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SCIENTOMETRIC PORTRAIT OF BARBARA McCLINTOCK: THE NOBEL LAUREATE IN PHYSIOLOGY

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Abstract

Barbara McClintock (1902-1992), the winner of Nobel Prize in physiology for 1983 was the prime intellectual driving force behind the Cornell Genetics Group between 1929 and 1935. Her discovery that transposition is a vital part of genetic mutation was a veritable break through in experimental genetics. The fact that she could achieve this in spite of all odds posed by the social set up of that time, makes her a typical scientific figure worthy of detailed analysis. By analysing the publications of Barbara McClintock, the present paper identifies her peak period of publication productivity, her collaborating authors and the extent of collaboration, the scattering of her publications in various sources and the keywords used for the titles of her papers. Typical characteristics of her personality and implications of her achivements are illustrated by citing incidents from her life.

1 Introduction

The history of women's participation in the sciences is one of unrelenting struggle to be allowed to study these fields in the first place, and then to be permitted to work as fulfledged scientists rather than assistants to men. Women had to struggle to have publications accepted and proposals funded, to gain admission to professional societies and their several benefits, and finally to be rewarded in the usual ways with recognition, election to honorary academies, and prizes. Many women experienced difficulties in juggling work and home life. Some chose not to marry; others had no children, and still others eventually divorced (Hornig, 1993).

Having found patches of colour in the leaves of a bunch of experinmental Indian corn seedlings - unlike anything noticed before - Barbara McClintock examined their growth with interest. The problem of variegation in maize was of slight importance from a practical point of view, but it fascinated Barbara because it evidently could not be explained on the basis of Mendelian genetics. She analysed this phenomenon by studying chromosome changes and the results of crossing experiments in maize with different patterns of variegation. She was able to identify a series of genes on chromosome number 9 that determine pigmentation and other characteristics of the endosperm. She found that variegation occurred when a small piece of chromosome 9 moved from one place on the chromosome to another close to a gene-coding for a pigment. The usual effect was to switch off the gene, and furthermore, the chromosome frequently showed a break at the site of integration. In a moment of great intuitive insight she saw regularity in these color patches and speculated that something was regulating the rates of mutation. Barbara believed that she was observing something called 'transposition'. McClintock called these types of genetic material 'control elements' since they clearly altered the function of neighbouring genes. In a series of very advanced experiments carried out between 1948 and 1951, McClintock mapped several families of control elements. These elements effected not only the pigmentation pattern of the maize kernels but other properties as well. She also pointed out that mobile genetic elements were probably present in insects and higher animals. In spite of this, her observations received very little attention. This was because her findings when first presented, were overshadowed by the discovery that the DNA molecule stores the genetic information in its structure. It also became evident that mutation involving only the change on one of the building blocks in the DNA molecule could have serious effects. Under these circumstances, it is not surprising that few geneticists were prepared to accept that genes could jump in the irresponsible manner that McClintock proposed for controlling elements. The 'state of the art' in molecular genetics at that time made it difficult to accept 'jumping genes' and thus McClintock had to await the development of methodological tools enough to verify her great discovery in biochemical terms (Ringertz, 1993).

The announcement that Barbara McClintock had won the Nobel Prize, electrified the scientific community like no other recent prize - as much for the beauty of her motivation and dedication as for her scientific tour de force. When McClintock accepted her award from King Carl Gustaf in Stockholm, the ovation from the normally reserved and formal audience was so loud that it made the floor of the concert hall vibrate. Her solitary excellence, her quiet thuoghtfulness, and her perseverance in the face of male prejudice and scientific rejection had captured their imaginations. Talking briefly with a Carnegie trustee afterwards, McClintock parted with the words, 'We women have to stick together' (McGrayne, 1993).

Countless other women mathematicians and scientists remain unsung. There are no easy ways to find biographical information about them beyond the barest outline in such publications as ***American men and women of science*** or ***World who's who in science***. In particular, it is difficult for someone who is not a specialist, to learn about their work and achievements. Although modern technology makes it easy to conduct literature searches, a mere compilation of titles is insufficient: we need interpreters to guide us through the significance of work in disciplines outside our own (Hornig, 1993).

2 Methodology

Bibliographic details of all publications of Barbara McClintock were documentd on reference cards and sorted as per requirement to extract various data (Fedoroff, 1994). Normal count procedure was followed, giving full credit to each author regardless of whether he/she happens to be the first or the last author (Pravdic and Oluic-Vukovic, 1986). It is widely recognised that scientists all over the world look at their own papers in that way only. Similarly titles of the papers were analysed and one score was alloted for each keyword, subject, journal, etc. The degree of collaboration was estimated as the ratio of the number of collaborative research papers to the total number of research papers published in the discipline during a certain period of time (Subramanyam, 1983).

Publication density was calculated as the ratio of the total number of papers published to the total number of journals in which the papers were published, and publication concentration as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study (Vinkler, 1990). Productivity coefficient was calculated as the ratio of 50 percentile age to the total productivity age (Sen and Gan 1990). Frequency of keywords from the titles of the articles was recorded, also the number of pages per paper was counted. Data obtained from these bibliometric indicators are analysed and discussed.

3 Results and Discussion

Descriptive accounts of biographical details and achievements of Barbara McClintock are available in Keller (1983), Opfell (1986) and Schlessinger and Schlessinger (1986) and a resume of it is given as appendix of this paper. The objective of the present paper is to quantify the publication productivity of Barbara McClintock and to analyse the variables of it so as to arrive at valid conclusions.

3.1 Publication productivity

McClintock had published 73 papers during 1926-1984. The number of pages per paper is in the range 1 to 62 with a mean of 14.14 and standard deviation 12.89. An year-wise break up of these publications reveals that she had published 11 papers during 1929-33, the first peak period of her productivity which happens to be at her age 28-32. The second peak of 11 papers is during 1941-45 at her age 40-44 and third peak of 11 papers during 1953-57 at the age 52-56. Out of the 73 publications of McClintock, 66 are single authored papers. Among the other seven papers of joint authorship, six are two authored and the other is by four authors. In one of the two-authored papers and in the four-authored paper she is the first author. Her collaborators in two authored papers were L F Randolph (first author in one paper), G W Beadle (first author in two papers), H E Hill (second author in one paper), and M M Rhoades (first author in one paper). T Angel, Y Kato, and A Blumenschein are the joint authors in the four authored paper.

TABLE 1 : AUTHOR PRODUCTIVITY IN THE RESEARCH GROUP OF BARBARA McCLINTOCK

Name of Researcher(s)	No.of Author(s) in the Research Paper (s)								Percen-tage	Period	
	Single	Two		Four				Author-ship (s) Total		First Paper	Last Paper
	I	I	II	I	II	III	IV				
McClintock, B.	66	1	5	1	–	–	–	73	89.02	1926	1984
Randolph, L.F.	–	1	–	–	–	–	–	1	1.22	1926	1926
Beadle, G.W.	–	1	–	–	–	–	–	1	1.22	1928	1928
Creighton, H.B.	–	2	–	–	–	–	–	2	2.44	1931	1935
Hill, H.E	–	–	1	–	–	–	–	1	1.22	1931	1931
Rhoades,M.M.	–	1	–	–	–	–	–	1	1.22	1935	1935
Angel, T.	–	–	–	–	1	–	–	1	1.22	1981	1981
Kato,Y.	–	–	–	–	–	1	–	1	1.22	1981	1981
Blumenschein, A.	–	–	–	–	–	–	1	1	1.22	1981	1981
Total	66	6	6	1	1	1	1	82			

I = First Author, II = Second Author, III = Third Author, and IV = Fourth Author

The total authorship of the 73 papers is 82, as illustrated in table-1. About 89% of authorship credit belongs to Barbara McClintock only. The degree of collaboration in her case is 0.096, a value which is too low. Productivity coefficient comes to 0.4 only indicating her high publication productivity during her early period of career.

3.2 Solitary life

Barbara McClintock was a unique personality, the 'Lonely Wolf', as Vinkler has described. Like Mendel, she preferred to work in solitude and like him, she did not win immediate recognition for her most brilliant research. In her private life, too, she was a loner. She never associated closely with even family members and never felt a strong necessity for a personal attachment of any kind. She was a paradigmer. McClintock correlated the genetics and cytology and thereby launched a major new speciality in Modern Biology.

3.3 Advisor par excellence

Late in the summer of 1929, Harriet Creighton came to Cornell as a botany graduate student from Wellesley College. Within minutes of meeting, McClintock had organized Creighton's academic career too, steering her to the right courses and advisers. Technically, instructors were too low-level to advise graduate students, but practically speaking, McClintock was in charge. McClintock gave Creighton her best research project as a thesis topic. In the late 1920s, there was circumstantial evidence, but no hard proof, that chromosomes carried and exchanged genetic information to produce new combinations of physical traits. McClintock wanted the proof.

3.4 Break through in the career

She had bred a special strain of corn with an easily identifiable ninth chromosome that usually produced waxy, purple kernels. Under her microscope, she could see an elongated tip on one end of the ninth chromosome and a knob that readily absorbed stain at the other end. According to her mathematical analysis, the elongated tip was located near the region of the chromosome that determined whether the plant would produce waxy kernels. She suspected that the region near the knob was responsible for supplying purple pigment.

That spring, Creighton and McClintock planted waxy, purple kernels from the strain. In July, they fertilized the silks with pollen from a plant of the same strain whose kernels were exactly opposite types, that is, they were neither waxy nor purple. That fall, when McClintock and Creighton harvested the ears, some of them had the usual waxy, purple kernels and some kernels were the opposite, neither waxy nor purple. But some ears were different; they had inherited one trait - but not both. Thus, they were either waxy or purple, but not both. When McClintock and Creighton examined the chromosomes of these new kernels under their microscopes, they could see that their structure had changed markedly. Physical bits of the ninth chromosome - either the knob or the elongated tip - had actually exchanged places. Whereas every elongated chromosome in the parent plants had a knob, they now found a mix; elongated chromosomes without knobs and knobby chromosomes without tips.

McClintock and Creighton had proved that genes for physical traits are carried on the chromosomes. They had produced the first physical proof that exchanging chromosomal parts helps create the amazing variety of forms present in the biological universe.

Unlike the case in present day papers, McClintock was very particular to include enormous amount of data to support her findings. So she had to wait for a second crop before publishing the observations. Fortunately, Thomas Hunt Morgan happened to visit Cornell and hear about the experiment. He urged them to publish the findings immediately. In his excitement, he wrote to a journal editor that an important article would arrive in two weeks. Thanks to Morgan, McClintock's article entitled ***"A Correlation of Cytological and Genetical Crossing—over in Zea mays"*** was published in the Proceedings of the National Academy of Sciences, August 1931. A few months later, another German geneticist, Curt Stern, published a parallel data on fruit flies. Had McClintock waited for another crop, the credit would have gone to Stern.

The paper was instrumental in bringing McClintock international reputation. Mordecai L Gabriel and Seymour Fogel acclaimed, 'Beyond any question, this is one of the truly great experiments of modern biology', in their book ***Great Experiments in Biology***. James A Peters, editor of ***Classic Papers in Genetics***, wrote, 'This paper has been called a landmark in experimental genetics. It is more than that - it is a cornerstone.' Then he warned, 'It is not an easy paper to follow, for, the items that require retention throughout the analysis are many and it is fatal to one's understanding to lose track of any of them. Mastery of this paper, however, can give one the strong feeling of being able to master almost anything else he might have to wrestle with in biology'. James Shapiro, a University of Chicago microbiologist, told the ***New Scientist*** magazine that the experiment should have won a Nobel prize by itself.

However, at the top of her profession, she was at the bottom of the career ladder (McGrayne, 1993). She began reaping the benefits of her international reputation during her early years at Cold Spring. In 1944, she was elected the first woman president of the Genetics Society of America. The same year, she was named to the prestigious National Academy of Sciences, which had admitted only two other women in eighty-one years. Surprisingly, when McClintock heard about the honour, she burst into bitter tears. Had she been a man, she said, she would have been delighted by the honour. But as a woman, she felt trapped. She wanted to be free to walk out on genetics if she ever got bored. Now she would never be able to leave it. 'It was awful because of the responsibility to women', she explained, 'I couldn't let them down'. As she wrote a friend, 'Jews, women, and Negroes are accustomed to discrimination and don't expect much, I am not a feminist, but I am always gratified when illogical barriers are broken - for Jews, women, Negroes, etc. It helps all of us'.

In an hour-long talk at a major Cold Spring Harbor Symposium in 1951, McClintock summarized her findings before a group of leading scientists. The report was long, complicated, and dense with statistics and proofs. When she finished, there was dead silence, Witkin remembers, 'It fell like a lead balloon', Harriet Creighton recalls, 'McClintock felt as if she had collided with the stable chromosome'.

3.5 Challenges

Scientists scrambling to learn molecular biology wanted it simple; they did not like a genetic system that was fluid, moving, changing, and intricately regulated. They reacted with puzzlement, frustration, and even hostility. 'I don't want to hear anything about what you're doing. It may be interesting, but I understand it's kind of madness', a biologist told her. A leading molecular biologist called her, 'just an old bag who'd been hanging around Cold Spring Harbor for years'. Naturally, McClintock was upset and disappointed. She summarized her work in a longer article published in 1953. Maize geneticists understood and accepted the data, but she wanted the science community at large to realize the wider significance of her work. Only three scientists outside her field, however, requested copies of the article. McClintock concluded that publishing was a waste of time. From then on, she wrote up her work in large notebooks, all tabulated, documented, and analyzed, and filed the notebooks on a shelf. She submitted only brief summaries of her work for publication in the annual reports of the Carnegie Institution of Washington – which only a few libraries purchased.

3.6 Distribution of publications

She had published 27 reports in *Carnegie Institute Washington Year Book* during 1942-1971 (table 2). She had published nine papers in *Genetics* during 1929-1953. The *Proceedings of National Academy of*

Table 2 : Distribution of Publications of Barbara McClintock

Sl.No.	Channel of Communication	No. of Papers	%	Cumu %	Period FPY	Period LPY	SCI JCR1992 Impact Factor	SCI JCR1992 immediacy indx	Coverage in A&I jnls	Cntry of publication
1.	Carnegie Inst. Wash. Year Book	27	36.98	36.98	1942	1971	—	—	3	U.S.
2.	Genetics	9	12.33	49.31	1929	1953	3.673	0.813	34	U.S.
3.	Proc. Natl. Acad. Sci. USA	8	10.96	60.27	1930	1950	—	—	40	U.S.
4.	Maize Genet Coop. News Latt.	5	6.85	67.12	1944	1965	—	—	—	U.S.
5.	Cold Spring Harbor Symp. Quant. Biol.	3	4.11	71.23	1941	1956	1.922	—	8	U.S
6.	Science	3	4.11	75.34	1928	1984	20.967	3.600	89	U.S
7.	Am. Nat.	2	2.74	78.08	1926	1961	2.271	0.503	32	U.S
8.	Brookhaven Symp. Biol.	2	2.74	80.82	1956	1965	—	—	8	U.S
9.	Mc. Agric. Exp. Stn. Res. Bull.	2	2.74	83.56	1931	1938	—	—	—	U.S.
10.	Z. Zellforsch. Mikrosk Anat.	2	2.74	86.30	1933	1934	—	—	19	Germn
11.	Am. J. Bot.	1	1.37	87.67	1945	1945	1.602	0.152	38	U.S.
12.	Bot. Rev.	1	1.37	89.04	1935	1935	2.563	0.000	26	U.S
13.	Dev. Biol. Suppl.	1	1.37	90.41	1968	1968	3.779	0.627	18	U.S.
14.	J. Hered.	1	1.37	91.78	1929	1929	0.841	0.175	35	U.S.
15.	Stadler Symp.	1	1.37	93.15	1978	1978	—	—	4	U.S.
16.	Stain Technology	1	1.37	94.52	1929	1929	0.805	—	21	U.S.
	CHAPTER(S) IN BOOK(S)									
17.	Colegiode Postgraduactos, Escwela National de Agricultura Chapingo Edo Mexico	1	1.37	95.89	1981	1981	—	—	—	—
18.	Mobilization and Reassembly of Genetic Information, Academic Press, New York.	1	1.37	97.26	1980	1980	—	—	—	—
19.	Maize Breeding and Genetics, Wiley New York	1	1.37	98.63	1978	1978	—	—	—	—
20.	The Clonal Basis of Development, Academic Press, New York.	1	1.37	100.00	1978	1978	—	—	—	—

FPY = Year of First Paper, LPY = Year of Last Paper, SCI = Science Citation Index, JCR = Journal Citation Report

Sciences, USA, published her eight papers during 1930-1950. She had contributed five papers to ***Maize Genet. Coop. Newsletter***. She had published three papers each in ***Cold Spring Harbor Symp. Quant. Biology and Science***. In all she used 20 sources as channels of communications. Except two papers in German Journal ***Z. Zellforsch. Mikrosk Anat.*** all of her papers were published through sources of U S origin. The Impact Factor, Immediacy Index, coverage in abstracting and indexing journals and country of publications of all channels are provided in table-2. Scattering of publications of Barbara McClintock is depicted in Fig.2 revealing channelwise frequency of publications and cumulative publications.

Publication Density is 3.6 and Publication Concentration is 10.00

The idea that genomic rearrangements may play a role in the life cycles of normal organisms and even contribute to their development and tissue specific differentiation, began to emerge only when Barabara McClintock discovered the so-called Controlling Element's in maize in the 1940's. In the 60's and early 70's, the discovery of bacterial plasmids and transposons led to extensive characterization of rearrangements associated with them.

3.7 Medical applications

In the mid-sixties, mobile genetic elements were found to play an important role in the spreading of resistance to antibiotics from resistant to sensitive strains of bacteria. This type of transferable drug resistance is a serious problem in hospitals since it causes infections that are very difficult to treat. During the 1970's, more support was found for the medical significance of mobile genetic structures. It was found, for instance, that the transposition of genes is an important step in the formation of antibodies. It has always been a mystery how the body, using a limited number of genes, can form an almost endless number of different antibodies to foreign substances. Nature has solved this problem according to the building block principle. When an individual is born, the chromosomes carry a set of mobile building blocks for antibody genes. By recombining these blocks in various ways in different cells, the body is able to generate millions of genes for antibodies.

During the last few years mobile genetic structures have attracted great interest in cancer research. In certain forms of cancer, growth regulating genes called oncogenes, are transposed from one chromosome to another. Tumour viruses in birds and mice have been found to carry oncogenes which they, in all likelihood, originally picked up from a host cell. If a virus then introduces these genes in the wrong place on the chromosomes of a normal cell, the latter is transformed into a cancer cell. McClintock's discovery of mobile genetic elements in maize, therefore, has been found to have counterparts also in bacteria, animals and human beings.

What led McClintock to devote her research to the variegation of maize kernels was that it did not fit in with Mendelian genetics. With immense perseverance and skill, McClintock, working completely on her own, carried out experiments of great sophistication that demonstrated that hereditary information is not as stable as had previously been thought. This discovery has led to new insights into how genes change during evolution and how mobile genetic structures on chromosomes can change the properties of cells. Her research has helped to elucidate a series of complicated medical problems.

Impetus for the molecular studies came after the transposable elements were observed in prokaryotes and the gene cloning systems became available. To date, the maize molecular studies have been attempted mainly with one system, the so-called ***Ds-Ac*** and these are restricted to about four gene loci viz. shrunken, waxy, bronze all on the short arm of chromosome 9 and ***Adh1 - F*** (alcohol dehyrogenase) gene located on chromosome 1. The analysis has concentrated on the insertions that have taken place in or near the gene. Not too much is known about the mechanisms by which transpositions occur; whether excision is involved or/and these occur during some replicational events or by a reverse transcription mechanism. This problem is further complicated by the occurrence of repeated DNA sequences and in fact as many as 30 repeats of a ***Ds*** sequence at the ***Adh-1*** locus have been reported. Considering the numerous genetical properties of controlling elements, ***Ds-Ac*** is a relatively simple system – at least it illustrates a number of features of the controlling elements. Eukaryotic chromosomes are multirepliconic and they commonly contain repeated sequences. With repeated sequences, unusual opportunities for recombination may also arise. To what extent do these have developmental or evolutionary significance, remains to be elucidated. However, these should be usable for making plant DNA transfers, it has been proposed that cloned DNA carrying ***Ds*** or ***Ac*** ends with the DNA to be transferred can be added to the germinating pollen for transformation. Or alternatively such DNA can be added to plant protoplasts. It may also be worthwhile to inject such DNA into immature embryos.

'The creative scientist has much in common with artists and poets. Logical thinking and an analytical ability are necessary attributes to a scientist, but they are far from sufficient for creative work. Those insights in science that have led to a breakthrough were not logically derived from pre-existing knowledge: The creative processes on which the progress of science is based operate on the level of the subconscious' (Salk, 1992). However, it takes belief in one's own ability and ideas, and courage to be a potential rising star and it takes a special kind of person like Barbara McClintock to push out the frontiers of knowledge beyond the current state of the art.

3.8 Analysis of Keywords

Keywords in the titles of the papers of Barbara McClintock, having frequency two or more are listed in table 3. The study material Maize

Table : 3

Keywords in the titles of the papers of McClintock having two or more frequency

Keyword	Frequency	Keyword	Frequency
Maize	36	Cytogenetic (s)	3
Zea mays	15	Development	3
Mutation (s)	11	Gene action	3
Chromosome (s)	10	Instability	3
Cytological	9	Meiosis	3
Loci	7	Spm	3
Mutable	6	America	2
Deficiencies	5	bm 1	2
Gene (s)	5	Bronze locus	2
Gene expression	5	Chromosome Constitution	2
Genetical	5	Ds	2
Neurospora (crassa)	5	Fusion	2
Ac	4	Gene Loci	2
Control system (s)	4	Method	2
Homozygous	4	Mutant (s)	2
Race (s)	4	Nuclear	2
Behaviour	3	Origin	2
Chromosome 9	3	Ring shaped chromosome	2
Controlling elements	3	Stability	2
Controlling gene action	3	Suppressor-mutator system	2
Correlation	3	Varieties	2
Crossing over	3		

has a frequency of 36, while the botanic name of it, ie *Zea mays* has a frequency 15. The term 'Mutation' comes next in the list, with a frequency of 11. Chromosome(s) and Cytological have the values 10 and 9 respectively. This indicates the domains of work of Barbara McClintock.

Keywords having the value of frequency 1 are: A1, a1-m2, Aberrant, Acetocarmin smears, Allelic series, Bacteria, Breakage-fusion-bridge-cycle, Chromatide breakage, Chromosomal aberration, Chromosomal element, Chromosomal region, Chromosome behaviour, Chromosome morphology, Chromosome organisation, Chromosome size, Clones, Control system, Deficient, Detecting, Demonstration, Division, Endosperm, Genic disturbance, Genetic system, Genome, Guatamalan, Identification, Induction, Interchange, Intranuclear systems, Inversion Location, Locus, Mechanism, Meiotic anaphase, Mexican, Midprophase, Migration, Mitotic, Modified chromosome, Mosaic, 2N-1 Chromosomal chimera, Non-homologous, Nucleoli, Phenotype, Plants, Polyploidy, Potential, Preliminary observations, Production, Regulation, Regulator(s), Reorganise, Restoration, R-G linkage simulation, Short arm, Sister half chromatids, specific, Spontaneous alterations, Structurally modified chromosome-9, Suppressor mutator system, Topographical relation, Translocation, Transposable elements, Transposition, Triploid, Variegation, and Versatility.

4 Conclusion

History of science is replete with examples of the great scientists who were totally independent in their thoughts and behaviour and did not care even if they had no followers but only critics and had the courage to stand alone on ones firm, intuitive, creative, introvery nature, being true to oneself, and they were the ones who have opened new vistas in science and technology which has benefited humanity immensely. Once more Barbara McClintock proved that her total involvement with the study material was the only thing dear to her. Science policy makers and science educationists have to take into consideration the value of such genius 'The Lonely Wolf' category of giants and provide full scope for their developments from early childhood itself, so as to nurture and culture their talent. Gifted children are the most valuable resource of a nation. Had Barbara McClintock been provided with all the best possible facilities and securities of life, probably she would have contributed much more, at least for certain she would not have spent her valuable time and energies in defending herself and digesting the insulting situations. Or is it that these unfavourable circumstances only induce a few personalities of her kind to further progress in the line of their work, and prove that they were right and everyone else had no standing to realise their stand? This is indeed an interesting area of further studies. Even today we have people who are willing to stand up, and even die, for their beliefs and ideas. It is better to watch them closely rather than discard them as miscreants.

Appendix

BARBARA McCLINTOCK

Born : on 16 June, 1902, at Harifold, Connecticut, U.S.A.

Secondary Education : Erasmus Hall High School, Brooklyn, New York.

Earned Degrees:

B S (Cornell University, Ithaka, New York) (1923)

M A (Cornell University, Ithaca, New York) (1925)

Ph D (Cornell University, Ithaca, New York) (1927)

Positions Held:

Instructor in botany, Cornell University, 1927-1931

Fellow, National Research Council, 1931-1933

Fellow, Guggenne im Foundation, 1933-1934

Research Associate, Cornell University, 1934-1936

Assistant Professor, University of Missouri, Columbia, 1936-1941

Staff Member, Carnegie Institution of Washington, Cold Spring Harbor, New York. 1942-1967

Distinguished Service Member, Carnegie Institution of Washington, Cold Spring Harbor, New York, 1967-till death

Visiting Professor, California Institute of Technology, 1954

Consultant, Agricultural Science Programme, The Rockefeller Foundation, 1963-1969

Andrew D White Professor-at-Large, Cornell University, 1965-1974

Honorary Doctor of Science:

University of Rochester, 1947

Western College for Women, 1949

Smith College, 1957

University of Missouri, 1968

Williams College, 1972

The Rockefeller University 1979

Harvard University, 1979

Yale University, 1982

University of Cambridge, 1982

Bard College, 1983

State University of New York, 1983

New York University, 1983

Honorary Doctor of Humane Letters:

Georgetown University, 1981

Awards:

Achievement Award, Association of University Women, 1947

Merit Award, Botanical Society of America. 1957

Kimber Genetics Award, National Academy of Sciences, 1967

National Medal of Science, 1970

Lewis S Rosenstiel Award for Distinguished Work in Basic Medical

Research, 1978

The Louis and Bert Freedman Foundation Award for Research in Biochemistry, 1978

Salute from the Genetics Society of America, August 18, 1980

Thomas Hunt Morgan Medal, Genetics Society of America, June, 1981

Honorary Member, The Society for Developmental Biology, June, 1981

Wolf Prize in Medicine, 1981

Albert Lasker Basic Medical Research Award, 1981

MacArthur Prize Fellow Laureate, 1981

Honorary Member, The Genetical Society, Great Britain, April, 1982

Louisa Gross Horwitz Prize for Biology or Biochemistry, 1982

Charles Leopold Mayer Prize. Academic des Sciences.

Institute de France. 1982

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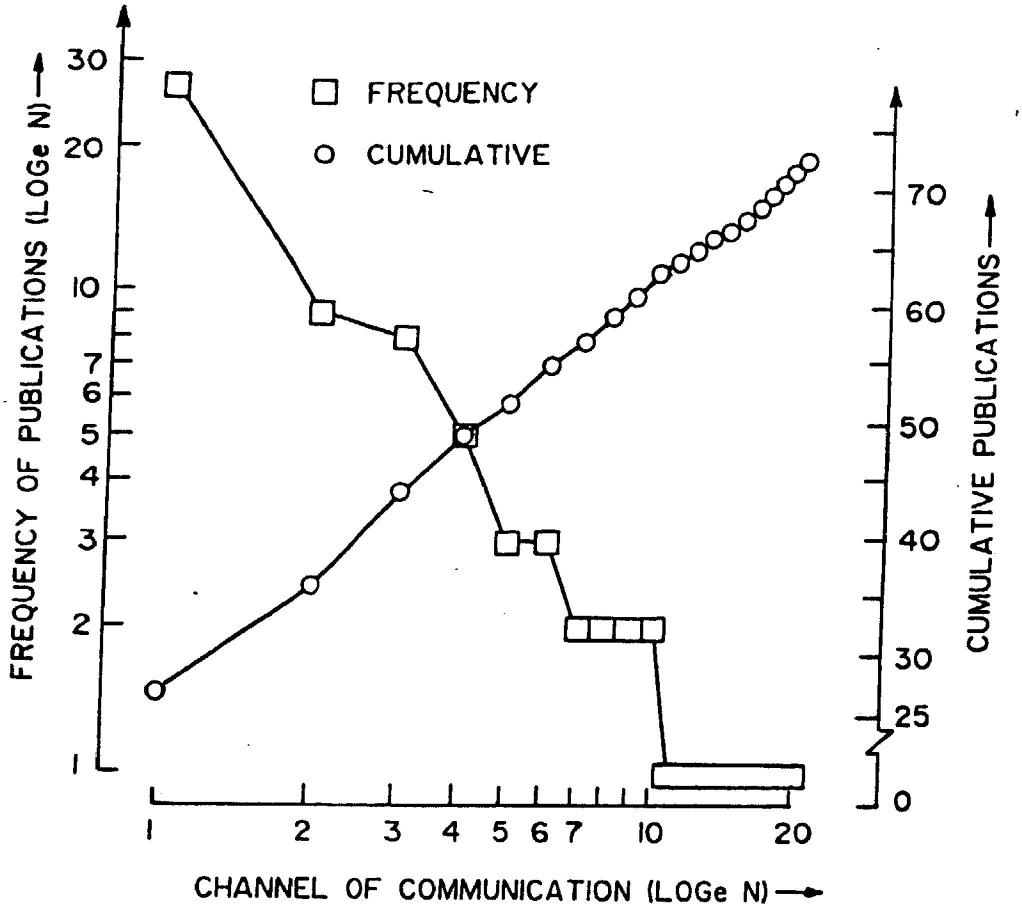

FIG. 2. SCATTERING OF PUBLICATIONS OF BARBARA McCLINTOCK

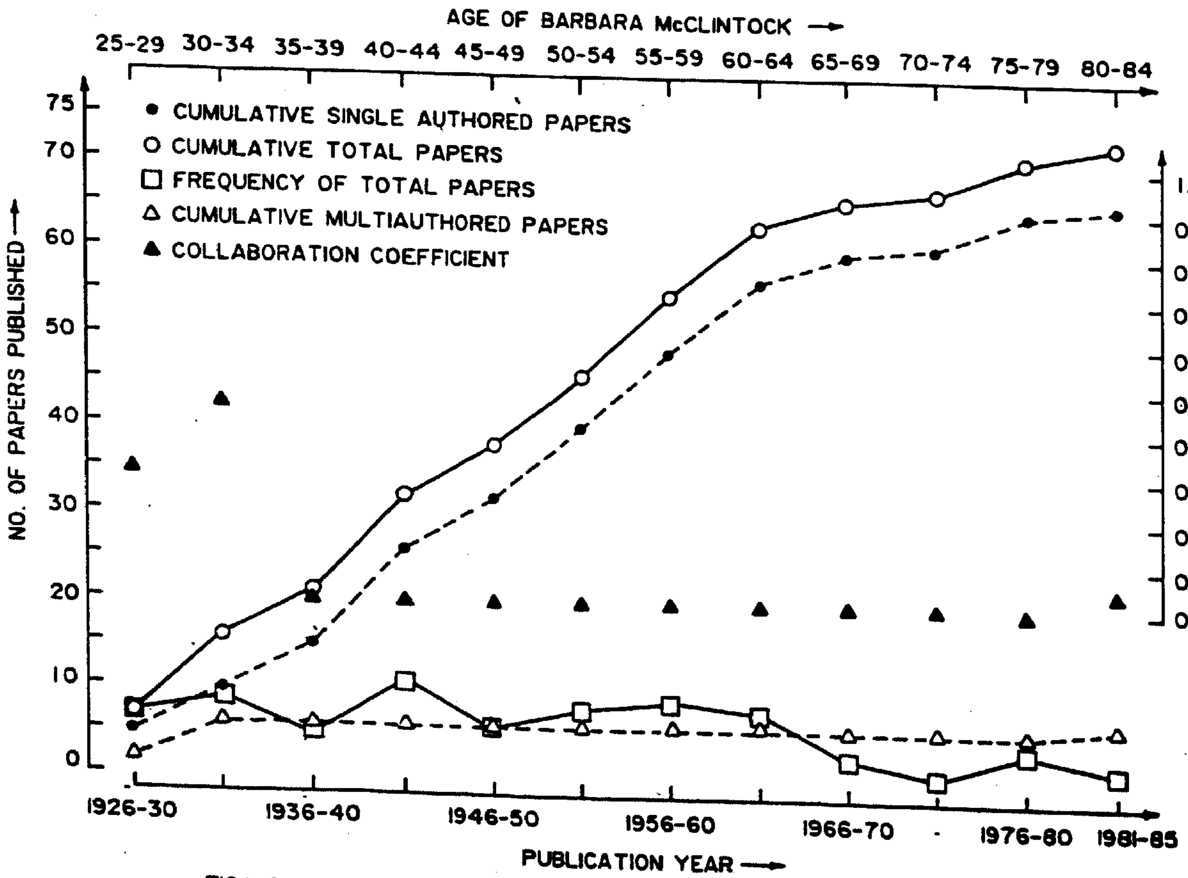

FIG.1. QUINQUENNIAL PUBLICATION PRODUCTIVITY OF BARBARA McCLINTOCK

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