

# Perspectives

## Anecdotal, Historical and Critical Commentaries on Genetics

*Edited by James F. Crow and William F. Dove*

### **Records and Recollections: A New Look at Barbara McClintock, Nobel-Prize-Winning Geneticist**

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**B**ARBARA McClintock (1902–1992), one of the foremost women scientists in twentieth-century America, is most noted for her pioneering research on transposable elements in maize, for which she was awarded the 1983 Nobel Prize in Medicine or Physiology. Much has been written about McClintock's life, but a great deal of what is known of her early career at Cornell's College of Agriculture and at the University of Missouri is based on memories, anecdotes, and rumors. Questions arise from the popular accounts based on McClintock's recollections gleaned from interviews, understandably compressed and beclouded after 50 years (KASS 1998, 2002a; FRIEDLANDER 2002). Were women graduate students excluded from Cornell's Plant Breeding Department? Did McClintock's work go unrecognized for many years? Was she disadvantaged in academic appointments because of her gender? Did she leave Missouri for Cold Spring Harbor out of choice or necessity? Why did she remain at Cold Spring Harbor rather than accept opportunities to return to Missouri?

Recognizing that memories and anecdotes can be embellished, skewed, contradictory, self-serving (PROVINE 1994), and biased by current views (SCHACTER and SCARRY 2000), I have supplemented the oral interviews with records and documents in hopes of presenting a more nearly accurate historical perspective of this extraordinary woman. Here I offer a few examples of new insights into McClintock's early life and work. My methods and sources are described in the APPENDIX.

#### RECORDS AND RECOLLECTIONS

**Women in plant breeding, 1919–1927:** The first examples are related to women in the Plant Breeding Department at Cornell between 1919 and 1927, when McClintock was a student. It has been accepted that Cornell's Plant Breeding Department was not open to women during that period (KELLER 1983; MCGRAYNE 1993; NASH 1999; ANONYMOUS 2001).

Barbara McClintock graduated from Cornell Univer-

sity in 1923, with a B.S. in Agriculture, concentrating in plant breeding and botany [Kroch Rare and Manuscript Collections, Cornell University (CU), Ithaca, NY; KASS and PROVINE 1997]. Although many would like to think her exceptional (NASH 1999), McClintock was part of the group of 222 women out of 272 in her graduating class who studied subjects other than domestic economy (CU). She regularly attended class reunions, as documented by her alumni folders in the Cornell archives.

Before McClintock arrived at Cornell and throughout her undergraduate years, the College of Agriculture employed 18 female assistant or full professors (1913–1923)—half in departments other than home economics (CU). The first woman full professor was appointed in 1920—5 years prior to the establishment of Cornell's College of Home Economics (CU).

McClintock received both her master's (1925) and doctoral degrees (1927) from Cornell's College of Agriculture. Her graduate school files show that she majored in cytology, with Lester Sharp in the Botany Department, and minored in genetics, with A. C. Fraser in the Plant Breeding Department. McClintock may have considered majoring in genetics, but documents in Cornell's archives and libraries make clear that she never applied for admission to the Plant Breeding Department.

Yet, while McClintock was a graduate student, many women were enrolled in both undergraduate and graduate classes in plant breeding, and a few of them also were awarded master's degrees from the Plant Breeding Department. Helen Trajkovich's graduate school file reveals that she majored in plant breeding with R. A. Emerson, head of the department. She was awarded her master's degree on the very day that McClintock received her bachelor's degree in 1923 (TRAJKOVICH 1924). Another woman, Elizabeth Bodger (BODGER 1927), received a master's degree with A. C. Fraser in the Plant Breeding Department the same year that McClintock was awarded her Ph.D. from the Botany Department in 1927. By the early 1930s, Emerson had accepted a number of women



FIGURE 1.—Barbara McClintock and Harriet Creighton, June 1930, in front of Stone Hall, College of Agriculture, Cornell University (with permission of H. Creighton).

graduate students to work with him toward the doctorate. They did not complete their Ph.D.'s, although they were awarded master's degrees (CU). Leona O. Schnell was the first woman to complete a doctorate in Cornell's Plant Breeding Department in 1946 (R. P. MURPHY, unpublished results; CU; SCHNELL 1946).

Emerson and other Plant Breeding Department faculty *did* accept female graduate students. Can we clarify why McClintock did not apply to major in Emerson's department? Can we explain why the story of discrimination against women in Cornell's Plant Breeding Department has been generally accepted?

Professor R. P. Murphy joined Cornell's Plant Breeding faculty in 1946 and headed the department from 1953 to 1964. His understanding is that before he arrived at Cornell, it was accepted practice in the Plant Breeding Department, and elsewhere, to admit students into their programs only if professors thought they could place students in jobs after graduation. (This practice was common during the 1970s when I was a Cornell graduate student. My first advisor discouraged me from majoring in my chosen subject and encouraged me to switch to a field with job opportunities.) Harriet Creighton, McClintock's friend, student, and collaborator in Cornell's Botany Department (Figure 1), suggested that Emerson may have discouraged McClintock

from majoring in the Plant Breeding Department given this rationale (see also CREIGHTON 1992). This account says more about societal customs and the availability of jobs for women in the field of plant breeding during this era (ROSSITER 1982) than it does about Emerson's presumed antifemale attitude. Emerson's letters in the Cornell archives demonstrate that he dealt with similar circumstances in placing African Americans and Jews during this time. Stories of discrimination in Cornell's Plant Breeding Department have been interpreted and embellished in the context of contemporary views.

**Barbara McClintock's graduate career:** During McClintock's early graduate career, she was an active member of the Synapsis Club, the Plant Breeding Department's student/faculty organization, which met weekly for seminars and social events (CU). In her first year in graduate school (1923–1924), she helped organize their 1924 annual Razzberry Meeting, where both students and faculty poked fun at each other. Additionally, in her first graduate year she was awarded the graduate scholarship in botany. Her master's thesis (MCCLINTOCK 1925) was a literature review of cytological investigations of the cereals, with particular attention to wheat.

In the fall of 1924, L. F. Randolph hired McClintock, then a second-year graduate student, to assist him in continuing the cytological investigations he had begun earlier that year. Randolph, a U.S. Department of Agriculture (USDA) employee and a collaborator of Emerson's, had obtained his Ph.D. in Cornell's Botany Department in 1921. He had studied cytology with Sharp, minored in plant breeding with Emerson, and was Sharp's teaching assistant when McClintock enrolled in cytology during the winter of 1922.

At that time the base number for chromosomes in many corn varieties was still in question. By the spring of 1924, Randolph had applied BELLING's (1921a,b, 1923) iron-aceto-carmin smear technique to clarify the chromosome numbers reported in the literature [LONGLEY 1924; National Archives of the United States (NA), College Park, MD]. He realized the value of this technique for associating hyperploidy with genetic characters and would soon share it with his new assistant, Barbara McClintock (NA; KASS and BONNEUIL 2003).

In February of 1925, McClintock began work for her Ph.D. Her interest was in the "B" or accessory chromosomes of corn, a project in which Randolph had an interest much earlier. In the summer of 1925, McClintock found a triploid maize plant in the Cornell cornfields. They applied Belling's smear technique to study the chromosomes in the pollen mother cells of this plant, and together (Figure 2) they reported its cytology in the *American Naturalist* in February 1926 [NA; American Philosophical Society Library (APS), Philadelphia]. Soon afterward, they ended their working relationship, as recorded by RHOADES (1984). Emerson's correspondence revealed that McClintock was upset that her name appeared second on their article when she believed she

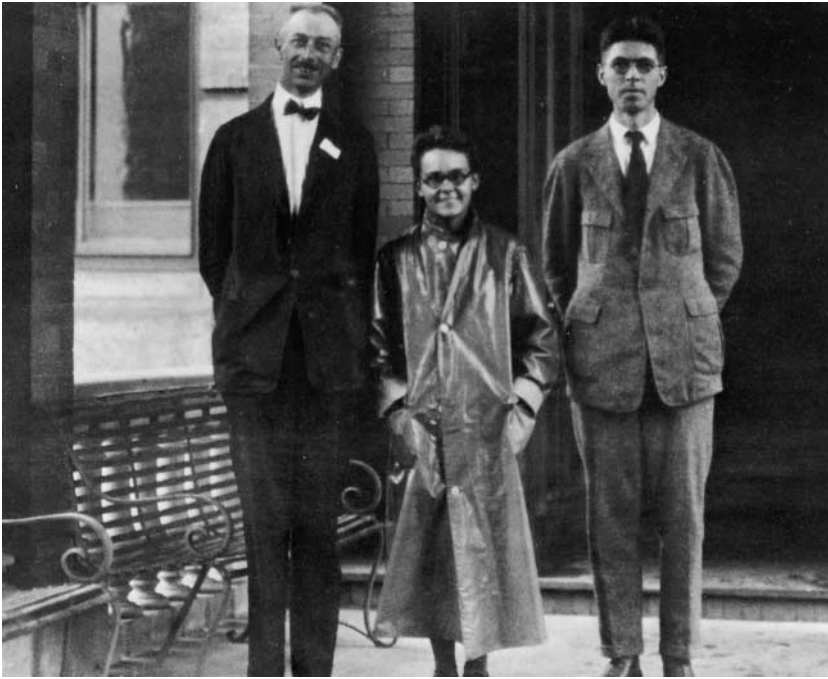


FIGURE 2.—(Right to left) L. F. Randolph, Barbara McClintock, and F. D. Richey *ca.* 1925 in the alcove of Stone Hall, College of Agriculture, Cornell University (with permission of H. Creighton).

had done most of the work (CU). Her disassociation from Randolph probably distanced McClintock from the plant breeding faculty (NA; KASS and BONNEUIL 2003). The following summer, Randolph independently reported their findings at the 1926 International Botani-

cal Congress at Cornell (CU). McClintock was in charge of the cytological demonstrations (Figure 3; KASS 1999b). Approximately 50 years later Provine interviewed her about working with Randolph, but she was uneasy and preferred not to discuss specifics (PROVINE and SISCO

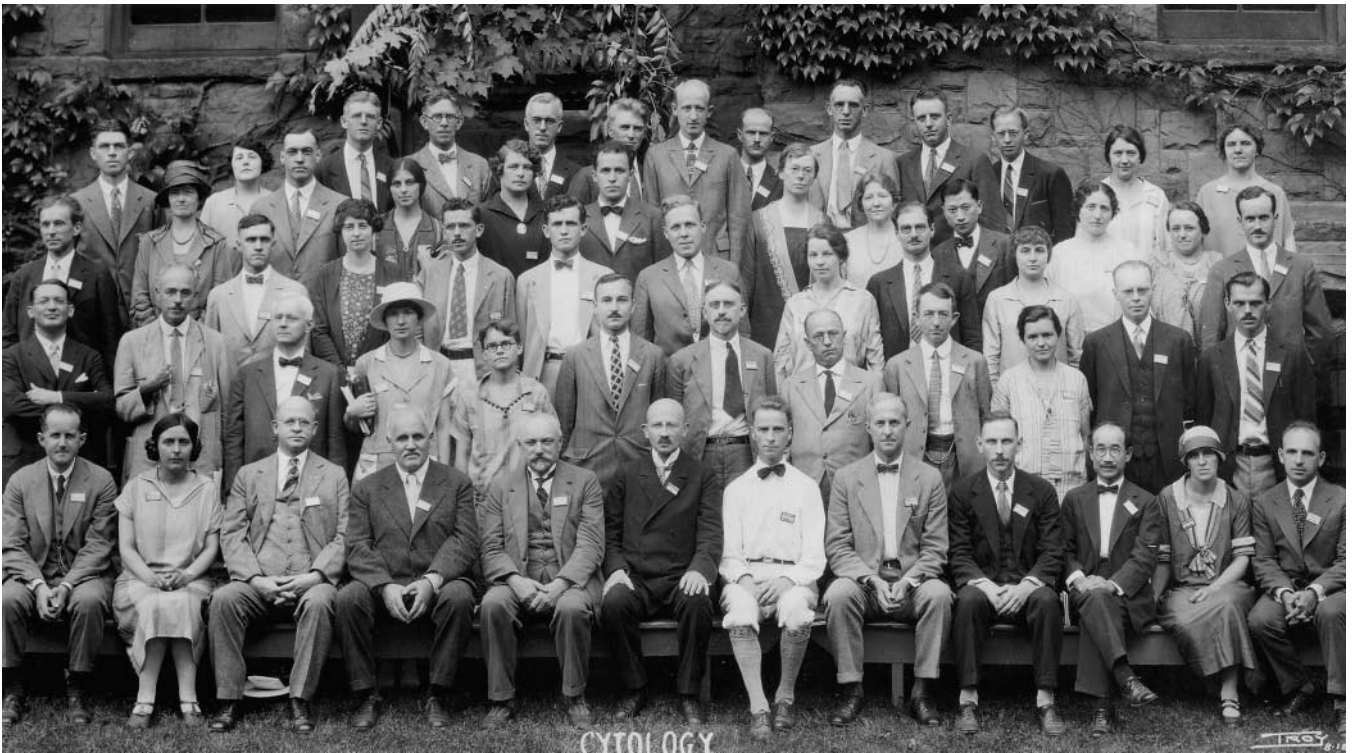


FIGURE 3.—Group photo of cytologists at the 1926 International Botanical Congress in Ithaca, NY. (Reprinted from *Photographs, International Congress of Plant Scientists [SIC], 1926*). Persons are identified from left to right. Front row: Lester W. Sharp (seventh). Second row: Barbara McClintock (fifth), A. F. Blakeslee (seventh, above Sharp). Fourth row: Lowell Fitz Randolph (first).

1980). Her experience with Randolph seems to have played a part in her decision to encourage students to work independently.

Finding the triploid maize plant changed the focus of McClintock's dissertation project. She investigated the cytology and genetics of this unusual plant, but her material did not yet permit her to morphologically distinguish each of corn's 10 chromosomes (McCLINTOCK 1927).

**Recognition and discrimination, 1928:** McClintock was appointed as instructor in the Botany Department at Cornell following the completion of her Ph.D. in February 1927. A few months later, Emerson, as dean of the graduate school, nominated her for an International Education Board (IEB) Fellowship. Records of this event revealed that gender played a part in the IEBs denying her an award. They asked for Emerson's recommendation of McClintock, keeping in mind that "the applicant is a woman and may leave the field of science at any time" [CU; Rockefeller Foundation Archives (RF), Sleepy Hollow, NY].

Emerson's reply was very supportive. He stressed her commitment to continue in cytological research and that Cornell wished to continue to employ her at her current rank (instructor). He emphasized that a year abroad would be most beneficial, but he did not specify that she had made any outstanding contribution to her field. Neither did Sharp's letter of recommendation or McClintock's IEB application indicate that she had any innovative plan for her studies abroad. The IEB committee notified Sharp that they did not fund McClintock's proposal and simultaneously returned the reprint of RANDOLPH and McCLINTOCK (1926) that she had submitted with her application form (RF). McClintock never reminisced about her IEB rejection, yet it is conceivable that her feelings about discrimination in Cornell's Plant Breeding Department were related to Emerson's association with this process.

**Significant contributions, 1928–1931:** McClintock remained at Cornell. Within the year she began to make significant contributions to her field while working cooperatively with students and postdocs in botany and plant breeding (BEADLE and McCLINTOCK 1928; McCLINTOCK and HILL 1929; BEADLE 1930; HILL 1930, 1933; KASS and BONNEUIL 2003; KASS and MURPHY 2003). In the context of recalling the work she did with Randolph from September 1924 to February 1926 (PROVINE and SISCO 1980), McClintock explained how she identified the morphology of corn's 10 chromosomes while a first-year graduate student (see also KELLER 1983; KASS and PROVINE 1999; COMFORT 2001). McClintock did indeed elucidate the shape and form of these chromosomes. But she worked out the technique between 1928 and 1929, after she had obtained her Ph.D.—as revealed by her doctoral dissertation (McCLINTOCK 1927, 1929a), her corn record cards and papers at the American Philosophical Society (SPECTER 1993; APS), and a careful

reading of her primary papers. The records clearly show that it was not during her first year in graduate school that McClintock initially described the morphology of corn's chromosomes; also, she did not use pachytene chromosomes to do so (KASS 2002b).

In an unpublished book chapter, McCLINTOCK (unpublished results; APS) explained that she had devised a technique for using late prophase and metaphase stage chromosomes in *mitosis* to describe the morphology of the corn chromosomes, as depicted in her articles published in 1929 and later (B. McCLINTOCK, unpublished results; APS; McCLINTOCK 1929b; McCLINTOCK and HILL 1929, 1931). These documents show that between 1929 and 1930 she first observed pachytene stage chromosomes in *meiosis* while looking for translocations in Charles Burnham's semisterile corn strains (BURNHAM 1930; McCLINTOCK 1930a,b; KASS 1999a, 2000b). BURNHAM's (1982; see also BURNHAM 1992) accurate recollections of this event are strengthened by his primary papers and correspondence from the era [University of Minnesota Archives (UMN), Minneapolis; University of Wisconsin Archives (UWI), Madison, WI]. Her studies with graduate student Harriet Creighton led to another important early contribution—the first cytological demonstration of crossing over in *Zea* (McCLINTOCK 1931a; CREIGHTON and McCLINTOCK 1931, 1935; CREIGHTON 1933).

Thomas Hunt Morgan's work with *Drosophila* led him to propose an explanation of linkage based on the assumption that linked characters are located in the same chromosome and remain together in inheritance. Creighton and McClintock's experiments in corn provided the first cytological proof for the genetic theory that linked genes on paired chromosomes did exchange places from one homolog to the other. Creighton recalled that Morgan knew that Curt Stern was close to solving this problem using *Drosophila*. Morgan urged them to publish their results quickly (CU; KELLER 1983), although their data were limited (WALLACE 1992). RHOADES (1992) partly disagreed with Creighton's recollections. He believed that Morgan would not have encouraged them to publish to beat out the *Drosophila* group. Garland Allen, Morgan's biographer, wrote to me (December 1, 2000) that it would have been uncharacteristic of Morgan to "encourage that kind of priority concerns." Correspondence in the Cornell archives shows that Morgan's good friend Emerson communicated their 1931 article to the Proceedings of the National Academy of Science (CU). It was additional confirmation of the chromosomal theory of inheritance for which Morgan would be awarded a Nobel Prize in 1933.

McClintock was an instructor at Cornell during these productive 4.5 years. At that time an instructor appointment was the first step leading to tenure at colleges and universities like Cornell and the University of Missouri, which adhered to the guidelines of the American Association of University Professors (AAUP). Those guidelines

recommended tenure and promotion to associate or full professor after a 10-year probationary period.

**Awards and recognition, 1931–1935:** McClintock's contributions were both rewarded and recognized. She received a National Research Council Fellowship (beginning in 1931, renewed through 1933) to study with E. G. Anderson at Caltech and L. J. Stadler at the University of Missouri [CU; California Institute of Technology Archives, Pasadena, CA; Western Historical Manuscript Collections (WHMC), Columbia, MO]. At Missouri, McClintock's innovative research for the first time placed a gene in a particular linkage group by other than purely genetic methods (McCLINTOCK 1931b). At the 1932 International Congress of Genetics, Emerson recognized her creative use of trisomy and translocations to develop maize cytogenetics (EMERSON 1932; KASS 2001; KASS and BONNEUIL 2003). McClintock's outstanding achievements qualified her for a Guggenheim Fellowship to study abroad for 1 year, beginning in November 1933. By April 1934, after approximately 6 months in Nazi Germany, she returned to Cornell, where she completed her fellowship but worried about finding a job (APS; CU; UMN; UWI). McClintock and many of her postdoctoral colleagues, including George Beadle, Charles Burnham, and Marcus Rhoades, found no permanent job opportunities owing to a worldwide depression that had left countless people homeless and destitute.

In 1934, Emerson was awarded a grant from the Rockefeller Foundation to support the Maize Genetics Cooperation at Cornell University for 5 years (CU; RF). He recognized McClintock's abilities toward this enterprise and requested a separate grant-in-aid to hire her as his research assistant at a good annual salary for that time of \$1800, which was renewed in 1935 (RF; BONNEUIL and KASS 2001; KASS and BONNEUIL 2003). She was free to work on any problem she wished—a policy that Emerson encouraged among his graduate students and postdocs (RF; RHOADES 1949). Within the year, EMERSON *et al.* (1935) recognized McClintock's many contributions toward their maize linkage studies.

Concurrently, L. J. Stadler and W. C. Curtis had requested funds from the Rockefeller Foundation and the USDA to establish a Regional Laboratory of Plant Genetics at the University of Missouri (WHMC; RF). By 1936, the foundation approved their funding because McClintock—their “Exhibit A”—had agreed to join the group as Assistant Professor of Botany (CURTIS 1949; RF). By August 1942, however, she officially resigned that position [University of Missouri Archives, Columbia, MO].

#### TRANSITION

In this section, I consider contemporaneous AAUP guidelines for tenure and promotion as I reexamine popular newspaper accounts and historical interpreta-

tions that McClintock left her assistant professor appointment at the University of Missouri in 1941 because she was denied tenure (GEYER 1983; HITT 1983; ANON 1985; BENNETT *et al.* 1993; ROSSITER 1995). McClintock never said she had been denied tenure at Missouri, which is made clear in KELLER's (1983) biography of McClintock. Yet, it is a good story and in the context of women's battle for legitimacy (HECHINGER 1985), it was misrepresented after McClintock received the Nobel Prize (ANONYMOUS 1985; NASH 1999).

The story (KELLER 1983) often repeated (*e.g.*, KITTRIDGE 1991; BUCKNER 1997) is that Stadler created a faculty position especially for McClintock at Missouri in 1936 because she needed a job. She eventually left that position because she saw no chance for promotion. When McClintock learned that she would probably be fired if Stadler left Missouri, she requested a leave of absence, intending never to return. Within the year, she reluctantly accepted a position at the Department of Genetics, Carnegie Institution of Washington, at Cold Spring Harbor, New York, although she was ambivalent about losing her freedom if she committed herself to any position.

Misrepresented accounts of this story have resulted in a legend that McClintock left Missouri because she was denied tenure (GEYER 1983; HITT 1983; ANONYMOUS 1985; BENNETT *et al.* 1993; ROSSITER 1995) or was dismissed (NASH 1999) or quit science (McGRAYNE 1993) and that she eventually accepted a job at the Department of Genetics at Cold Spring Harbor because she had no place else to go (KITTRIDGE 1991). McClintock was not denied tenure at Missouri, she was not dismissed, and she did not quit science, yet newspaper accounts magnified the story of McClintock's departure from Missouri and often coupled it with a message that her award as the first woman to receive an unshared Nobel Prize in Medicine or Physiology rectified this injustice (HITT 1983; ANONYMOUS 1985).

Abbreviated accounts of McClintock's experiences at the University of Missouri (*i.e.*, KITTRIDGE 1991; ROSSITER 1995; BUCKNER 1997; NASH 1999) have relied almost exclusively on the interviews that KELLER (1983) conducted with McClintock and her colleagues and on interviews she gave elsewhere (BRONTE 1993; McGRAYNE 1993). This remains the case even in a recent biography that interprets the tenure legend in light of current academic guidelines and suggests that McClintock was not eligible for tenure (COMFORT 2001). Historical perspective demands that we interpret McClintock's eligibility for tenure in the context of the time. (David Botstein suggested that I pursue the question of whether Missouri had a tenure system while McClintock was there.) The reasons that McClintock left Missouri are more complex than is known from the popular tales. Many records at the University of Missouri and elsewhere indicate why McClintock left her academic posi-



FIGURE 4.—Stadler's genetics group at the University of Missouri, February 1938 (negative provided by George Redei and used with permission; originally printed in *Stadler Genetics Symposia* 1976). Persons are identified from left to right. Front row: J. W. Cameron, K. O. Mills (deBoer), F. Clark, M. J. Guthrie, B. McClintock, E. W. Landron. Second row: G. F. Sprague, F. M. Uber, H. B. Glass, L. Smith, G. Francis, H. Roman. Top row: L. J. Stadler, J. G. O'Mara, W. R. Singleton, R. Winters, E. R. Sears.

tion and reveal the circumstances that led her to accept an offer at Cold Spring Harbor.

**University of Missouri to Cold Spring Harbor, 1936–1942:** In brief, the documents disclosed that Stadler and Curtis had proposed establishing a genetics research institute at the University of Missouri and required the services of a cytologist. In 1935, Stadler identified McClintock as the best cytologist in the world for the Missouri appointment (Figure 4; RF; WHMC; KASS 2003). Similar procedures were common practice in academic circles during that era. Stadler's Rockefeller Foundation grant initially paid McClintock's salary, but the renewal was contingent upon the university assuming financial responsibility for her appointment. McClintock felt impeded by teaching responsibilities, and she believed they distracted her from her research. In 1940, Stadler was offered a job at Caltech and contemplated leaving Missouri. As a result, the university administration considered eliminating his research group; McClintock thus felt betrayed by Stadler [WHMC; Lilly Library (LL), Bloomington, IN].

In February 1941, A. F. Blakeslee, the director of the Department of Genetics at Cold Spring Harbor, invited McClintock to spend her summer there [Cold Spring Harbor Laboratory Archives (CSHA), Cold Spring Harbor, NY]. Within a month of accepting Blakeslee's invitation, Stadler confidentially wrote to McClintock's friend Marcus Rhoades that she had "decided to quit at the end of this term" (LL; COMFORT 2001). McClintock may have wanted to quit her job, but she did not leave permanently. She judiciously requested a 1-year leave of absence to seek employment elsewhere, after learning from her dean that if she were tenured, and Stadler were to leave, her duties would be changed (LL). The

dean did not clarify what those changes would demand. Records at Missouri indicated that other faculty members were required to take on additional teaching duties at the time. Within the week, she wrote to Rhoades, "This job, regardless of permanent tenure, would certainly kill my vitality." She added, "Even permanent tenure is no inducement. When one is definitely not desired, it is a great handicap to one's enthusiasm" (LL). In McClintock's later years, after the Carnegie Institution of Washington had honored her with the title of Distinguished Service Member, McClintock recalled that one day she got fed up with her position at Missouri and packed her bags and left (PROVINE and SISCO 1980; KELLER 1983; B. McCLINTOCK, personal communication 1973). Her recollections may have revealed her determination of 40 years earlier; however, it does not provide the picture of what led to her decision. Her letters to colleagues, particularly Rhoades and Burnham (UMN; LL), show that she had been contemplating leaving Missouri for quite some time and finally requested a leave of absence to consider finding an alternative position. George SPRAGUE, SR. (personal communication, Aug. 7, 1998; see Figure 4) recalled that McClintock argued with Stadler about many things and often left his office in tears. Creighton had no recollection of McClintock mentioning leaving Missouri permanently. "If she had been denied tenure, we would have talked about it," she said. McClintock planned to spend her summer at Cold Spring Harbor, and Rhoades arranged for her appointment as a visiting researcher at Columbia University for the remainder of her leave. All documents that I found demonstrate that both McClintock and her employer assumed she would return to Missouri if she did not find another post [WHMC; State

Historical Society of Missouri, Columbia, MO; CSHA; RF; L. B. KASS, unpublished results).

Learning that McClintock might leave her job, Stadler wrote to Rhoades that C. M. Tucker, her department chair, had told her that she had been recommended for promotion (LL; COMFORT 2001). By 1940, new AAUP guidelines were formulated, which recommended tenure after 7 years of service, but these were not endorsed until 1941 and were not applied retroactively (JOUGHIN 1967; see also KASS and GALE 2002; KASS 2002a). Curtis, her dean, was a founding member of the AAUP. Stadler was President of the University of Missouri's AAUP chapter, and Tucker had recently been elected to membership (KASS 2002a; L. B. KASS, unpublished results). They were aware that McClintock was eligible for promotion (RF) on the basis of years of service both at Cornell and Missouri.

Concurrently, McClintock learned from her friend Marcus Rhoades of a possible job opening at Cold Spring Harbor, if Milislav Demerec (then the assistant director) were appointed their new director [Columbia University Archives (COU), New York]. Demerec did succeed Blakeslee and was appointed acting director of the Department of Genetics in November 1941 (HARTMAN 1988). He immediately offered McClintock a visiting investigator appointment there for the duration of her leave (August 1942). McClintock was pleased to accept his offer [CSHA; Carnegie Institution of Washington Archives (CIWDC), Washington, DC; Missouri Botanical Garden Archives (MBG), St. Louis].

**Missouri Compromise:** Demerec then offered McClintock a permanent staff position, but the University of Missouri immediately counteroffered with a large raise to supplement her previously recommended promotion with tenure (CIWDC; COU; WHMC). Records from the time indicate that she was ambivalent about which offer to accept, but was gratified that her financial needs would be met by both institutions (COU; CSHA). She was not denied tenure, but was considered essential at Missouri. Paradoxically, her appointment at the Department of Genetics was even more precarious than she feared would be the case at Missouri. McClintock had told Stadler that she did not wish to remain in an insecure position (LL), and Missouri's offer of tenure rectified that situation (CSHA). The appointment she finally accepted at Cold Spring Harbor, however, was contingent on her name appearing in the annual budget (CIWDC).

McClintock was empowered to shape her future, and she wisely considered both opportunities. She rejected an anticipated offer of tenure for a full-time research investigator appointment with no interference and complete freedom. She exchanged tenure and security at Missouri for an uncertain future at Cold Spring Harbor with freedom to pursue research without teaching responsibilities, committee work, graduate student advising, or deadlines for publications. She felt uncomfort-

able with this compromise, but it seemed to be the best decision at the time (COU). It was a turning point in her career (KASS 2002a).

After accepting the job at Cold Spring Harbor, she wrote to a colleague at the Missouri Botanical Garden that she believed remaining at Cold Spring Harbor was "the wisest thing to do—being a woman!" (MBG). Gender was a strong contributor in her desire to leave Missouri, but it was not the only factor. Other considerations that played a part in her decision to leave academe were a restrictive university atmosphere, teaching distractions, an uncertain future in research (caused by lack of trust in the head of her program), and the value she placed on her freedom (WHMC; LL; KASS 2002a; L. B. KASS, unpublished results).

McClintock was not denied tenure at Missouri. On the contrary, she declined their offer of an associate professorship with tenure and a salary of approximately \$4000 in exchange for an uncertain future at Cold Spring Harbor for a similar amount of money but with more independence (KASS 2002a; L. B. KASS, unpublished results; WHMC; CSHA; COU). Almost 40 years after she left Missouri, she still expressed strong feelings of rejection: "I knew I was going to be fired sooner or later, so I fired myself" (PROVINE and SISCO 1980).

McClintock's desire for autonomy is summed up concisely in her reply to an invitation requesting that she return to Missouri to head the genetics project following Stadler's death in 1954:

My present situation with the Carnegie is unique . . . I feel it would be difficult to acquire anywhere else the degrees of freedom that this position offers. The new President will continue the policy of no interference and complete freedom. I just go my own pace here with no obligations other than that which my conscience dictates. This seems to fit my personality rather well (WHMC).

## DISCUSSION AND CONCLUSION

In the *Dynamic Genome*, a gift to McClintock on her ninetieth birthday, Nina Fedoroff wrote, "The influence of her early work is greater than that of any of her peers . . . Had she done no more, McClintock would have become a major figure in the history of genetics" (FEDOROFF and BOTSTEIN 1992; KASS 2000a). These examples document just a few of McClintock's early achievements and general recognition, long before her work on transposable elements.

Archived documents and records are undoubtedly more reliable sources than interpretations founded on oral histories, memoirs, or autobiographical recollections. Research on memory has shown that stories people tell about their past are shaped by the beliefs they hold in the present and are often reexamined in terms of current experiences (SCHACTER and SCARRY 2000; SCHACTER 2001). Psychologists who study the nature of autobiographical memory conclude that current beliefs

can shape and sometimes distort recollections of past events. The quest for precision can lead biographers to criticize the factual inconsistencies, exaggerations, falsehoods, or self-deceit often found in autobiographies (SCHACTER and SCARRY 2000; SCHACTER 2001).

My aim in writing an intellectual biography of Barbara McClintock is to use written documents to place in historical perspective the many autobiographical reminiscences, recollections, and stories told by and about McClintock. Telling stories about each other is a strong tradition among scientists, and this custom is passed on from teachers to students (PROVINE 1994; KASS 1998). Historians use these accounts to lead them to documents that confirm or refute these legends. Distinguished scientists are often asked to recount their lives and work as memoirs or oral histories. These chronicles are usually recorded from memory at an age far removed from the events and without written verification of the incidents. Abe Eisenstark, Emeritus Professor at the University of Missouri, has given after-dinner talks on "The art of name dropping." If one cannot be famous, he recently told me, fame might come from association with the famous.

McClintock's memories were genuine but condensed (PROVINE and SISCO 1980; KELLER 1983). Papers and correspondence written at the time portray a more complete picture of the environment at Cornell during the late 1920s and early 1930s and at Missouri when McClintock was employed there between 1936 and 1942. The records permit us to conclude that there is a kernel of truth in many recollections, but situations are truly more complex than memories reveal. I am perpetually reminded of Samuel Johnson's words, "All history, so far as it is not supported by contemporary evidence, is romance."

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## APPENDIX

Over 25 years ago—years before Barbara McClintock won her Nobel Prize in 1983—William B. Provine began collecting documents to support stories of McClintock's life. Provine has argued that the primary (although not always reliable) history of science for scientists is the oral tradition of stories (PROVINE 1994). McClintock first granted Provine a day-long interview in her laboratory at Cold Spring Harbor in 1976. In 1980, he and Paul Sisco, then a graduate student in corn genetics at Cornell, audiotaped 8 hours of conversation with her about many subjects (PROVINE and SISCO 1980; KASS and PROVINE 1999). Provine deposited these tapes at the Cornell University Archives (CU) with the stipulation that they be unavailable to scholars until after McClintock's death. In 1993, Provine shared his tapes

with me and suggested that we write an intellectual biography of McClintock. In 1996, we shared the transcripts with other scholars, including N. Comfort, who recently wrote *The Tangled Field*, using these same sources (KASS and PROVINE 1999; COMFORT 2001). Comfort's reconstruction of McClintock's early career relies very heavily on these and other, mostly oral history, sources (KASS 2002b).

Our approach was to assess what interviewees tell us by seeking documents to verify their recollections. For example, in 1994, I interviewed Harriet Creighton. McClintock suggested Creighton's thesis problem and worked closely with her on the project beginning in 1930 (CREIGHTON 1933). Creighton led me to documents for stories told at Cornell's 75th Synapsis Club reunion. For this reunion, Provine had organized a symposium on the Golden Age of Corn genetics (1929–1935) that was recorded. Those oral histories and other recollections led me to find records and documents that clarify many stories told by and about McClintock.

One aim of this biography is to examine those stories in light of these documents. I checked the interview transcripts against correspondence, institutional records,

other interviews, and any other sources I could find. Assertions unsupported by other tangible evidence were largely discounted. On the other hand, biographers expect these interviews to give excellent insight into the stories that provide historical context for scientists themselves, and interviews often bring to light documentary evidence that was previously unknown (PROVINE 1986, 1994).

Biographical material about McClintock (KELLER 1983) was publicized throughout the world after she was awarded the 1983 Nobel Prize. National news stories about McClintock's life were embellished and interpreted in the context of then-contemporary views about women's role in society (NASH 1999). To place those stories in historical perspective, I scoured the campuses of Cornell University, the University of Missouri, and elsewhere to find archival records and personal correspondence; academic transcripts and files; department, employment, and performance records; and other appropriate institutional manuscripts and publications. In this article I use new documentation from many collections deposited at 15 archives and libraries throughout the country.