JAN0835 Science as a way of knowing: A narrative about community and connectedness

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Abstract

In this paper the nature of science is examined through the narrative of unconventional scientist Barbara McClintock. Her initial groundbreaking work in maize cytogenetics earned her a place among the leaders in genetics and she was elected to the prestigious National Academy of Sciences in 1944 and became the first woman President of the Genetics Society of America in 1945. Despite such recognition, her classic paper detailing the function of the nucleolar organizer region was in the main not registered by the biological community. For several reasons, as Barbara's discoveries became more complex, the scientific community lost interest in her papers. The reasons for her ineffectiveness at getting her new findings accepted by the scientific community are discussed. Though her research was often dismissed as wildly unorthodox, she pursued it, making discoveries that changed the map of modern genetics. In 1983 she was awarded the individual Nobel Prize in Physiology/Medicine. As a scientist Barbara treated the organisms she studied as her friends and she felt a connectedness to nature. She appreciated a naturalist's approach to research and predicted a paradigm shift that would emphasise relationship and connectedness. This paper was informed by socio-cultural-historical theory with the narrative of Barbara McClintock being generated by using Rogoff's three planes of analysis. On the individual plane, the personal lens enabled a description of the influences that shaped her personality in the early years, including interactions with family members. The interpersonal lens revealed her relationships with her peers in various institutions where she carried out her scientific endeavours. The community lens identified how the scientific community reacted to her scientific discoveries and radical theories. This narrative of Barbara, as a non-stereotypical scientist, is useful in the classroom because it helps students to understand that doing science is far more than an objective, dispassionate and disconnected process.

Research question and theoretical framework

The reason for doing this study is the declining interest in science by secondary school students. Alternative pedagogical strategies were explored and put forward as a solution to the problem. One strategy is the use of narrative to introduce students to stories of scientists who were successful in the past. The research question addressed was: How did the scientific community react to Nobel prize winner Barbara McClintock's discoveries in genetics?

The theoretical framework that informed the research was socio-cultural-historical theory. Rogoff's (1998) three planes of analysis (personal, interpersonal and community) comprised the research approach. A focus on the 'personal lens' enabled me to generate a description of Barbara as an individual, including her distinguishing characteristics and her family's historical background that influenced the development of her personal traits. Applying the 'interpersonal lens' I focused attention on the complex, mother-daughter relationship that significantly shaped Barbara's personality. This lens also facilitated an examination of the interactions between Barbara and her colleagues that occurred at several of the institutions where she undertook her scientific work. The narrative also identifies Barbara's preferred way of working and unique approach to integrating cytology and genetics (cytogenetics). The 'community lens' shifted my focus to the scientific community at the time, revealing how their members reacted to her radical discoveries and theories, and the recognition she finally gained for her scientific breakthroughs.

Research method: Narrative as a research tool

Narrative was the research tool used to tell the story of Barbara McClintock and it begins with her early childhood and the family interactions that influenced her personality. The interpersonal relationships associated with her career as a researcher are discussed, together with a description of how the scientific community responded to her radical scientific discoveries.

The first in a series, the particular narrative presented here, arose from my reflections on reading Evelyn Fox Keller's (1983) biography of Barbara's life and work as a scientist. This text of Barbara's story is validated, wherever possible, by her own words given in interview responses, when she talked about her personal characteristics, explained the genesis of her boundary pushing theories, and revealed the scientific community's reactions to these 'ahead of her time' theories. But first I need to explain how narrative relates to story. The terms 'narrative' and 'story' can be defined in the following way.

> Story is a powerful way to communicate ideas through a sequence of events that can be told in various ways, depending on the storyteller. When the same story is told in different ways, different versions called *texts* are generated. These texts constitute multi-layered 'narratives' consisting of the sequences of events (the stories), the versions of the stories (the texts) and the "*way in which* these events are presented" (the fabulas) (Bal, cited in Berger, 1978:34).

Narratives - stories that take place at a particular time - are powerful catalysts for deeper understanding. Berger (1997:67) defines story as the various events that occur in a narrative. The story is not identical to the text; a given story can be told in several different texts. In films many stories have been told several times. For example there are two film versions of *King Kong* and three of *A Star is Born*, not to mention re-workings of the same stories made under different titles. The basic stories are the same (or very similar), but they are told somewhat differently each time, using different actors, emphasizing different themes, and so on. Personal stories can be vehicles for passing on cultural traditions, as Neville explains.

> A great deal of what we know we know as story. Our basic assumptions – the things we take so completely for granted that we never reflect on them – are embedded in the story of who we are and where we come from. … We inherited it from our parents, our family, our religious tradition, and, more widely, from our culture. … Our cultural narrative is expressed in lots of different ways in the stories we tell our children. (Neville, 2005: 95)

Story can promote understanding by placing 'what is to be known' in context which often generates an emotional response.

> Stories can provide context enriched by emotion, a deeper understanding of how we fit in and why that matters. The Conceptual Age can remind us what has always been true but rarely been acted upon – that we must listen to each other's stories and that we are each the authors of our own lives. (Pink, 2005:113)

Narratives can be very engaging and therefore are effective as a form of communication. For example, Parker Palmer (1990) used narratives from the Taoist, Jewish and Christian religious traditions to show that spiritual life can facilitate a deeper engagement with the world, and does not require abandoning it, as in the monastic life. In Parker's narratives, the nature of 'active' life is highlighted, but in addition, he pays attention to its paradoxical partner, the 'contemplative' life, emphasising the need for both.

Scientific community's reactions to her discoveries in genetics

Barbara's initial groundbreaking work in maize cytogenetics earned her a place among the leaders in genetics. She was elected to the prestigious National Academy of Sciences in 1944, and the next year became the first woman President of the Genetics Society of America. Despite such recognition, her classic paper detailing the function of the nucleolar organizer region was in the main not registered by the biological community. "I find that it was only a relatively few people who got the point of the organization – of why I called it an organizer" (McClintock cited in Keller, 1983:69).

Barbara described herself as a 'maverick' and valued her privacy. She deliberately chose a reclusive lifestyle that assured her autonomy and independence. However, living as a recluse helped to position her on the peripheral of the science community in which worked (Keller, 1983). Yet, being 'connected' to the subjects of her studies, Barbara was living in *an alternative relational world*.

In 1944, Evelyn Witkin came to Cold Spring Harbor as a student geneticist. For a decade Barbara shared her intuitions and discoveries with Evelyn. Barbara recalls, "She was the only one who really had any understanding of what I was doing" (McClintock cited in

Keller, 1983:137). Unlike others in the scientific community, Witkin understood because she had looked over Barbara's shoulder and experienced her way of exploring the world.

As Barbara's discoveries became more complex, the scientific community lost interest in her papers. She remembers a geneticist visiting Cold Spring Harbor saying, "Now, I don't want to hear a thing about what you're doing. It may be interesting, but I understand it is kind of mad" (cited in Keller, 1983:140). The scientific community described her as "incomprehensible", "mystical" and "mad" but she said, "it didn't bother me at all" (McClintock, cited in Keller, 1983:142). It was both her way of working and her way of communicating her findings that they could not 'connect' with. She exemplified a mysticism of connectedness that was unique.

However, Barbara was ineffective at getting her new findings accepted by the scientific community, and this was the case for several reasons. Firstly, the findings had revolutionary implications. Secondly, the particular nature of her knowledge and understanding was complex, and thirdly, they were *generated from a very different way of knowing*.

Her way of knowing was by seeing (compare with Dillard, 1985), which was central to her scientific endeavours. "She knew by seeing, and saw by knowing". This reciprocity between cognitive and visual was well developed for Barbara who had continuity between mind and eye. Through "integrating what you saw" (McClintock cited in Keller, 1983:151) she built a theoretical vision of the ordered world within the cell. Also she was isolated, having worked alone for the past six years, and the problem was one of communication. She spoke an alternative language, because she was not in dialogue with colleagues.

The results "she reported in 1951 were totally at variance with the view of genetics that predominated" (Keller, 1983:144). In the 1950s a common vision was elusive because geneticists were following a different path, molecular biology, with the emphasis being on simple models. In 1953 Watson and Crick proposed the DNA double helix, with its precise sequences of bases, as the code for genetic information. Barbara did not agree with models and was critical of the dogma at the time. She argued, "Trying to make everything fit into set dogma won't work… So if the material tells you, 'It may be this,' allow that. Don't turn it aside and call it an exception, an aberration, a contamination….*If you'd only just let the material tell you*" (McClintock cited in Keller, 1983:179). This view is very important and consistent with Kuhn's ideas of *revolutionary science*.

In 1960, after failing to communicate her findings at yet another seminar, she withdrew and retreated further, still determined to carry out her research on transposition. In 1965, after a fourth attempt to describe her findings, with little effect, she said, "I knew I was right" (McClintock cited in Keller, 1983:182).

Though her research was often dismissed as wildly unorthodox, she pursued it, making discoveries that changed the map of modern genetics. "Her reports on transposable genetic elements were not readily accepted by her scientific peers until her genetic insights were verified by molecular biologists in the 1970s"(Peterson, accessed 20/12/04, p.1).

Nearly thirty years passed before she received several major awards, which included the National Medal of Science (1970), the Lasker Prize, and the first MacArthur Foundation grant (1981), and culminated in 1983 with the individual Nobel Prize in Physiology or Medicine, for her work on 'mobile genetic elements', or genetic transposition, the ability of genes to change position on the chromosome. By then she was 81 years old having "lived most of her life alone – physically, emotionally and intellectually" (Keller, 1983:17). After receiving these prestigious awards she merely tolerated the inevitable publicity that impacted on her solitary lifestyle. She remained affiliated with the Cold Spring Harbor Laboratory, New York, until her death at Huntington Hospital, on September 2, 1992, at the age of 90.

McClintock's way of working as a scientist

As a mature scientist, her individual style (partly learned, partly self-generated) was highly idiosyncratic. Her method was to look for difference, rather than similarities, which differed from the prevailing paradigm.

> Her passion is for the individual, for difference. "The important things is to develop the capacity to see one kernel that is different, and make that understandable," she has said. "If [something doesn't fit, there's a reason, and you find out what it is." McClintock believes that the current focus on classes and numbers encourages researchers to overlook difference, "To call it an exception, an aberration, a contaminant." She sees the consequences as very costly, as it is easy for them to miss "what is going on". (Keller, 1983:xiii)

"She possessed a special talent to recognize the underlying order and provide an explanation for the most perplexing observations" (Nelson cited in Peterson, 2004:2). Rhoades remembers, and commented: "I've often marvelled that you can look at a cell under the microscope and can see so much!" She said, "Well, you know, when I look at a cell, I get down in that cell and look around" (Keller, 1983:69).

Her reported capacity to process and interpret her observations meant that it became difficult to delegate any part of her work. Barbara's highly developed ability to observe and experiment "has drawn as much from herself as from her milieu. The role of vision in her experimental work provides the key to her understanding" (Keller, 1983:xiii). Her trained, direct perception resulted in a unique blend of observational and cognitive skills. Importantly she recognised the limits of oral explanation and came to rely on her "feeling for the organism". "She insists on the utmost critical rigor, and, like all good scientists, her understanding emerges from a thorough absorption in, even identification with, her material" (Keller, 1983:xiv). There was a mind set of connectedness in her way of working.

> It was her conviction that the closer her focus, the greater her attention to detail, to the unique characteristics of a single plant, of a single kernel, of a

> single chromosome, the more she could learn about the general principles by which the maize plant as a whole was organized, the better her "feeling for the organism". (Keller, 1983:101)

McClintock sought intimate, deep and rich knowledge about each and every maize plant. She believed that the larger whole could be understood by focusing on the smallest of details. She also saw the problem clearly. "The problem is not something that's ordinary, but it fits into the whole picture, and you begin to look at it as a whole…. It isn't just a stage of this or that. It's what goes on in the whole cycle. So you get a feeling for the whole situation of which this is [only] a component part" (McClintock cited in Keller, 1983:67).

Keller wanted to know what enabled Barbara to see sharper, further and deeper into the mysteries of genetics than her colleagues. "Over and over again she tells us one must have the time to look, the patience to 'hear what the material has to say to you,' the openness to 'let it come to you' "(Keller, 1983:198). Barbara could deal with broken chromosomes and recognised them as an issue in plants.

> McClintock wondered how plant cells sense the presence of broken chromosomes and activate the appropriate repair mechanisms, and she marvelled at the 'smart cells' that underwent specific migrations in animal embryogenesis. McClintock was known to ask seminar speakers, "How does it all fit together?" She considered reductionism as an approach, not an answer. The secret of McClintock's success in the face of incomprehension and prejudice, was her fearless and complete intellectual freedom - to admit "I don't know," and then to wrestle the answer from the data (Shapiro, cited in Peterson, 2004:2).

Barbara did not objectify her subject, nor did she take the textbook approach and analyse it into bits of data. Instead, she approached the genetic material assuming it could best be understood as a communal phenomenon. McClintock "made a crucial discovery by recognising that the genetics of living organisms is more complex and interdependent than anyone had believed. By observing how genes function in their environment rather than regarding them merely as isolated entities, she discovered that bits of genes can move about on chromosomes" (Rosser, 1992:46). Barbara recognised the importance of connectedness issues in the area of cellular information processing. "Although McClintock had the reputation of a mystic, she always drew her conclusions from her observations—this is what she meant when she admonished us to 'listen to the plant'" (Sundaresan cited in Peterson, 2004:2). Barbara advocated that the scientist needed to 'connect' with the material being investigated.

When Keller interviewed Barbara for the biography, it became clear that the communal premise of her work went well beyond the relationship among genes: it included the relationship between the genes and the scientist who studied them. Knowing that there are limits to rational explanations, Barbara trusted and valued the process of creative insight which she cultivated. Below she describes how her understanding seemed to bypass any conscious awareness.

> When you suddenly see the problem, something happens that you have the answer – before you are able to put it into words. It is all done subconsciously. This has happened too many times to me, and I know when to take it seriously. I'm so absolutely sure. I don't talk about it, I don't have to tell anybody about it, I'm just *sure* this is it. (McClintock cited in Keller, 1983:103)

By incorporating a different form of connectedness, of integration, in her scientific work Barbara was able to make some major discoveries. For example, when she returned to her microscope after a time of meditation and contemplation, her changed level of consciousness enabled her to see things differently and she then discovered the *Neurospora* chromosomes.

> McClintock was frustrated by her inability to see the transposition of genes under the microscope. She retreated to sit under a eucalyptus tree and meditate. …When she felt she was ready, she returned to the microscope, and the chromosomes were now to be seen. (Lebacqz, 1997:24)

Barbara felt that what happened under the eucalyptus tree was crucial to her observations of the meiotic cycle of *Neurospora*. A change had occurred whereby she became re-oriented, and this new orientation enabled her to immediately integrate what she saw looking down the microscope. With a mindset that "everything is going to be all right", instead of disorder, she could identify the chromosomes easily. "I found that the more I worked with them the bigger and bigger [they] got, and when I was really working with them I wasn't outside, I was right down there and these were my friends" (McClintock cited in Keller, 1983:117). Here we see her *connectedness with nature*. She then said: "As you look at these things, they become part of you. And you forget yourself. The main thing about it is you forget yourself. I'm not there! The self-conscious "I" simply disappears" (McClintock cited in Keller, 1983:117-118). This experience with the *Neurospora* chromosomes was consistent with the feelings of total absorption she knew as a child. Now as an adult, she was using this capacity to make her scientific discoveries.

After this experience "she returned to Cold Spring Harbor ready to embark on the work that would lead to the major discovery of her career" (Keller, 1983:118). Barbara continued to treat the organisms she studied as subjects rather than objects. She loved her maize plants and spoke of them as her friends. Her attentiveness to these plants facilitated the idea that they responded to their environment by changing their genes, and led her to propose a 'jumping genes' theory.

Barbara was a scientist who in addition to valuing science, also valued different ways of knowing. Her attitude to nature, and to what is to be known, reflects a different image of science from a purely rational, dispassionate endeavour. Barbara's 'contemplative frame of mind' became an asset to her scientific work. "Scientists observe closely and mindfully and, by contemplation, allow their minds to make original connections" (Erricker, 2001:89). When McClintock, arguably the greatest biologist of our century, is asked to name the heart of her knowing, she invariably uses the language of relationship, of connectedness, of community. She "gained valuable knowledge by empathizing with her corn plants, submerging herself in their world and dissolving the boundary between object and observer" (Rosser, 1992:46). Her way of doing science was distinguished by precise analytical thinking, impeccable data collection and an attitude of connectedness. At the time the prevailing paradigm was one of disconnectedness.

Interpersonal lens: Becoming a scientist and interactions with colleagues

In contrast to her solitary childhood, first year at college was very social, with Barbara being elected president of the women's freshman class. Her single-mindedness made her determined to remain independent, so she refused to conform to fashion in dress or hairstyle. Relations with men were short lived, because she had no need of intimacy and was content being single.

> These attachments wouldn't have lasted. I knew [with] any man I met, nothing could have lasted. I was just not adjusted, never had been, to being closely associated with anybody, even members of my family…. There was not that strong necessity for a personal attachment to anybody. I just didn't feel like it. And I could never understand marriage. I really do not even now…. I never went through the experience of requiring it. (McClintock cited in Keller, 1983:34)

McClintock's career came about while she was following her passion. She recalls, "I remember I was doing what I wanted to do, and there was absolutely no thought of a career. I was just having a marvellous time" (McClintock cited in Keller, 1983:34). With no thought of a career, or any professional aspirations, the subject matter was always foremost in her mind. "I was just so interested in what I was doing I could hardly wait to get up in the morning and get at it. One of my friends, a geneticist, said I was a child, because only children can't wait to get up in the morning to get at what they want to do" (McClintock cited in Keller, 1983:70). She had interests in various vocations such as meteorology, and while working in Missouri spent numerous hours at the local weather bureau (Green cited in Peterson, 2004:1).

She succeeded in becoming a professional research scientist who held a unique worldview despite having no mentors or role models. Keller went on to say:

> Every scientist comes to his subject with a worldview that is uniquely his own – a worldview reflected in his relations to people as well as to his subject. Each brings a distinct set of interests – interests stamped by his or her own personality. (Keller, 1983:49-50)

On completion of her undergraduate degree Barbara remembers, "I knew I just had to go on". She became a graduate student in the botany department, majoring in cytology with a minor in genetics and zoology, because women were not allowed to major in genetics at Cornell. Her thesis supervisor, cytology professor Lester Sharp, fully supported her endeavours in a way that suited her style of working. She said, "He just left me free to do anything I wanted to do, just completely free". Green recalled Barbara's motto about graduate students, "Let them sink or swim", she did not believe in coddling them (Green cited in Peterson, 2004:1).

At that time, geneticists studied *Drosophila*, that reproduced rapidly, or *Maize,* whose lifecycle was much longer. Studies of the tiny fly, *Drosophila,* had identified individual chromosomes, but being so small their fine structure eluded scientists. Barbara chose to work with *Maize,* despite the time required for successive generations. Inheritance studies of *Maize* were very time consuming, and restricted to two per year. Barbara soon established herself as the foremost investigator in cytogenetics of *Maize*.

After gaining her PhD, Barbara continued as a researcher at Cornell, integrating the two forms of genetic research by combining the breeders' work with results of the scientists studying chromosomes. She also devised new staining techniques that enabled her to see more detail in *Maize* chromosomes than was possible in *Drosophila* chromosomes. Her superior findings generated friction between her and the geneticists who could not comprehend what she was trying to do. Genetics was undergoing a process similar to that talked about by Kuhn (1970) in *The Structure of Scientific Revolutions*. Kuhn argued that science progresses in periodic paradigm shifts rather than as a linear accumulation of knowledge. When a finding does not fit the prevailing paradigm, the scientific community may view the incongruence as the mistake of the researcher rather than calling the paradigm into question. The lack of understanding of Barbara's discoveries by the geneticists is seen as consistent with Kuhn's central argument that it is impossible to comprehend one paradigm through the conceptual framework of an opposing paradigm.

Barbara's ground breaking cytological work enabled new questions, which she explored with Marcus Rhoades and George Beadle, two young graduate students who came to Cornell to work with leading *Maize* breeder, Professor Rollins Emerson. She recalls, "We were a group all of us highly motivated, and we used to have our own seminars from which we'd exclude the professor – just us and a few others." (McClintock cited in Keller, 1983:48). Barbara became highly influential in this small group that studied *Maize* cytogenetics, the genetic study of corn at the cellular level.

However, many scientists misunderstood her work because she was years ahead of her time, and her impatience with the slowness of others meant that the situation deteriorated. These two factors resulted in Barbara experiencing communication problems with other geneticists. Fortunately, Rhoades, who recognised her genius, chose to mediate for her. In an interview he acknowledges Barbara as the real inspiration of their small collaborative group.

> One thing that's to my credit – that I recognized from the start that she as so good, that she was much better than I was, and I didn't resent it at all. I gave

> her full credit for it. Because – hell – it was so damn obvious: she was something special (Rhoades cited in Keller, 1983:50)

On the other hand, Beadle was not personally close to Barbara. He respected and recognised her unique cytological expertise: "she wasn't like the rest of us", "she was so good", "the best job that has been done". But their relationship became strained when Barbara interpreted his data before he was capable of doing so.

Another significant person in Barbara's working life was Harriet Creighton who arrived at Cornell as a young graduate student. Barbara was welcoming, quick to take on a mentoring role, and unselfishly gave Harriet an important investigation to begin with. In 1931, they published a seminal paper on genetic crossing-over in *Maize* that provided evidence of the chromosomal basis of genetics.

Barbara was first and foremost a research scientist, and she struggled to obtain a position that did not involve teaching. She was happy with a laboratory and an opportunity to do her research. When at Cornell on a fellowship (primarily to work with Emerson), Lewis Stadler became Barbara's close friend and colleague. Five years later, he invited her to the University of Missouri to participate in his new research involving mutagenic effects of X rays. In 1936, with a Rockefeller Foundation grant, Stadler persuaded the University to take her on as assistant professor so they could be collaborative colleagues.

Unfortunately, being a woman seemed to reinforce Barbara's eccentricities in the eyes of academia. When she demanded her right to be evaluated against the same standards as men, her colleagues reacted to the "chip on her shoulder" attitude by not wanting to work with her. "Visible evidence of her difference was an essential part of her self-definition" (Keller, 1983:85), and she was committed to pursuing whatever gave her the most pleasure. Her free-speaking and forthright manner of speech also caused her colleagues some concern. She criticised scientists who could not achieve her high standards, including Stadler, an excellent theoretician, but no match as an experimentalist. Although he showed no resentment, others did. In 1940, the dean of Liberal Arts called her a "trouble-maker". She became disillusioned with university life and after five years she left Missouri because she did not fit the male role, and placed no importance on the university's formal calendar. Barbara said she would, "do things others didn't do – I never thought anything about it" (McClintock cited in Keller, 1983:83). "It meant that there was no hope for a maverick like me to ever be at a university" (McClintock cited in Keller, 1983:86). Barbara recognised her disconnectedness with colleagues and the university, but maintained connectedness in herself.

Throughout her career Barbara dealt with many scientific and personal challenges from scientists who felt threatened by her independence, originality, and extraordinary accomplishment. One such scientist was her advisor Lowell Randolph, who became irritated when Barbara solved a problem he had been struggling with his entire working life. When she became the dominant member of his research team he found the situation intolerable (Ardell, accessed 20/12/04, p.1).

Despite the institutional difficulties, interpersonal conflicts, and lack of a professional niche, Barbara still had the enthusiastic support of her most respected colleagues. Her institutional and relational marginality, and professional dislocation may have strengthened her intellectual and emotional commitment to her work, which by then had taken on a life of its own in the form of connectedness to the natural world.

The personal lens: Barbara McClintock's childhood and connectedness to nature

Barbara McClintock (1902-1992) was a scientist who had a significant impact on scientific knowledge in the field of genetics. She was born in Hartford, Conneticut, USA, and named Eleanor Barbara McClintock. Her mother Sara was high-spirited, resourceful, and inherited her grandfather's love of adventure and independent-mindedness that drove him to captain his own ship at 19 years of age (Keller, 1983). Sara was an amateur painter and poet, as well as accomplished pianist. Her father, Reverend Benjamin Handy, being a righteous, stern man was very protective of his daughter and disapproved of all her suitors. He even called her future husband, Thomas Henry McClintock a foreigner because his parents were Celtic immigrants from the British Isles. However, Thomas was a determined young man who persisted until he married Sara just before graduating from Boston University Medical School in 1898.

Dr McClintock and his wife had four children quite close together: Marjorie (1898), Mignon (1900), Eleanor Barbara (1902) and Malcolm Rider (1903). When Eleanor was four months old, her strong fortitude and unique temperament led her parents to decide that the name Eleanor did not suit her character because it was too delicate and feminine. From then on they called her by her second name, Barbara.

Barbara recognised her 'capacity to be alone' originated when she was a baby: "My mother used to put a pillow on the floor and give me one toy and just leave me there. She said I didn't cry, didn't call for anything" (McClintock cited in Keller, 1983:20).

Throughout her life, there was constant tension between Barbara and her mother, which led to the little girl growing up solitary and independently. In part this was due to Sara having to raise four small children on her own, while her husband concentrated on his fledgling medical practice. To make matters worse, Sara also taught piano in order to make ends meet. Consequently, as stress relief she periodically sent Barbara for lengthy stays to paternal relatives in Massachusetts. Barbara, instead of resenting being sent away relished those times, "I enjoyed myself immensely and was absolutely not homesick" (McClintock cited in Keller, 1983:20).

When Barbara was six years old, her family moved to a semirural part of Brooklyn, New York. She recalls, "I remember getting up early in the morning and walking with the dog. I used to love to be alone, just walking along the beach". Her favourite past time was sitting alone, just "thinking about things". Right from childhood she had the capacity to be intensely absorbed. "I loved information. I loved to know things" (McClintock cited in Keller, 1983:26). She experienced an alternative form of connectedness, and had the capacity for 'absorption' as a child and as an adult.

> The portrait that emerges from McClintock's recollections so far gives us only glimpses of the characteristics that would be so important in defining her as a scientist. As a child McClintock had a striking capacity for autonomy, self-determination, and total absorption. But what was truly exceptional was the extent to which she maintained her childlike capacity for absorption throughout her adult life. (Keller, 1983:36)

In contrast to most girls, Barbara disregarded her appearance and talked about wanting to be free of her body. Fortunately, her mother valued self-determination, so Barbara was not pressured to conform to social expectations. Her parents knew she was different from her siblings, and so did she. At high school Barbara understood "that I just had to make these adjustments to the fact that I was a girl doing the kinds of things that girls were not supposed to do. … I would take the consequences for the sake of an activity that I knew would give me great pleasure. Whatever the consequences, *I had to go in that direction*" (McClintock cited in Keller, 1983:28).

Despite her mother's initial objections, Barbara was determined to go to college and study science. Cornell University was an ideal choice, because at that time it was one of only two universities that actively supported female students in science courses. She endured initial enrolment difficulties, due to a lack of paperwork, which was eventually overcome. Barbara remained positive and persevered until she was accepted into a zoology course in 1919. "I was doing now what I really wanted to do, and I never lost that joy all the way through college" (McClintock cited in Keller, 1983:31). Barbara's enthusiasm for the sciences she studied is evident.

Conclusion

This paper, informed by socio-cultural-historical theory is a narrative of Barbara McClintock that was generated by using Rogoff's three planes of analysis. On the individual plane, the personal lens enabled a description of the influences that shaped her personality in the early years, including interactions with family members. The interpersonal lens revealed her relationships with her peers in various institutions where she carried out her scientific endeavours. The community lens identified how the scientific community reacted to her scientific discoveries and radical theories. This narrative of a non-stereotypical scientist is useful in the classroom because it helps students to understand that doing science can be a complex and highly individual endeavour, and that there are other ways of knowing beyond a disconnected 'objectivity'.

References

Ardell (http://www.accessexcellence.org/Rc/AB/BC/Barbara_McClintock.html accessed 20/12/04, p.1

Berger, A. A. (1997). Narratives in popular culture, media, and everyday life. London: Sage Publications.

Dillard, A. (1985). *Pilgrim at Tinker Creek*. New York: Perennial Classics.

Erricker, J. (2001). Meditation and science: developing a contemplative frame of mind. In C. Erricker & J. Erricker (Eds.). pp. 89-94. Meditation in schools. A practical guide to calmer classrooms. London: Continuum.

Keller, E. F. (1983). *A feeling for the organism. The life and work of Barbara McClintock*. New York: W.H. Freeman and Company.

Kuhn, T. S. (1970). The stucture of scientific revolutions. 2nd ed. Chicago: The University of Chicago Press.

Neville, B. (2005). Educating psyche. Emotion, imagination and the unconscious ion learning. Greensbrough: Flat Chat Press.

Palmer, P. J. (1990). The active life. A spirituality of work, creativity and caring. San Francisco: Jossey-Bass Publishers.

Peterson, http://www.nal.usda.gov/pgdic/Probe/v3n1_2/mcclinto.html accessed 20/12/04, p.1)

Pink, D. H. (2005). A whole new mind. Moving from the information age to the conceptual age. Crows Nest: Alllen & Unwin.

Rogoff, B. (1998). Cognition as a collaborative process, in D. Kuhn and R. S. Siegler (Eds.), Handbook of Child Psychology, Vol, 2, 5th edn. New York: John Wiley, pp. 679-744.

Rosser, S. V. (1992). “The Gender Equation” *Sciences*, Sept-Oct. 1992, p. 46.

Appendix

Brief Chronology

- 1902 - Born Eleanor McClintock in Hartford, Conneticut, but soon became known as Barbara (June 16).
- 1908 - McClintock family moves to Brooklyn, New York
- 1919 - Graduates from Erasmus Hall High School, Brooklyn
- 1919-25 - Earns undergraduate (1923) and graduate (1925) degrees in botany, Cornell University
- 1927 - Receives PhD (botany), Cornell University
- 1927-31 - Instructor and researcher in maize genetics, Cornell University
- 1931 - Publishes (with H. Creighton) article on genetic crossing-over in maize
- 1931 - Fellow, National Research Council; conducts research at Cornell, University of Missouri at Columbia, and California Institute of Technology
- 1933-34 - Fellow, Guggenheim Memorial Foundation; conducts research at Kaiser Wilhelm Institute, Berlin, and Botanical Institute, Freiburg (Germany)
- 1934-36 - Researcher, Cornell University
- 1936-1940 - Assistant Professor of Genetics, University of Missouri at Columbia
- 1941-67 - Researcher in Genetics, Carnegie Institution of Washington Cold Spring Harbor, Long Island, New York
- 1944 - Elected to the National Academy of Sciences
- 1945 - Elected President, Genetics Society of America
- 1951 - Gives controversial lecture at Cold Spring Harbor Symposium on her theories of “controlling elements” in maize
- 1957-66 - Embarks on series of research trips to South America to study different races of maize

- 1967 - Distinguished Service Award, Carnegie Institution of Washington; stays on as Distinguished Service Member until 1992
- 1971 - Receives National Medal of Science from President Richard M. Nixon
- 1981 - Recipient, MacArthur Foundation Grant (inaugural recipient, lifetime award)
- 1981 - Recipient, Albert and Mary Lasker Award
- 1983 - Receives Nobel Prize in Physiology or Medicine
- 1992 - Dies in Huntington, New York (September 2)