At times we would see a lot of each other; at others, circumstances would force us apart. However, even when we were closest, I soon came to realize that she was a very private and strictly 'compartmentalized' person.

Rosalind Franklin's background

I was eleven when I started at St Paul's Girls' School in 1931; Rosalind came in 1932. We became friends early on in our school life. We were both always in the first division for Maths, French, Latin and Science, but however good my exam marks were, Rosalind's would always be higher – except for one particular occasion well remembered by me! We both enjoyed sport and were members of most school teams until our second year of work for the Higher School Certificate. Rosalind studied Physics, Chemistry, and Pure and Applied Mathematics – I abandoned Chemistry.

Rosalind's background and upbringing were very different from anything that I had been used to. Her maternal grandfather, Jacob Cohen, won a scholarship

in mathematics to University College London, at the age of thirteen, where he graduated with first class honours in Maths and Classics. He read for the bar and combined his work as a barrister with that of his professorial duties in Political Economy at University College; he was the first Jewish professor appointed to an English university. Rosalind's father was Ellis Franklin – a man whose great-grandfather Abraham was the first of member of the Franklin family to come to England from Breslau, where Abraham's father was a Rabbi. Abraham settled in London in 1763, where he soon established himself as a Merchant Banker and prospered in his career. Throughout his life, he devoted much time, money and energy to a very wide range of charitable schemes. His was an orthodox Jewish family with a strong liberal tradition.

In 1938, the Franklin family took their usual summer holiday, renting two large houses in St David's, and invited me to stay with them there. I was overawed to find that, as well as hiring local help for the 'rough', they had taken three of their maids with them.

Throughout the 1930s, Hitler's persecution of the Jews had increased. The Franklins spent much time working with the German/Jewish Refugee Committee in Woburn Square, and it was there that Rosalind and I spent many hours during the weekends and in our school holidays helping to sort out endless papers, and trying to impart some kind of order in dealing with the vast numbers of heart-rending pleas for help.

In the Franklin family, there were a number of powerful and influential women who had made their mark by public work. They had concentrated their efforts on the disadvantaged members of the community and were at the forefront in seeing that women should have an education that would enable them to take their rightful place in society. Ellis Franklin had always assumed that his two daughters would follow the family tradition and use their time, energy and talents for the direct benefit of the community, rather than take up a career. This then is what he expected of his powerful, able and formidable daughter. I use the word 'formidable' deliberately, for although when relaxed Rosalind was far from that, she was one of those very able people of

great sensitivity who tend to mask their shyness with a brusque, abrupt manner. She never suffered fools gladly!

Cambridge

Rosalind was determined to get to Cambridge as soon as possible and succeeded in gaining a place at Newnham a year earlier than was then normal. I went to Girton a year later, but during our university years Rosalind and I did not see so much of each other.

Rosalind worked exceptionally hard throughout her undergraduate years; however, in Finals, she did not fulfil the expectations of her tutors, her friends or her family, and just failed to get a First. I suspect that she answered the questions on the papers in an unusual and original way that did not commend itself to the examiners. She was a prime example of those with good Seconds who achieve much more than those with good Firsts.

Rosalind considered her disappointing finals results to be a failure; I don't imagine that she had ever before encountered academic failure. She had always set herself extremely high standards and could not bear falling short of them. This did not always make her easy to work or live with. She was, however, offered a research grant and stayed on for a year in Cambridge to do research on gas-phase chromatography, under the supervision of Ronald Norrish; in 1945, her PhD thesis was accepted.

During that year, Rosalind lived in and helped to run a hostel that had been established by a French refugee, Adrienne Weil. The two became close friends and Adrienne – a scientist – helped Rosalind to emerge from her formal family background and traditional schooling at St Paul's. Adrienne supported her in the struggle to break away from the pattern expected of Rosalind by her parents. Rosalind was steadily becoming increasingly uneasy with the political outlook her family adopted and was very ready to move further toward a socialist standpoint. In the clever, lively Adrienne she found the friend, companion and guide that she needed and, subconsciously, had been looking for. With Adrienne's support and friendship, Rosalind was able to crystallize both her political ideas and her religious beliefs.

The war years

Rosalind and I left Cambridge in 1942 and were directed into war work. Rosalind joined BCURA (the British Coal Utilization Research Association), where



Figure 1

Rosalind Franklin, by courtesy of the National Portrait Gallery, London. Every effort has been made to trace the owner of this portrait but the name of the photographer remains unknown.

she did research on the structure of carbons; I went to work for BAC (the Bristol Aircraft Corporation) and later joined the staff of Bristol University as an Assistant Lecturer in Applied Mathematics.

I don't think that either of us had much leave during the latter years of the war, but we did manage to fit in two walking holidays – one in Snowdonia and one in the Peak District. I particularly remember the Welsh holiday. One day we had made our way up Snowdon to the snow-covered Crib Goch ridge, when the mist set in. I was thankful for that as I was no longer able to see the steep drop on either side. I just managed to make my way along the ridge – driven more by my fear of Rosalind's tongue than of falling over the edge.

Paris

In 1947, things changed for both of us. In August of that year, I got married, resigned from the University and came to live in London. With the war over by the spring of 1946, Rosalind had decided that she should leave BCURA. She had written a note to Adrienne, who was back working in Paris, asking her to keep a lookout for someone anxious for the services of 'a physical chemist who knows very little physical chemistry, but quite a lot about holes in coal'. A friend of Adrienne's, Marcel Mathieu, a distinguished scientist, held a responsible position in a government agency that supported and controlled a great part of French scientific

research. He had emerged from his wartime resistance activities with a reputation as a hero. Adrienne knew that Mathieu was to attend a conference on carbon research in London in 1946 at which Rosalind was to present a paper. They met and immediately took to each other. Obviously, here was someone that Rosalind could admire and respect, so she had no need to show her defensive side. Mathieu found her charming and was able to make a shrewd estimate of her outstanding scientific ability. She was appointed 'chercheur' at the Laboratoire Central des Services Chimique de l'État in February 1947.

Rosalind spent four years in Paris, living for the most part in very cramped quarters. She had a single room in a flat belonging to a Professor's widow, where she was allowed use of the bathroom once a week; otherwise, she had to make do with a tin basin placed behind a screen. This single room made a strange contrast to the spacious, double-fronted house in Pembroke Place in which she had been brought up. Suffice it to say, she was very happy during her time in France. The cramped flat seemed to augment rather than limit her freedom and personal development. Her work went well; she was valued for herself; and so she blossomed in many ways.

My husband, Michael, and I stayed with Rosalind in her cramped quarters in Paris in 1948. Later, in 1951, with our two children, we set off from London in an

old London taxi and camped out for six weeks in a derelict farmhouse in the Dordogne, at St Léon sur Vézère. Unfortunately, Joanna, our daughter, developed chickenpox just before she came. I remember sending a telegram to Rosalind: 'Joanna Varicelle (Chickenpox) A bientôt'.

Undaunted however, Rosalind did come to stay with us, and we spent a very happy and relaxed time together. One day, leaving the children with Michael, she and I drove over to Montignac and went into the Lascaux caves – now no longer open to the public. Another day, we went to Rocamadour, leaving Ben, then aged about six months, with *Grand'mère*, who owned and lived in half of the house that we were renting. Joanna won Rosalind's admiration by saying as we reached the top step, having climbed a long way up from the car-park to the village, 'Can we do it all again?' Rosalind flourished in the freedom of a holiday like that. She was kind, generous, relaxed and always at her best with children. That is how I remember her. From St Léon, she returned to London, having had a break in Paris en route.

By then, a happy and rewarding period of Rosalind's life was over. She had gained much from her time at the Laboratoire Central: her research work had gone well; she had felt her contribution was appreciated; and she got on well with colleagues, who esteemed her for her intellectual prowess, her experimental skill and her ability to work with single-minded concentration on whatever she was doing. She did not experience any sex prejudice in Paris – had Madame Curie set the pattern? She had also been free to live as she wished, to expand her extensive culinary skills, to acquire a French dress sense, to enjoy herself in mixed company and so shed many of the restricting inhibitions that had surrounded her.

It was shortly after Rosalind's return to England that my life was disrupted and I changed from being one of a two-parent family with two children to being a single parent of four. I was very busy and had little time or energy for anything other than keeping going. During that period, I seemed to have had no conscience about asking for help from others, and I was able to find friends and relations who appeared not only willing but anxious to have my children to stay while I had a brief holiday. In 1953, Rosalind and I went together by train (the 'Tauern Express' travelling from Victoria) to Athens, changing at Munich and Ljubljana. In Ljubljana, we stopped for a truncated 24-hour break and stayed with Duysan, a scientific

colleague of Rosalind. I remember him saying to me, 'she makes my clockwork tick'. After a brief stay in Greece, Rosalind went on to Israel for a hitchhiking holiday and I returned home. Later in 1955, Rosalind and I went on a cycling tour in the Brittany–Normandy area. This was another high spot for me, in what was a grey and tough period of my life, and I am sure I was not sensitive to her needs. Despite our other preoccupations, our friendship was stalwart enough to endure and we had a really good holiday – although she was back to jumping on me. This time, it was for replying to the question of what did I do, by saying that I was a 'femme de ménage'. Nevertheless, that holiday was another time when we enjoyed being together and felt free from the constraints and criticisms of our daily work.

King's College

Paris, for Rosalind, had been a happy and productive period. She had seemed ideally suited, both in temperament and in intellect, to continue working in France. However, the Laboratoire was a government funded institution and it was unlikely that she, an alien – there was no European Union in the 1950s – could have had a permanent post or a fulfilling career there. She knew that, in order to further her career, she must move, and that she should extend her area of research. She was primarily an X-ray crystallographer, and work in that field had grown from being concerned with metallurgy and mineralogy into the field of biology. She certainly was greatly attracted to the new challenge of using the X-ray diffraction technique on biological substances and would therefore have been especially tempted by the possibility of carrying on her research at King's College London, which was then at the forefront of such work. This career benefit would weigh more than any personal inclination. She returned to England, but at this point things went wrong. She was horrified to find, when she arrived at King's, that the Senior Common Room (SCR) was out of bounds to all women – whatever their status. This was a restriction that she could not take lightly and her forceful reaction can hardly have endeared her to her colleagues.

Rosalind had been appointed to her post by Sir John Randall, Professor of Physics and Director of the MRC Biophysics Research Unit, to do her own research and to set up and expand a new X-ray diffraction unit. She understood that the X-ray diffraction unit was to be

her unit. It was most unfortunate that, on the day of her appointment, Maurice Wilkins was on holiday. Wilkins was the second in command in the laboratory and was already working on DNA structure. At the time Rosalind was interviewed, Raymond Gosling (Wilkins' PhD student) had been asked to join Randall and was told that he would be Rosalind's student in future. Wilkins returned to find Rosalind installed and with Raymond Gosling working with her as her PhD student.

It was only years later that Wilkins saw Rosalind's letter of appointment, which set out, in a rather ill-defined way, the nature of her responsibility. The latter never seems to have been made clear either to Rosalind or to the senior staff at King's. This cannot have made things easy for anyone. She came to King's on what she believed to be the understanding that she was to be working in her own area of research, but that she could expect to enjoy cross-fertilization of ideas and discussions with colleagues who might perhaps use a very different line of approach from her own. She was not the only one to have misunderstood what was being required of her.

It is pointless now to argue how or why this misunderstanding first arose, although it does appear that lack of open communication may have been a contributory factor. Suffice it to say, it resulted in much unhappiness and frustration. It is only necessary to read Jim Watson's book *The Double Helix* to realize that time and energy were wasted in cross-purposes with crossed lines (see Box 1).

Neither Rosalind nor I had much time for leisured meetings, but I do remember that she spoke to me about the rebuff she had felt in being excluded from the

SCR. This veto might appear trivial to some; to her it appeared just stupid. It led her to think that King's did not take women seriously; her reaction would have been to be on the defensive and to hide the hurt she felt with aggression. Once she had decided this, she would have appeared unapproachable and become submerged in her work.

The double helix

Scientifically speaking, Rosalind had come to England at the right moment. Research on heredity was on the verge of taking a great leap forward; much work had already been done. It appeared that determining the actual structure of the DNA molecule would be fundamental, although at this stage the connection between DNA and heredity was only a theory lacking any form of proof. It was not clear whether further research should be based on X-ray diffraction work alone or combine such an approach with model building, or indeed, involve X-ray work at all.

During the first two months of 1953, the pace hotted up. Rosalind had already discovered that there were two forms of the helix, which she had christened A and B. She worked on the A-form using the laborious Patterson Technique – a lengthy and tedious process of mathematical analysis of the diffraction patterns generated. I remember our being in her flat one evening and churning away on a hand calculator to produce some of the results. She would show me her patterns with great pride, but I never had the remotest idea of the enormous importance of the work she was doing, nor did I appreciate the great significance of her achievements. At the same time, she

Box 1. Setting the record straight

In the last two paragraphs of the epilogue to the *Double Helix*, James Watson speaks of those whom he had mentioned:

All of those people, should they so desire, can indicate events and details they remember differently. But there is one unfortunate exception. In 1958, Rosalind Franklin died at the early age of thirty-seven. Since my initial impressions of her, both scientific and personal (as recorded in the early pages of this book), were often wrong, I want to say something here about her achievements. The X-ray work she did at King's is increasingly regarded as superb.

The sorting out of the A and B forms, by itself, would have made her reputation; even better was her 1952 demonstration using Patterson superposition methods, that the phosphate groups must be on the outside of the DNA molecule. Later, when she moved to Bernal's lab, she took up work on tobacco mosaic virus and quickly extended our qualitative ideas about helical construction into a precise quantitative picture, definitely establishing the essential helical parameters locating the ribonucleic chain halfway out from the central axis. Because I was then teaching in the States, I did not see her as often as did Francis (Crick), to whom she frequently came for advice or when she had done something very pretty, to be sure he agreed with her reasoning. By then all traces of our early bickering were forgotten, and we both came to appreciate greatly her personal honesty and generosity, realising years too late the struggles that the intelligent woman faces to be accepted by a scientific world which often regards women as mere diversions from serious thinking. Rosalind's exemplary courage and integrity were apparent to all when, knowing she was mortally ill, she did not complain but continued working on a high level until a few weeks before her death¹.

had continued to take X-ray diffraction photographs and had an excellent photo of the B-form, which in January she handed to Wilkins. Two days later, she wrote what was to be her last paper at King's. A further two days passed before a paper by Linus Pauling on DNA arrived in Watson and Crick's laboratory in Cambridge. This paper demonstrated that Pauling was within easy reach of the solution but had it wrong. Watson decided to travel posthaste to King's, in order to consult with his friend Wilkins. However, when he arrived, Wilkins was not immediately available and Watson looked in on Rosalind. What exactly happened then is not entirely clear, but apparently they almost came to blows before Wilkins arrived and took Watson away. It was then that Wilkins, in good faith, showed Watson the photo that Rosalind had taken. It appears that Rosalind had given it to him for his own use and did not expect him to hand it to those she considered the opposition. The showing of the photograph further exacerbated the situation. It was particularly destructive, as Rosalind did not even know that it had happened.

Rosalind's draft paper on 17 March 1953 outlined her conviction that the B-form was helical and comprised two coaxial chains (the double helix). By this time, Watson and Crick had already reached the same conclusion and were all ready to publish². Watson and Crick had set out to discover the secret of life using the technique of model building, while Rosalind's approach was based on her X-ray diffraction patterns of both the A-form and B-form of the sodium salt of DNA³.

Tobacco mosaic virus

By the time the Watson and Crick's paper on the Double Helix² was published in *Nature* on 25 April 1953, Rosalind had already left King's for a new post at Birkbeck College. Professor J. D. Bernal, who headed the Birkbeck lab, was someone whom Rosalind could respect as a scientist, but she would have found his dogmatic political views unattractive and her brand of socialism was a far cry from his old-fashioned communism. However, she must have found his active support of women students, and his eagerness to promote them, encouraging and endearing.

On her arrival at Birkbeck, Rosalind continued the work on the tobacco mosaic virus that Bernal had started in 1935. She worked in a small fifth-floor, attic-type room in an old house in Torrington Square. I remember visiting her in this small lab, where, although cramped, she

was happy doing her research – even though the X-ray camera was in the semi-basement. Perhaps, as with the cramped conditions in the Paris flat, the physical conditions did not bother her that much, provided she was at peace with her work, with her colleagues and with herself.

Rosalind was in charge of a team working on the tobacco mosaic virus and she quickly infected those working with her with her enthusiasm and drive. In the four and a half years she was at Birkbeck, she produced 17 papers (three published after her death), which gives an indication of the prodigious amount of research she carried out during that period. This would be a remarkable achievement under the best of circumstances, and was astounding when one realizes that for much of that time she was seriously ill and was very well aware of the prognosis for an inoperable cancer. Aaron Klug had come to Birkbeck in 1954. In Aaron, Rosalind found an ideal working partner and it was with him that the majority of her published papers were written. After she died, Klug took over the post as the head of the virus structure research group.

It must have been during the summer of 1957, when she already knew that she was terminally ill, that Rosalind prepared and took my four young children and myself for a river picnic on the Thames near Hurley. She had brought ice-cream with her, and the main memory my children have of this occasion is the behaviour of the dry ice that she had brought. They were all fascinated as she threw it out and they watched with awe as it zoomed about, apparently steaming around on the surface of the water. The inclusion of the dry ice in the picnic basket demonstrated again her kindness and thoughtfulness for others, especially children. She shared the children's delight as the ice whizzed about.

Rosalind died in April 1958; what she had achieved, her courage and her determination impressed all who knew her.

Tributes

In 1962, the Nobel Prize for Medicine or Physiology was awarded to Francis H. C. Crick, James D. Watson and Maurice H. F. Wilkins. The three men, almost a decade earlier, had worked together, merging data from chemistry, physics and biology, to solve the structure of DNA – Crick and Watson building a hypothetical model that would conform in all its parts to what Wilkin's X-ray pictures had already shown of the molecule. The interplay of ideas, temperaments and circumstances was an especially fortunate

one, since the result was something that, in Watson's words, was too pretty not to be true: the Double Helix.

Rosalind could not have received even a share in the Nobel Prize in 1962, as it cannot be awarded posthumously. There are, however, friends and colleagues who think it sad, perhaps unjust, that so little mention was made of her achievements either then or later. There is a blue plaque outside her flat at the corner of the Fulham Road and Drayton Gardens, and Maurice Wilkins showed me a plaque on the wall at King's commemorating all those who were involved in the DNA work: the four names – Rosalind's included – fit nicely in round the rim.

In paying tribute to a friend with whom I had a long association, I hope that what I have told you has brought to life one of the most able women scientists of our generation.

References

- 1 Watson, J. D. (1968) *The Double Helix*, Atheneum
- 2 Watson, J. D. and Crick, F. H. C. (1953) *Nature* 171, 737–738
- 3 Klug, A. (1968) *Nature* 219, 808–810; 843–844

ANNE PIPER

8 Lower Common, London, UK SW15 1BP.

Reflections

Reflections contains articles that not only consider historical events in biochemistry, but also developments in molecular biology and genetics, comparing the differences between working in the early days of molecular biology with the present. We also hope to include articles that reflect the roots of discovery of much of the molecular information and the techniques used by molecular biologists in the 1990s.

If there is a topic that you think might be a suitable contribution to the *Reflections* column, please contact either

Jan Witkowski

(Email: witkowsk@phage.cshl.org)

or **Mary Purton**

(Email: tibs@elsevier.co.uk)