Dorothy Hodgkin’s (1910-94) Networks in Science and World Politics.

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Chart 2: D. Hodgkin’s Networks in World Politics

- Leading scientist who solved complex structures with large teams of collaborators; (penicillin, vitamin B-12, insulin)
- Woman scientist before the era of affirmative action; (1972-)
- A “neat case” for studying the impact of gender in science due to lack of other adverse markers; (race, class, re/li/gion)
- Participant in the work on protein structure, 1934-, a major research program in the history of molecular biology, which required international and transdisciplinary networking and collaboration.

Historical context of DCH’s Life, 1910-94

- **1910s**: Familial network cut off by WW1- parents stranded in ME; living with relatives, as eldest child, DCH is in charge of 3 sisters;
- **1920s**: Regular travel to British Empire dominions as daughter of civil servant, archeology active, father excavating in Egypt, Sudan, Transjordan, P-LI; (Rockefeller Museum in East Jerusalem) travel -Pacifist activism in League Nations w mother who lost all 4 brothers inWW1;
- **1930s**: Socialist sympathizer & fellow traveller; student of J.D. Bernal, FRS, founder of the Association of Scientific Workers; spouse of Thomas Hodgkin, Quaker & communist activist in Northern England.
- **1950s**: Champion of socialist countries during the Cold War era
- **1970s**: Scientific ambassador to the Third World; (as President of Pugwash, 1975-85, Nobel Laureate, 1964-, O.M. recipient, 1965-)
Family Networks: birth order, social class, maternal role model, (non-conformist) marriage

- First born among four daughters; no competition from a male sibling; managerial responsibility for younger siblings; negotiation skills w relatives during prolonged parental absence;
- Family inter-dependence - studies financed by an aunt;
- Social class: precarious in the parents’ generation; lower gentry (M) versus upward mobility via Oxford education & colonial service; (F)
- Maternal role model: mother travelled widely, while pursuing her own interests in ancient textile; independent woman of higher social class;
- Marriage to non-scientist quasi-gentleman, hence no patrilocality;
- Marriage into Oxford’s and Quaker aristocracies: father-in-law, Master of Queens College; aunt-in-law, Principal of Somerville; cousin-in-law Alan Hodgkin, Nobel Laureate, Master of Trinity. (Cambridge)

**Educational background:** institutional stability but relative marginality at Oxford

- **Early donship** as Fellow of Somerville, (1936, age 26) thus acquiring both academic status & economic independence for life; ability to retain the donship after marriage, (1937) due to recent progress = no displacement upon marriage.

- **Ability to work during WW2** - Oxford was in the countryside; further benefitting from evacuees from blitzed London and refugees from Europe; attracting research grants from the Rockefeller Foundation at a time most men were at war.

- **Election to Reader** (against a man) in 1946 and to RS Research Professorship; (no election to a regular Chair)

**DCH as a graduate student, c. 1936**

*Fig. 1.1: Dorothy when I first knew her.*
Scientific Background: Biomolecular Crystallography as a Tight Network of Transdisciplinary Pioneers

- Ph.D. studies at Cambridge (1932-1936) with a stimulating, popular, and well connected founder of a new area, J.D. Bernal. (1901-1971)
- The challenge and opportunity of a new, interdisciplinary field at the interface of physics, chemistry, biology, and mathematics.
- Co-authorship of a historical paper with JD Bernal in 1934, the first (globular) protein (pepsin) X-ray photo. (Abir-Am 1992)
- Starting independent work on “her own protein” in 1935; (insulin)
- Ph. D. (Cambridge) on the 3-dim structure of sex hormones. (1936)
- Clearing up Bernal’s work on TMV once he joined the war effort;
- The penicillin breakthrough during WW2 and election to RS; (1947)
- Solving vitamin B-12 (1957) and a sole Nobel Prize; (1964)
- The challenge of insulin and the collaboration with China; (1969)

DCH’s early network of collaborators: Denis Riley’s recalls gender profiling at Oxford in the 1930s

- "Having said that we were both Oxford chemists, which fact gave us much in common, it must be stated that pre-war Oxford was a masculine stronghold and the science faculties even more so. Although women had been admitted into membership of the University in 1920, their numbers were limited by statutes to about one fifth of those of men... Women students were not admitted to membership of the Oxford Union. It was in this environment that Dorothy Crowfoot started her career. I was Dorothy's very first research student. I started work on my Part II with her in September 1937. This at the time was quite revolutionary and several eyebrows were lifted. Here was I, a member of a prestigious college, choosing to do my fourth year research in a new borderline subject with a young female who had no university appointment but only a Fellowship in a women's college. At the House, as Christ Church is always called, there were some misgivings. I was after all an Exhibitioner and by that fact 'on the Foundation' and my tutor, Dr. A.S. Russell, was still in loco parentis. He was somewhat less than enchanted with the idea but did see Dorothy and discuss it with her. Having done so, he indicated to me the college's acceptance of the proposal... (Riley, 1981, 17)"
DCH’s networking ability among (5 male) protein X-ray crystallographers, at a time of controversy and polarization

- “I remember in early 1939 that Dorothy and Dennis Riley visited J.D. Bernal and Fankuchen at Birkbeck...I was a complete newcomer to crystallography, having just joined Bernal as an M.Sc. research student in the Department of Physics...I was impressed by the young and attractive Dorothy who appeared to be carrying the day in her arguments...Little did I realize that Dennis Riley, who also spoke authoritatively at this meeting, was Dorothy's first research student, and that later that year, after war broke out, I was to be her second...In late September, he [Bernal] told me that he had made arrangements for me to continue my research work at the University Museum, Oxford, with Dorothy, and that I was to take the Department's X-ray equipment there...I took my research problem to Oxford.” (Carlisle, 1981, 30)
DCH’s Laboratory as a Community Network

• “There was a family atmosphere in this room upstairs. Each member of the community took his or her turn, weekly, to provide the little cakes that went with the afternoon’s cup of tea …Mutual assistance was frequent; animated, even heated discussions were normal. [The desk] looked totally disorganized…heaps of scientific papers…reprints of articles mingled with lecture notes, diagrams, tables of figures, and her children’s drawings. Yet Dorothy seemed always instantly able to find anything she needed. (Robertson, 1981, 73).”

DCH’s network of research students; between experimental skill and casual guiding style

• "...The greater part of her time Dorothy would spend with her research students, drifting inconspicuously from one to another, sometimes settling at one table for hours at a time, sometimes working downstairs with the X-rays or the polarizing microscope. Dorothy was extremely skilled in the use of the polarizing microscope...She was in any case a skilled micromanipulator, as good as any in the laboratory, and better than most and this despite the horrid distortion of her finger joints and wrists which her long-standing arthritis had inflicted on her.” (Robertson, 1981, 74).
DCH’s networks among leading colleagues. (Sir Lawrence Bragg, Jack Dunitz, [Lord] David Phillips)

"This [the addition of two who had not worked directly on proteins] was Dorothy's doing. Anxious to build up a really strong group at the Royal Institution, Bragg had also asked Dorothy if she would join him there, but she was not prepared to leave Oxford at a time when her family commitments were heavy and the work on vitamin B-12 was promising well. Instead, with her inimitable knowledge of crystallographers around the world, she suggested that Bragg should ask Jack Dunitz and me to join him..." (Phillips, 1981, 17)
DCH watching a model of lysozyme with leading protein X-ray crystallographers Bernal, Kendrew, Phillips (lyz. struc. discoverer-1965)

DCH’s institutional networks: envisioning the moving of a whole group from Royal Institution/London to Oxford University

• “Dorothy came often to see us at the Royal Institution...and she never failed to convey a conviction that proteins would eventually follow vitamin B-12 in submitting to the most detailed and refined study. But her support went far beyond encouragement and advice. As early as 1958 she was discussing the possibility of our helping to build up a protein-structure group...at Oxford...The happy result was that most of us who had worked with Bragg at the Royal Institution were able to move to Oxford...the traces of Dorothy's influence can be seen everywhere...and everywhere, it seems, there are Fourier maps - as larger and larger structures submit to refined analysis as she knew they would (Phillips, 1981, 13-16).

DGH’s network of colleagues (Bernal, Pauling, Robertson, Perutz) as an input into her work.

• "Of course, Dorothy's work was not done in isolation. It owed much to the example and inspiration set by her contemporaries: Bernal, Pauling, Perutz, Robertson, and others. But her own work had a quite individual direction about it, a direction that soon led her to be acknowledged as the leading crystallographer on the field of natural product research. Dorothy had an unerring instinct for sensing the most significant structural problems in this field, she had the audacity to attack these problems when they seemed well-nigh insoluble, she had the perseverance to struggle onward where others would have given up, and she had the skill and imagination to solve these problems once the pieces of the puzzle began to take shape. It is for these reasons that Dorothy's contribution has been so special" (Dunitz, 1981, 47-59).
DCH’s place in a network of pioneers in protein X-ray crystallography. (Bernal, Bragg, Keilin, Perutz)

- "The four people who took an interest in my early X-ray work on haemoglobin were J.D. Bernal, W.L. Bragg, D. Keilin and Dorothy… she labored on the structure of life in a place [the University Museum's nave of skeleton of extinct species] that was, but for her vitality, quite dead. Her tables were piled high with structure-factor and Fourier calculations; there were viewing boxes for looking at X-ray pictures. Her X-ray and dark rooms were adjoining. The gothic window was high above as in a monk's cell, and beneath it there was a gallery, reachable only by a ladder, on which stood a table with Dorothy’s polarizing microscope. To mount one of her precious crystals of penicillin, Dorothy would climb up there, stick the crystal to a thin glass fibre, stick the fibre to a goniometer head, and descend again, clutching her treasure with one hand while holding on the ladder with the other. I don't think she ever lost a crystal.” (Perutz, 1981, 5)

DCH’s network of undergraduate students (“girls doing structures”) as a reservoir of humanpower

- For all its gloomy setting, Dorothy's lab was jolly place. As Chemistry tutor at Somerville she always had girls doing crystal structures for their fourth year and two or three students of either sex working for their Ph.Ds. They were a cheerful lot, not just because they were young, but because Dorothy's gentle and affectionate guidance led most of them on to interesting results...(Perutz, 1981, 5)
DCH’s belated Nobel Prize, or the limits of networking for women in science. (Bragg, Kendrew, Perutz)

- I felt embarrassed when I was awarded the Nobel Prize before Dorothy, whose **great discoveries** had been made with such **fantastic skill and chemical insight** and **had preceded my own**...Anyway it was easy to make a good case for her; Bragg and Kendrew signed it with me, and to my immense pleasure it produced the desired result soon after" (Perutz, 1981, 5-12).

DCH as a Nobel Laureate
(Chemistry, 1964, for structure of vitamin B-12; sole laureate)
DCH’s network of British socialist scientists: (Bernal, Lonsdale, Wooster) their input into scientific détente with China

• "During the years 1959-1977 Dorothy came to China four times. During these long years she helped to facilitate the flow of information and understanding between crystallographers in China and abroad... I thought it remarkable that Dorothy was still emotionally attached to insulin when occupied with the work on vitamin B-12...In the 1950s we received few Western visitors, but English crystallographers were an exception...When Dorothy came to China in 1959 she had already accomplished her outstanding work on vitamin B-12 and we were celebrating the tenth anniversary of the founding of the People's Republic of China. We welcomed her to Peking University to give a lecture on vitamin B-12...she surpassed her predecessors [J.D. Bernal, P. Wooster and Kathleen Lonsdale] and established an intimate and lasting friendship with Chinese crystallographers...By the time Dorothy came to Peking in 1977 we were still overjoyed with the collapse of the 'Gang of Four' in the previous year...This time she brought with her Guy Dodson and gave us a chance to meet a crystallographer of the younger generation...Dorothy will be remembered with great affection and respect by the Chinese crystallographers" (Tang You-Chi, 1981, 43-44).

DCH compares maps of insulin in Beijing; & tours the Great Wall
DCH’s network of **foreign doctoral students**
(Canadian, Americans, Pakistani, Indian, British)

- “She welcomed having colleagues from every part of the world and always insisted on their going back to their own countries and working there….I felt it would be ideal if Indian crystallographers could hitch their wagon to this star…I went to Oxford for a year (1964-65) ostensibly to ‘look after’ Dorothy’s doctoral students when she was away in Ghana with her husband….**they were an international lot…[Canada, USA, Pakistan, UK, India]…** At Stony Brook, Dorothy reminded me of our meeting Vijayan in Bangalore just two years previously. ‘I feel so happy that Vijayan did join the insulin group. In Sanskrit I am told Vijayan means the Victorious: truly he did finally bring us victory.’” *(Ramaseshan, 1996, 117, 118, 122)*

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**DCH & research associates in Bangalore, India**

*Bangalore, 1970s: Vijayan and Kalpana are to the right of Dorothy. Sri Ramasubban stands behind his wife Ramadipa. (Courtesy of the Hubbard family)*
DCH’s diverse international network of “revolutionaries, refugees, students, colleagues, friends” as house guests

• “They [DCH and her family] kept an open house and the guests included the powerful and the famous, revolutionaries and refugees, and their own innumerable students, colleagues, and friends. To her students and colleagues she was a teacher, mother, friend, and guide, rolled into one…Einstein said of Mahatma Gandhi: “Generations to come, it may be, will scarce believe that such a one as this ever in flesh and blood walked upon this earth”. This is true about Dorothy Hodgkin to a large measure”. (Vijayan, Crystallography World Wide, 20 Sept, 1994, p. 3)

DCH supporting Vietnamese countryside women in 1971
DCH w colleagues at Intnt. Congress of Crystallography, Tokyo, 1972

DCH as President of Intnt. Congress of Crystallography, Tokyo, 1972
DCH (Pred. 1975-85) arrives at a Pugwash Meeting with her successor Joseph Rothblatt

DCH’s network of wo/men students turned famous crystallographers (Barbara L., Jenny G., Margaret A., Guy & Elinor Dodson)

• “Always on the lookout for new and better ways to solve structures, she pioneered the use of Patterson maps...Cholesteryl iodide was one of the first analyses based on three dimensional calculations, and it established the relative stereochemistry at each carbon atom of the steroids...With Barbara Rogers-Low, Dorothy determined the structures of the sodium, potassium, and rubidium derivatives of benzylpenicillin, using isomorphous replacement, optical analogs and difference maps...Dorothy used the Cobalt atom to phase the hexacarboxylic acid derivative of vitamin B-12, even though everyone advised her that it would not work because the scattering power of the cobalt atom was too weak with respect to the rest of the molecule...After her retirement Dorothy, with Guy Dodson and his colleagues, published a definitive monograph on insulin”. (Glusker and Adams, 1995, p. 1-2)
DCH’s network of distinguished women scientists who trained in her lab

- Johnson supplied names of the major collaborators for each structure, but especially the names of a galaxy of distinguished women scientists who trained in DCH’s lab at Oxford, including “Pauline Harrison, Jenny Glusker, Marjorie Harding, Margaret Adams, Eleanor Dodson, Judith Howard, and Carol Huber, among others”.

DCH as Chancellor of Bristol University in a gown created for Winston Churchill (portrait above)
DCH’s family network: 3 sisters, her own 3 children, several grandchildren (one in photo)

Painting of DCH in the National Portrait Gallery, 1985 (age 75)
Conclusions

- DCH was able to overcome the adversity of being a woman in science by judicious use of interlocking and international networks of collaborators:
  - Undergraduate “captive” women students;
  - International doctoral students; (mainly from Commonwealth countries, incl. spouse labor)
  - Chinese colleagues via her détente stance;
  - British & European colleagues via diplomacy;
  - Women scientists via her network of pioneers in the rising field of biomolecular structure.

Chart 1: Dorothy Hodgkin’s Networks in Science

- **Biotheoretical Gathering, ‘30s** (Abir-Am 1987)
- **2nd World Scientists esp. China (Beijing)**
- **Women Scientists** (comp. KL, REF, LJ)
- **Protein X-ray Crystallographers** (Abir-Am 1992, SE)
- **“Small” Mol. Chem. crystalogr. & methods** (D, S & G, eds. 1981)
- **3rd World Scientists (esp. India)** (R-96; CW-96)
- **Leading Students** W: BL, JG, CB, MA M: DR, DS, GD, TB
- **British Science Orgs:** BAAS, Royal Society, Bioch. Soc.
Chart III: Hodgkin's Networks in Science & World Politics

Socialism, Communism, Pacifism

Protein & small mol. Crystallographers & chemists

British Empire rels; (Sudan, Egypt, Trans-Jordan, P-LI, Ghana, India)

Oxford University

Dorothy C. Hodgkin 1910-1994; Oxford U: 1934-94; Nobel 1964

British academia (Ch, Bristol Univ.)

Visits to China & Soviet Union

Pugwash President, 1975-85; almost a Peace Nobel in 1995

Thatcher & Gorbachev

Chart 2: D. Hodgkin's Networks in World Politics

Socialism, Communism

British Empire Civil Serv. family

Quaker by marriage, post-WW1 Pacifism

Oxford University, Res. Prof.

Dorothy C. Hodgkin 1910-1994; Oxford U: 1934-94; Nobel 1964

Somerville College (F. dons)

British academia (Chancellor, Bristol U.)

Middle East, Africa, India, China, Vietnam, Soviet U.

World Politics, Pugwash, 1975-85 Thatcher & Gorby
Some pertinent literature by PGA


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