

# Perspectives

## Anecdotal, Historical and Critical Commentaries on Genetics

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

### Cornfests, Cornfabs and Cooperation: The Origins and Beginnings of the Maize Genetics Cooperation News Letter

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**I**N the early 1920s, the Maize Genetics Cooperation (MGC) began in an informal way among R. A. Emerson and his students. His ethical and cooperative spirit paved the way for an expanded network of maize researchers who freely shared their materials and unpublished research, thus resulting in rapid progress in fundamental genetic research (COE 2001; KASS and BONNEUIL 2004).

The first letter summarizing both published and unpublished maize linkage data was compiled by Emerson and his student George Beadle and sent to students of maize genetics on April 12, 1929. This communication was an outcome of a “cornfab” held in Emerson’s hotel room in December 1928, during the annual American Association for the Advancement of Science (AAAS) meetings. The “Historical Notes on Maize Cooperation” identifies Emerson’s 1929 communication as the *first* Maize Genetics Cooperation News Letter (MNL; EMERSON 1940). Beadle was the first secretary of the MGC and he solicited material for additional summaries of linkage data, which were distributed in two parts in 1930. Rhoades succeeded Beadle as secretary and continued to summarize and publish the reports of cooperators in the MNL, which continues to be published annually.

The cooperators met at the Sixth International Congress of Genetics (ICG) at Ithaca in 1932 and organized a committee to establish the maize stock center at Cornell University and to seek funding for their enterprise. Emerson’s grant application to the National Research Council (NRC) was denied and he was encouraged to apply immediately to the Rockefeller Foundation (RF),

who granted him funds to support his information and supply network in 1934. The work of Barbara McClintock in cooperation with Beadle, Rhoades, Creighton, Burnham, and others at Cornell between 1928 and 1934 resulted in a definitive correlation of chromosomes and linkage groups in maize—ultimately published in 1935 by Emerson *et al.* The cytogenetics of maize was also reviewed in that year (RHOADES and MCCLINTOCK 1935).

The exhibits that Emerson submitted to support his Rockefeller Foundation grant included a historical summary of the MGC and MNL. These documents allowed us to reconstruct the events that established these important resources for the maize genetics community. Emerson’s legacy lives on in the cooperative spirit of maize researchers and in the News Letter he founded 75 years ago.

At the 1932 ICG held in Ithaca, New York, Rollins Adams Emerson (NELSON 1993), Head of the Department of Plant Breeding at Cornell University, gave an opening address titled, “The Present Status of Maize Genetics.” In his introduction he declared, “I cannot refrain from noting here a very real advantage experienced by students of maize genetics . . . I am aware of no other group of investigators who have so freely shared with each other not only their materials but even their unpublished data. The present status of maize genetics, whatever of noteworthy significance it presents, is largely to be credited to this somewhat unique, unselfishly cooperative spirit of the considerable group of students of maize genetics” (EMERSON 1932, p. 141; KASS 2001).

During this Congress, Emerson called a meeting of ~45 students of maize genetics and formalized what would soon be called the Maize Genetics Cooperation. Following their meeting Emerson and his graduate student Marcus Rhoades issued on October 5, 1932, what has long been considered the first Maize Genetics Co-

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FIGURE 1.—R. A. Emerson with former and current students and colleagues at Fernow Hall, Cornell University, January 1, 1922, following the AAAS meeting in Toronto, where the second “cornfest” was held. Back row, from left to right: Milislav Demerec, Sterling Emerson, Ernest G. Anderson, and Charles Metz; front row, from left to right: Maxwell J. Dorsey, Sewall Wright, Rollins A. Emerson, William Bateson, Claude Burton Hutchison, Calvin Bridges, Frank P. Bussell, and Lewis A. Eyster (with permission of Royse P. Murphy, Department of Plant Breeding, Cornell University; see also PROVINE 1986, p. 103).

operation News Letter (RHOADES 1932a). Our research (BONNEUIL and KASS 2001; COE 2001; KASS and BONNEUIL 2004; E. H. COE and L. B. KASS, unpublished results), which we offer in keeping with the long tradition of maize cooperation, provides a historical perspective on the actual origin of the MGC and the beginnings of the MNL, which was first issued in 1929. We present here the history of Emerson’s successful negotiations with the Rockefeller Foundation to fund his cooperative enterprise at Cornell University following his unsuccessful attempt to obtain funding from the NRC. Future Nobel laureates George Beadle, Emerson’s student, and Barbara McClintock, Lester W. Sharp’s student and Beadle’s collaborator, freely submitted their results to the MNL; this laid the groundwork for a similar publication, the *Drosophila Information Service*, for the *Drosophila* geneticists in March 1934 (BRIDGES and DEMEREC 1934) and for the *Worm Breeders Gazette*, the community newsletter of the roundworm biologists (EDGAR 1975; COHEN 1995), among others. We rejoice in the founding of Emerson’s ideal and celebrate the 75th anniversary of the MNL.

#### EARLY COOPERATION

##### **Cornfests—a cooperative enterprise to map maize:**

As early as November 1918, Emerson wrote to Donald F. Jones at the Connecticut Agricultural Experiment Station that he was “hoping that all the men in this country who are working on related problems with corn may cooperate to such an extent that we can cover the field more quickly” [Emerson to Jones, November 8, 1918, Division of Rare and Manuscript Collections, Carl

A. Kroch Library, Cornell University (CU) Library, Ithaca, NY]. Soon afterward, Emerson arranged informal “cornfests” in conjunction with the AAAS meetings. It seems that Emerson organized these ~10 years before the famous “cornfab” held in his hotel room in New York City in December of 1928, as recalled by RHOADES (1984). Emerson much earlier had invited Paul Weatherwax of Indiana University to attend a “second cornfest” along with the “general genetics section” he had planned for the AAAS meetings in Toronto in 1921. Weatherwax apologized for not being able to attend (Weatherwax to Emerson, November 22, 1921, CU) but Emerson’s former and current students and colleagues joined him there and, following the meeting, held a reunion on January 1, 1922, at Cornell (Figure 1).

The following winter, Emerson emphasized the importance of agreeing on uniformity for factor notation (gene symbols) and he set the tone for cooperating on this problem in a letter on March 7, 1923 (EMERSON 1923, p. 147), “To Students of Corn Genetics: . . . It seems wise to follow the notation used by the *Drosophila* workers, tho, in some respects, their usage is perhaps no more nearly consistent than our own.” Emerson also asked his colleagues for assistance with numbering the maize linkage groups and requested advice on using bilateral gene symbols:

Shall priority of publication of any linkage determine the numerical order? Or shall the order be determined arbitrarily? . . . I suggest . . . that we number the groups in the order given by [William H.] Eyster and by [Claude B.] Hutchison as follows: 1-*C-wx*; 2-*g-R*; 3-*su-Tu*; 4-*B-Lg*; 5-*Y-Pl*; 6-*Pf*. . . . It may be wise, however, to assign no numbers to groups other than the six listed above until the newer groups have been tested further. Another prob-



FIGURE 2.—R. A. Emerson and members of the Synapsis Club, 1923. Herbert J. Webber started this student/faculty organization at Cornell in 1907, and Emerson continued and encouraged member participation (Department of Plant Breeding Records, Courtesy of the Division of Rare and Manuscript Collections, Cornell University Library). Members are identified from left to right (an asterisk designates corn researchers). Front row: William T. Craig, J. Randal Livermore, Ernest Dorsey, Franklin D. Keim, Robert D. Lewis, Laurens J. Henning, John P. Jones, \*Helen A. Z. Trajkovich, G. V. Wazalwar. Second row: Frank P. Bussell, \*Allan C. Fraser, Harry H. Love, \*Rollins A. Emerson, Clyde I. Myers, \*Roy G. Wiggans, \*Lester W. Sharp, \*Lowell F. Randolph. Back row: T. Sasaki, Archie F. Barney, Harold D. Brown, Leo A. Van Rooyen, \*Pavao Kvakan, Andrew D. Suttle, Walter A. Burkholder, Lua A. Minns, Edward L. Proebsting, Clifford V. Kightlinger, Merl C. Gillis, and \*Iang Chandrastitya.

lem is bothering us. Shall we continue to use bi-literal symbols for genes as we have usually done in the past [*i.e.*, *bl*, blotched leaf], or adopt the recommendations of the Naturalist's committee to use single letter symbols [*i.e.*, *b<sub>1</sub>*]? If the corn men desire to stick to the use of bi-literal symbols, we shall probably have to refrain from publishing in *Genetics* . . . but if the corn men think best to adopt the plan followed by *Genetics* [using single letter symbols], I shall use it (p. 149).

Emerson ended his five-page review with words for continued cooperation, "I am sending this to a considerable number of corn genetics workers. When I have received replies from the majority, I may want to refer some of our problems to the Chairman of the Naturalist's committee with the suggestion that he consider the advisability of referring it to the committee for consideration" (p. 149).

Two of Emerson's former students at Nebraska, Ernest G. Anderson (Figure 1) and Ernest W. Lindstrom, had followed him to Cornell in 1914 and continued to work on corn problems after graduating. Students and established researchers from around the country and throughout the world soon joined Emerson's group and studied corn breeding and genetics at Cornell. C. B. Hutchison (Figure 1), a former Cornell graduate, was appointed Professor of Plant Breeding in 1916. By 1921, he continued Emerson's unpublished study of *C-Sh* linkage and established that *Sh* was part of the *C-Sh-Wx* linkage group (HUTCHISON 1921, 1922). When Allan C. Fraser (Figures 2 and 3) succeeded Hutchison, he turned (from wheat) to maize (FRASER

1924). In addition to Anderson and Lindstrom, several other students pursued graduate work with Emerson on corn genetics (including women and students from abroad, Figures 2 and 3): William H. Eyster, Milislav Demerec (Figure 1), Helen A. Trajkovich, Pavao Kvakan, Thomas Bregger, Ivan F. Phipps, George W. Beadle, Hsien W. Li, George F. Sprague, Johannes D. J. Hofmeyr, Marcus Rhoades, Swarm Singh, Sylvia Allen, and others (R. P. MURPHY, unpublished results; CU).

During the period 1918–1920, Emerson realized that he could not avoid investigating the linkage of maize, which was crucial both to closing the gap with *Drosophila* workers and to providing a deeper basis for the breeding work on corn. Whereas from 1913 to 1928 *Drosophila* linkage mapping remained the concern of a few laboratories (WAGNER and CROW 2001), Emerson promoted the idea that maize genetic mapping should be a larger cooperative enterprise (KASS and BONNEUIL 2004), which would allow individuals to devote the best of their research time to more fundamental research projects. Furthering this end, Emerson also developed a regular collaboration and acted as advisor to the U.S. Department of Agriculture (USDA) program in corn research from 1920 onward [U.S. National Archives and Records Administration (NARA), College Park, MD]. Several graduate students, including Barbara McClintock, George Beadle, and Marcus Rhoades, were supported at Cornell by USDA funds, and some graduates obtained jobs with the USDA, including Arthur M. Brun-



FIGURE 3.—R. A. Emerson, Mr. S. C. A. R. Crow, and students of corn genetics posing in front of the Plant Breeding shed near the Plant Breeding Garden at Cornell University, 1927 (see also KASS and MURPHY 2003) (courtesy of William B. Provine). From left to right, front row: Hsien W. Li (China), Ivan F. Phipps (Australia), Allan C. Fraser, George Beadle's dog (Toto), George W. Beadle, and Harold B. Riley. From left to right, back row: Thomas Bregger, George F. Sprague, R. A. Emerson, S. C. A. R. Crow, Professor Emerson's dog, Roy G. Wiggins, and Wiggins' technician.

son, Thomas Bregger, Lowell F. Randolph, Marcus Rhoades, and George Sprague, all of whom contributed to the cooperative endeavors.

Following Emerson's early work on multiple factor inheritance (EMERSON and EAST 1913), his maize genetics school contributed concurrently to the progress of corn breeding and to general knowledge in genetics. In this respect, Emerson's program may be considered a parallel to Thomas Hunt Morgan's group [at Columbia University and later at The California Institute of Technology (Caltech)]. Emerson's students had close scientific associations with the *Drosophila* geneticists and with geneticists and cytologists at other institutions. Concepts, methods, standard nomenclatures, along with students (including E. G. Anderson, M. Demerec, G. Beadle, and M. Rhoades) who were trained in corn genetics and later also worked on *Drosophila*, circulated between the two communities. Maize geneticists maintained strong relations with *Drosophila* geneticists during the 1920s (e.g., C. Metz, C. Bridges; Figure 1). This connection was due primarily to Emerson and his students, who kept Emerson informed about the exciting work that was progressing in these laboratories. Consequently, Cornell maize geneticists were aware that the use of cytogenetics by *Drosophila* geneticists had opened a fertile second front to tackle problems.

**Linkage groups:** By 1928, however, significant general contributions to genetics from corn were quite limited (McCLELLAND 1930). Furthermore, maize linkage studies and genetic mapping stood nearly a decade behind *Drosophila*. The 10 linkage groups in corn were not all clearly identified and the mapping work in each group was still very rough, as illustrated by the "rainbow maps" drawn by Beadle and Emerson in April 1929 (Figure 4) (EMERSON 1929).

Within the year, however, Barbara McClintock's identification of the morphology of the corn chromosomes (MCCLINTOCK 1929) and her unpublished research on

trisomic ratios correlating genes with specific chromosomes were major contributions to Beadle's "Summary of Data on the Independence of the Linkage Groups in Maize," which Emerson distributed "To Students of Maize Genetics" on April 17, 1930 (EMERSON 1930a). McClintock, then an instructor at Cornell, collaborating with students George Beadle, Henry Hill, Harriet Creighton, and Marcus Rhoades, and with Charles Burnham, a visiting scientist, and others, began a golden age for maize genetics and cytogenetics at Cornell (RHOADES 1984).

At the Ithaca Congress in August 1932, Emerson could confidently present a genetic map with linkage groups correlated with numbered chromosomes, thus setting the stage for further cooperative and significant contributions to maize cytogenetics (RHOADES and MCCLINTOCK 1935). Rhoades also organized a "living chromosome map" in which mutant plants were arranged according to their chromosomal positions (CROW 1992).

#### FOUNDING THE MAIZE GENETICS COOPERATION NEWS LETTER

By February 1934, Emerson had applied to the RF for a grant-in-aid for support of work in collecting and disseminating maize stocks and information (CU). Emerson submitted a separate portfolio of exhibits (RF exhibits A–J, Rockefeller Foundation Archives, Sleepy Hollow, NY) to document his application dated February 6, 1934. Emerson's "Historical summary of cooperation among maize geneticists" (RF exhibit A) described how the maize cooperation began ~15 years previously in a small way among his former students. Soon other investigators were asked to be included. He documented interactions among these researchers with a "mimeographed summary of linkage in maize, 1929 [*sic*]" (RF exhibit D); this exhibit was actually Emerson's "second folder of mimeographed information issued sometime

C-SH-WX GROUP

List of Genes

ar	Argentia - finely striped leaf	Eyster 1929
au <sub>1</sub>	Aurea chlorophyll-yellow plant	Eyster 1929
au <sub>2</sub>	Aurea chlorophyll-yellow seedling	Eyster 1929
lp	Brown pericarp with a	Meyers 1927
C	Colored aleurone with A and R	East and Hayes 1911
d <sub>3</sub>	Dwarf plant	Suttle (Unpub.)
de <sub>15</sub>	Defective endosperm	Brink 1927
<del>fl</del>	<del>Floury endosperm</del>	<del>Hayes and Best 1915</del>
<del>gl</del>	<del>Glossy seedling</del>	<del>Hayes and Brewster 1925</del>
gm <sub>1</sub>	Germless	Eyster 1929
I	Inhibitor for aleurone color	East and Hayes 1911
pk	Polkadot leaf	Eyster 1929
v <sub>1</sub>	Virescent seedling	Demerec 1924
v <sub>14</sub>	Virescent seedling	Phipps (Unpub.)
v <sub>15</sub>	Virescent seedling	Phipps (Unpub.)
w <sub>11</sub>	White seedling	Demerec 1926
wx	Waxy endosperm	Collins 1909
yg	Yellow-green plant	Jenkins 1927

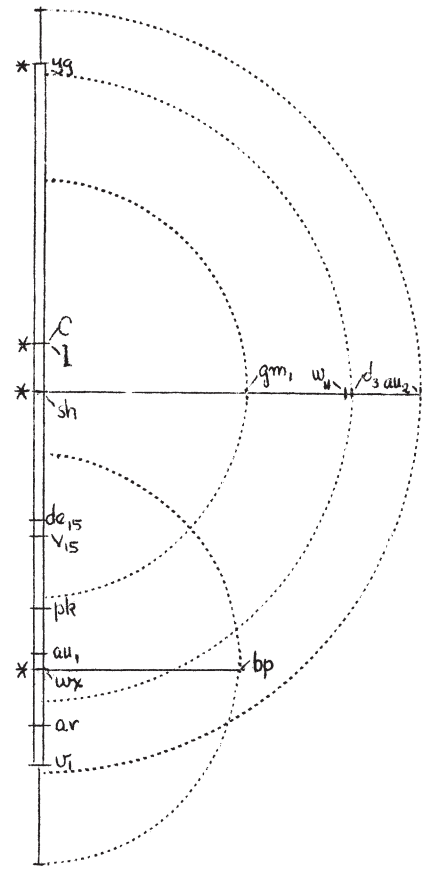


FIGURE 4.—Linkage group 9 and Rainbow map as of April 12, 1929 (after EMERSON 1929; excerpted from E. G. Anderson’s annotated copy in MNL archives; reprinted in MNL, Vol. 53, pp. 118–119, 1979).

after the first one” (mentioned in EMERSON 1940). His “mimeographed summary” (RF exhibit D) included all of the linkage data compiled and sent to maize geneticists on April 17, 1930, and July 26, 1930 (EMERSON 1930a,b). Emerson’s *first* (our emphasis) mimeographed letter, dated April 12, 1929 (EMERSON 1929), “considered News Letter 1” by Emerson himself (see EMERSON 1940), was distributed to maize geneticists shortly after the “corn-fab” held in Emerson’s hotel room at the time of the AAAS Christmas meetings in New York City in 1928. It included a long folder of linkage information and the names of researchers assigned each linkage group (see Table 1 based on the original). Emerson (April 12, 1929) carefully explained, “To those not at the New York Meeting . . . this assignment [of linkage groups] was . . . made in accordance with the expressed interests of those assuming the responsibilities entailed. It was far from our purpose to preempt groups for ourselves and thereby warn off other workers. Our purpose rather was to make sure that each known group would be given immediate and adequate attention to the end that the not very exciting job of chromosome mapping may go forward with some dispatch, thereby making possible an

attack on certain important genetic problems now awaiting just such tools as accurate linkage maps afford” (EMERSON 1929, p. 117).

Although Barbara McClintock’s name appears amid Emerson’s list of cooperators, we have no documentation that she attended the meeting and it would not have been appropriate in that era for a single woman to attend a gathering in a man’s hotel room. The cooperators who did attend, however, were most familiar with McClintock’s work (see KASS 2003) and would have recommended her for this endeavor. Following the New York meeting (December 1928), George Beadle acted as secretary of the group (BEADLE 1929a,b, 1930; EMERSON 1931). Beadle requested from maize cooperators the summaries of linkage data, which Emerson, in cooperation with Beadle and Fraser, would send to cooperators in the spring and summer of 1930. Beadle left Cornell in late 1930 for Caltech as a National Research Council Fellow (Plant Breeding Records, CU) (BERG and SINGER 2003), but continued to receive unpublished linkage data from cooperators (EMERSON 1931), until Marcus Rhoades subsequently succeeded him as secretary (RHOADES 1932a).

In his review of “The Early Years of Maize Genetics,”

**TABLE 1**  
**To whom linkage groups were parceled out at New York, at the “Cornfab”  
held in R. A. Emerson’s hotel room in December 1928**

Linkage group	Recipient
C-Wx	Eyster (Bucknell University); Beadle (Cornell University)
R-G	Lindstrom, Jenkins, Wentz (Iowa State University)
Su-Tu	Emerson (Cornell University)
B-Lg	Stadler (University of Missouri); McClintock (Cornell University)
Y-Pl	Hill (Cornell University)
P-Br	Emerson (Cornell University)
Ra-G11	Brewbaker (University of Minnesota); Jorgenson (Ohio University); Li (Cornell University)
D1-Pg2	Not assigned
A-Ts4	Brink (University of Wisconsin); Li (Cornell University)

Based on EMERSON (1929).

RHOADES (1984) recalled the New York City “cornfab,” which was his first with the maize cooperators. Rhoades had arrived at Cornell in the fall of 1928 from the University of Michigan, where he had studied with Emerson’s former student E. G. Anderson. Anderson was soon recruited by Morgan for his newly established Biology Division at Caltech. Rhoades then spent the 1929–1930 academic year there with Anderson (CU) (ANDERSON and RHOADES 1931; BIRCHLER *et al.* 2003). It seems clear, however, that the 1928 AAAS “cornfab” was not Emerson’s first.

#### ESTABLISHING AND FUNDING THE MAIZE GENETICS COOPERATION AT CORNELL

**Establishment of the Maize Genetics Cooperation:** Emerson also submitted to the Rockefeller Foundation a copy of Rhoades’ first letter to corn geneticists dated October 5, 1932 (RF exhibit C; RHOADES 1932a), which was retroactively numbered “Vol. 2,” in the Cornell Plant Breeding Department’s bound volumes of the MNL [MNL, Vols. 2–14, 1932–1940, and MNL, Vols. 15–21, 1941–1947; Plant Breeding Department Archives (PB), Cornell University, Ithaca, NY]. Therein, Rhoades summarized the resolutions discussed and favorably acted upon by a committee of maize-genetics workers at the Ithaca meeting held on August 26, 1932, in connection with the International Genetics Congress. In addition to discussing the numbering and naming of gene symbols, linkage groups, and chromosomes, the group agreed that Cornell should be the “clearing house” where the records would be kept and that a repository should be formed for storing and disseminating the new information. Emerson, chair of the committee to oversee their resolutions, along with R. Alexander Brink, Donald F. Jones, Paul C. Mangelsdorf, and Lewis J. Stadler, had chosen Rhoades (1) to act as custodian of the seed stocks, (2) to furnish a list of stocks received, and (3) to distribute stocks to workers. They also reallocated the 10 maize linkage groups to individuals who would

assume primary responsibility for the group assigned (Table 2) (see also COE 2001).

By this time McClintock had left Cornell but her pioneering contributions to maize cytogenetics had been both recognized and rewarded. She was awarded a National Research Council Fellowship (1931–1933) and, after spending time with L. J. Stadler at the University of Missouri, had joined Anderson’s group at Caltech, where she resumed cooperating with Beadle and Burnham. They returned to Cornell to attend the ICG in the summer of 1932, where EMERSON (1932) recognized their contributions to maize cytogenetics.

Following the Congress, Rhoades’ first letter to maize cooperators made clear that “anyone may begin or continue to work with any group whether or not it has been assigned to him.” It was expected that when “two or more are interested in the same group, they will work in close cooperation!” Rhoades then distributed a call for stocks, wants, and news items, on December 12, 1932 (RHOADES 1932b), and the third Corn News Letter followed on January 23, 1933 (RHOADES 1933; RF exhibit C in part). These two letters are bound together at Cornell (MNL, Vols. 2–14, 1932–1940, PB) and the latter is numbered “Vol. 3.”

**Funding the Maize Genetics Cooperation:** Emerson’s “historical summary” (RF exhibit A) additionally revealed that his committee was also responsible for devising a way to “carry out the work which the Cornell maize geneticists were asked to continue and to enlarge.” His committee did not find a way to provide funds, but it led to an alternative opportunity. The committee on agronomy appointed by the Division of Biology and Agriculture of the NRC, a unit of the National Academy of Sciences, unanimously recommended a grant-in-aid of \$1000/year for 5 years for an information and supply service for maize work to be headed by R. A. Emerson of the Plant Breeding Department of Cornell University, for the purpose of maintaining the service for “one of the most important crops and . . . for extending our knowledge in the field of genetics and cytogenetics”

**TABLE 2**  
**Reassigned linkage groups**

Linkage group	Recipient
Group 1, P-br	Emerson
Group 2, B-lg	Beadle
Group 3, a1-Rg	Brink
Group 4, su-Tu	Jones
Group 5, pr-v2	Burnham
Group 6, Y-Pl	Stadler
Group 7, gl1-ra	Jenkins
Group 8, j	Sprague
Group 9, c-wx	Eyster
Group 10, R-g1	Lindstrom

Maize linkage groups 1–10 were reassigned to individuals by the committee of maize researchers convened at the ICG on August 26, 1932 (after RHOADES 1932a). Researchers listed are from Rhoades' letter of October 5, 1932.

(RF exhibit B). The NRC committee supported their recommendation with six exhibits (cited as exhibits I–VI), which Emerson had submitted to document his accomplishments to date. These exhibits were not in the files at RF but we did locate two exhibits identified by Roman numerals: exhibit IV, Rhoades' letter dated December 12, 1932 (RHOADES 1932b), and exhibit V, dated January 23, 1933 (RHOADES 1933); we found these numbered exhibits in archived files of the Maize Coop (see also EMERSON 1940, where maize communications are identified by Roman numerals). The committee, composed of M. Francis Morgan, Ralph J. Garber, and Richard Bradfield (chairperson), emphasized that “maize occupies about the same relative position among plants that the fruit fly *D. melanogaster* does among insects” (RF exhibit B). Surprisingly, their recommendation was not accepted by the Council.

On December 26, 1933, the secretary of the NRC committee on grants-in-aid notified Emerson that after careful study of the application they had decided against making the grant of funds. Emerson received their letter upon returning from the Boston AAAS meetings, where both maize and *Drosophila* geneticists had suggested “standardizing nomenclature and symbolization for maize” (RF exhibit H). While there, Emerson had discussed with Frank Blair Hanson (Assistant Director, Natural Sciences, Rockefeller Foundation) an alternative plan for applying for funds to the Rockefeller Foundation should the NRC grant not be approved (Hanson's diary, RF). Four months previously (September 1933) RF officers Warren Weaver (Director, Natural Sciences) and Hanson, while visiting Cornell on other matters, had been apprised of Emerson's “information and supply service to corn geneticists” and his need for funds; but at that time Emerson was confident that the NRC would support the work (Weaver's diary, RF; Emerson to Stadler, November 8, 1933, CU).

Within a month of learning that the NRC grant appli-

cation had been denied, Emerson applied to the Rockefeller Foundation for funding and submitted Rhoades' most recent “mimeographed letter to maize geneticists,” dated January 25, 1934 (RF exhibit J; MNL Vol. 4, PB). By this time, among the 53 maize geneticists engaged in cooperative work on genetic mapping, it appears that not fewer than 30 were Emerson's collaborators at Cornell, had been graduate students there, or had done some postdoctoral work in his department. Emerson identified 24 cooperators as “most actively engaged in genetic studies”; 16 had been graduate students and 2 had been postdoctoral fellows at Cornell (RF exhibit E). He submitted the exhibits (RF exhibits A–J), which we have described here, and also explained that in the spring of 1933, parts of a manuscript of “A Summary of Linkage in Maize” then in the course of preparation by Fraser, Beadle, and himself (RF exhibit F) “together with work sheets had been sent to those to whom particular linkage groups had been assigned.” The draft manuscript was, of course, the notable “A Summary of Linkage Studies in Maize” that would be published by Emerson, Beadle, and Fraser in 1935.

On March 16, 1934, the Rockefeller Foundation appropriated \$5000 for the New York State College of Agriculture at Cornell University for the “support of collecting and disseminating maize stocks and information relating thereto” directed by Professor R. A. Emerson. Within the week, EMERSON (1934) asked cooperators if they were willing to allow him to use their unpublished linkage data in “the much heralded and too long delayed” general linkage summary to be published from Cornell (NARA). Students of maize genetics responded without reservations, fostered by Emerson's cooperative and enthusiastic, yet trustworthy, nature. Emerson soon after announced the Rockefeller award in a letter to cooperators on September 13, 1934 (MNL Vol. 7, 1934, PB). At that time, 60 genetics researchers were receiving the News Letter.

By April 1934, McClintock returned to Cornell where she completed her year-long Guggenheim Fellowship but worried about finding a job (KASS 2003). Emerson recognized her abilities toward his MGC enterprise and requested a separate grant-in-aid to hire her as his research assistant (RF; CU; KASS 2003) for continued research on maize cytogenetics. With Emerson's encouragement, his students took advantage of her presence to learn new techniques and to receive her cooperative guidance. Within the year, EMERSON *et al.* (1935) recognized McClintock's, and other maize cooperator's, contributions toward their maize linkage studies. Their linkage summary reported that, using trisomic ratios, McClintock identified 8 linkage groups with chromosomes 2, 3, 5, 6, 7, 8, 9, and 10. In 1935, Rhoades and McClintock reported that, by using trisomic methods, 6 of the 10 linkage groups had been associated with chromosomes: 2 [*B-lg*], initially incorrectly assigned to 4, 3 [*a1-lg*], 5 [*pr-v2*], 6 [*Y-Pl*], 7 [*gl1-ra*], and 10 [*r-g*]; and

that other methods (*i.e.*, reciprocal translocations) gave a definite check on previous trisomic determinations for linkage groups 1, 4 (*su-Tu*), and 9 (*c-wx*). The early MNLs (1929–1932, reprinted in MNL, Vols. 52–57, 71, and 72) demonstrate McClintock's and other cooperators' contributions to their maize linkage studies.

**Continued cooperation throughout the country and the world:** The work of maize cooperators stimulated interests in cytogenetics. By 1935 translocations were used to construct many tester lines that contained both phenotypic characters and a translocation. About one-third of the three-point and four-point tests reported in the linkage monograph (EMERSON *et al.* 1935) involved a translocation as a marker. Such translocation-associated three-point tests were extremely valuable, since they allowed confirmation of gene associations with specific chromosomes and gave the order of genes and of cytological locations with translocation breakage points (McCLINTOCK 1931; RHOADES 1931). In addition, CREIGHTON (1934) used pachytene stage chromosomes to continue deletion mapping studies.

Early on, Emerson fostered cooperation among researchers throughout the world. He encouraged both domestic and foreign students to join his research team at Cornell (Figures 3 and 4) and published their findings in the Cooperation's News Letter. Soon, this news circular, which united the maize genetics group, was not limited to offers and demands for strains but also disseminated unpublished results among the researchers. The rule was that any data appearing there could not be cited in publications without the direct consent of the contributor. Maize researchers from around the world—Austria, USSR, Yugoslavia, China, South Africa, Brazil, and Mexico—were honored to share their unpublished results, as we found in MNL reports through 1934.

**The first numbered Maize Genetics Cooperation News Letters:** The first set of bound News Letters, which we located in the Department of Plant Breeding at Cornell (MNL, Vols. 2–14, 1932–1940), was numbered by hand in pencil, beginning with Rhoades' letter of October 5, 1932, labeled "Vol. 2." This led us to believe that Rhoades' letter was not Maize News Letter 1. These News Letters appear to have been bound and numbered retroactively under the guidance of Emerson, who was the secretary for MNL, Vol. 14, 1940. The "Historical Notes on Maize Cooperation," listed on p. 56, of MNL, Vol. 14, although unsigned, were probably prepared by Emerson, who was secretary for that News Letter. Those notes clearly state that the mimeographed letter of April 12, 1929, is "considered News Letter 1." COE (1976, 1978) used the "Historical Notes" as a guide to compile an archival list of materials of the MNL and related cooperation. While conducting research on the history of maize linkage studies, KASS and BONNEUIL (2004) recently found some of the missing (starred) items on Coe's list. This new information permitted us to recon-

## MAIZE GENETICS COÖPERATION

### NEWS LETTER

19

February 15, 1945

The data presented here are not to be used in publications without the consent of the authors.

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FIGURE 5.—Cover of Maize Genetics Cooperation News Letter 19, February 15, 1945. The disclaimer was added to the News Letter cover for the first time in 1945.

struct the historical events leading to the establishment of both the MGC and the MNL and to update and expand the MNL files (COE and KASS 2005). The Plant Breeding Department also has a second set of bound News Letters with similar hand numbering (MNL, Vols. 15–21, 1941–1947); both sets are currently in the custody of Professor Margaret E. Smith on loan to L. Kass). Professor William B. Provine's reprint collection includes a set of unnumbered and unbound News Letters that belonged to Lester Sharp. Sharp's unnumbered collection spans the years 1933–1938 and includes important annotations to linkage in maize. Anderson's and Stadler's unnumbered collections span 1929–1939 and are also annotated. The first covered and hand-numbered News Letter that we found in Cornell's College of Agriculture Mann Library is "Maize Genetics Cooperation News Letter 13, April 15, 1939." Thereafter, the News Letter covers are professionally printed with the title, date, and place of publication—*i.e.*, De-



partment of Plant Breeding, Cornell University. In the reserve copies transferred from Indiana to Missouri in 1974, mimeo copies without covers were on file before 1940, followed by printed-cover copies beginning with Vol. 14. In 1943, Emerson consulted 13 of his most trusted maize cooperators about his concern that some MNL reports had been quoted without permission (Emerson to Cooperators, November 22, 1943, appended to MNL, Vol. 17, 1943, PB). A disclaimer was subsequently added to the News Letter cover in 1945 (Figure 5), and since that time the published covers have not changed with the exception of venue and the contraction to “Newsletter” on the cover beginning in 1990.

#### CHANGES AND TRANSITIONS IN MAIZE GENETICS COOPERATION

Emerson officially retired in 1941, and thereafter the MNL was edited by his colleagues, students, and occasionally by Emerson himself. He remained active in research until his death on December 8, 1947 (BUSSELL *et al.* 1948). Emerson’s colleagues, former students, and friends contributed to a memorial fund in his name (MNL, Vol. 27, 1953). The funds were applied toward the purchase of a lighted exhibit case placed in the hall of the Plant Breeding Department at Cornell (MNL, Vol. 29, 1955). Part of the exhibit case was used to display continuously some of Emerson’s own work. This case was on the first floor of the Plant Science Building at Cornell until the department moved to Emerson Hall, named for R. A. Emerson, in 1968 (WILLIAMS 1968). One of the authors (L. B. Kass) recalls assiduously exploring this case in the lobby of Emerson Hall when she was a graduate student at Cornell in the 1970s. The case is no longer maintained and its contents and whereabouts are not known at this time.

The Rockefeller Foundation supported the MNL and Stock Center at Cornell through 1953, when funding was withdrawn (MNL, Vol. 27, 1953). Rhoades recognized and confirmed that by the early 1950s scientists at Cornell were ready to forego the Stock Center and News Letter functions when RF withdrew funding, and he arranged to move them to Illinois (see MNL, Vol. 27, pp. 1–2, 1953; Table 3). In 1953, responsibility for the MGC-Stock Center collection moved from Cornell to Illinois, where it was again undertaken by Marcus Rhoades, joined by Earl Patterson (MNL, Vol. 28, pp. 2–10, 1954). Support was provided by the National Science Foundation (NSF) until 1981, following which the U.S. Department of Agriculture supported the program. The Stock Center is now a permanent USDA-Agricultural Research Service program under the direction of Marty Sachs. Its history, catalogs, and ordering procedures are at <http://www.aces.uiuc.edu/maize-coop/>.

After the Rockefeller Foundation withdrew support of the maize cooperation, Cornell funded the MNL

TABLE 3

#### Transitions of the Maize Genetics Cooperation responsibilities

Years	News Letter	Stocks	Database
1929–1953	Cornell	Cornell	NA
1953–1955	Cornell	Illinois	NA
1956–1957	Illinois	Illinois	NA
1958–1974	Indiana	Illinois	NA
1975–1991	Missouri	Illinois	NA
1991–2002	Missouri	Illinois	Missouri
2003–	Missouri	Illinois	Iowa State and Missouri

from 1953 to 1955, with subsidies from seed companies like DeKalb Agricultural Association; Green Giant; Northrup, King; and Pioneer Hi-Bred Corn (MNL 28: 1, 1954). In 1955, oversight of the MNL moved from Cornell to Illinois under Marcus Rhoades as secretary (MNL, Vol. 30, pp. 1–3, 1956) and it accompanied him to Indiana in 1958 (Table 3). At Illinois funding for the MNL was obtained from seed companies and a grant from NSF. The MNL continued to be edited by Rhoades, aided by Ellen Dempsey (his research associate and former student), as previously, and prepared and distributed at Indiana through 1974. That year the MNL transferred to the University of Missouri, under Edward Coe as secretary, until 2000, when Mary Polacco and Jim Birchler became cosecretaries. The News Letter (now “Newsletter”) continues to be compiled, edited, printed, and distributed at Missouri and is available online at <http://www.maizegdb.org/mnl.php> for previously printed issues or at <http://www.agron.missouri.edu/mnl/> for issues that are in process. Support for its distribution is from an endowment fund established from individual and corporate contributions.

Annual Maize Genetics Conferences were initiated in 1959, following a proposal from John R. Laughnan at the University of Illinois. The conferences are organized and run by a Steering Committee. The 2004 meeting was held in Mexico City. Information about past and future conferences is provided at <http://www.maizegdb.org/cooperators.php>.

The Maize Genome Database (MaizeGDB) was begun in 1991 as an extended medium for communication and for access to data, established by the U.S. Department of Agriculture-Agricultural Research Service at Missouri (USDA-ARS) under the direction of Ed Coe, joined by Mary Polacco. Content of the database, including gene lists, maps, bibliography, and cooperator’s addresses, initially was drawn directly from the files and compilations of the MNL, supplemented by entries of new data. In 2003, the MaizeGDB became a joint endeavor, supported by USDA-ARS, between Missouri (Mary Polacco) and Iowa State University (Volker Brendel, Trent Seigfried, Darwin Campbell, and Carolyn Lawrence). Curation of data content is conducted at the two locations,

and the database is served from Iowa State at <http://www.maizegdb.org/>.

In 2000, a Maize Genetics Executive Committee was elected whose mission is “to identify both the needs and the opportunities for maize genetics, and to communicate this information to the broadest possible life science community. This community includes scientists, funding sources for scientists, and the end users for the accomplishments of maize genetics, from farmers to consumers.” Information about the Committee is given at <http://www.maizegdb.org/mgec.php>.

This perspective was developed from a presentation given at the workshop, “The Mapping Cultures of 20th Century Genetics,” at The Max Planck Institute for the History of Science, Berlin, Germany, in March 2001. We thank R. MacIntyre for sharing bound and numbered copies of *Drosophila Information Service*, Vols. 1–8, 1934–1937; M. E. Smith for sharing bound and hand-numbered copies of MNL, Vols. 2–14, 1932–1940, and Vols. 15–21, 1941–1947; William Provine for sharing Lester Sharp’s unbound and unnumbered copies of MNL, 1933–1938, and for extensive use of his reprint collections; R. P. Murphy for significant insights and encouragement for this project and for sharing his unpublished manuscript on the history of Cornell’s Plant Breeding Department; archivists at the Rockefeller Archives Center, Sleepy Hollow, New York, with special thanks going to T. Rosenberg; U.S. National Archives and Records Administration, College Park, Maryland, with special thanks going to J. Schwarz; Division of Rare and Manuscript Collections, Carl A. Kroch Library, Cornell University, with special thanks going to E. Engst; librarians at the Mann Library, especially Tom Clausen; and The L. H. Bailey Hortorium Library, especially P. Fraissinet for bringing many valuable references to our attention. We are grateful to R. P. Murphy, W. B. Provine, and R. H. Whalen for reading early drafts of this article. L.B.K. acknowledges the following for support of archival research: National Science Foundation (grants SBR9511866 and SBR9710488); American Philosophical Society Library, Mellon Resident Research Fellowship; and the Departments of Plant Biology and Plant Breeding and Genetics, Cornell University, Ithaca, New York, for logistical support.

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