

MAIZE GENETICS COOPERATION

NEWS LETTER

12

March 6, 1938

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Department of Plant Breeding
Cornell University
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MAIZE GENETICS COÖPERATION
DEPARTMENT OF PLANT BREEDING
CORNELL UNIVERSITY
ITHACA, NEW YORK

November 17, 1937

To Maize Geneticists :-

Contributions of material for the annual Maize Genetics Cooperation news letter is hereby requested. Any new linkage data, methods, hypotheses, suggestions, or anything else that you think may be of interest to other maize workers will be incorporated in this news letter. Since it is desirable to have the information presented in a somewhat uniform system, it is suggested that you refer to some of the previous Co-op News Letters for ideas concerning the nature of your write-up. In order to be included in this News Letter your material must be received by the Co-op not later than January 15, 1938.

Several years ago when a number of maize geneticists found that they were unable to get their linkage data published in some of the leading journals, they conceived the idea of combining their relatively small papers into one larger paper and publishing collectively. This suggestion was approved by the Editor of Genetics, and the Secretary of the Maize Genetics Cooperation signified his willingness to collect the individual papers for the publication. But to date only one paper has been received by the Co-op. Perhaps the reason for this lack of response from maize workers has been due to some misunderstanding of the plan. With this possibility in mind, it may be advisable to quote from a recent letter to Dr. Dunn, Editor of GENETICS:

"The Maize Genetics Cooperation circular letter does not constitute publication and none of the material in it may be quoted except by permission of the author. Much of the material in this Co-op News Letter is not complete, but rather is merely some ideas and indications which the men have obtained in their studies and are willing to pass on to other workers in this field to speed up progress with maize. Some of the material, however, is more complete and should be published so that it will be more readily available to other geneticists. This latter type of material will be included in the Co-op News Letter in the same form as in previous circular letters. But it will also be written up in a different manner to be included in the collective publication.

"The details of the method of handling the material in the proposed collective publication of linkage studies in maize will, of course, have to be worked out cooperatively between the publisher and the Maize Genetics Cooperation. During the several years that this idea of collective publication has been discussed among maize workers, the following plan has been formulated. Each cooperator who has linkage data which he considers useful and of permanent value to other geneticists, shall write a short paper in the same manner as he would if he were to publish independently. Then each of these papers will be sent to the Secretary of the Maize Genetics Cooperation, who will group them into one larger paper with an introduction, etc., and will serve as author of the collective paper. The important point is that each short paper will be an individual and separate unit within this larger paper, with the name and address of the author affixed to it. The Secretary of the Maize Genetics Cooperation shall be responsible for the organization and composition of the whole collective paper, but the respective authors of the 'unit papers' shall be responsible for their data. This means that any citation from the collective publication must include the name of the maize worker who furnished that particular data."

Dr. Dunn has written:

".....there is nothing in the policy of GENETICS to interfere with publication of maize linkage data in the form you suggest. Our numbers early in the year are likely to be the heaviest so May or July publication would fit our schedule best. Submission of the first paper in February would be most convenient for us."

It is suggested that you write your contribution to the News Letter first; then excerpt certain linkage data from it and write a separate papers(s) to be included in the collective publication. The particular data which you select for publication will appear in both the News Letter and the group publication. For further information concerning the general form of a linkage paper, see the Co-op News Letter of March 4, 1936, page 2; or March 23, 1937, page 15.

Sincerely yours,

D. G. Langham

D. G. Langham,
Secretary

MAIZE GENETICS COÖPERATION
DEPARTMENT OF PLANT BREEDING
CORNELL UNIVERSITY
ITHACA, NEW YORK

January 22, 1938

To Maize Geneticists :-

A number of maize geneticists have already sent in their items for the annual Co-op News Letter, and many of you probably have your contributions in the mail now. The final date for the receipt of material for this 1938 Letter is January 31st.

In the circular letter of November 17, 1937, I discussed the proposed collective publication of linkage data in such detail that the cardinal points were apparently lost in the shuffle. In brief, the plan is that linkage papers, any one of which in itself would not be sufficient for separate publication, will be sent to the Secretary of the Maize Genetics Cooperation who will group them in much the same manner as in BIOLOGICAL ABSTRACTS and send them to the Editor of GENETICS for publication. Each unit paper must be written as if it were to be published independently. No alterations or additions will be made by the Secretary of the Co-op.

In order to be included in this collective publication, your paper must be received by the Co-op not later than March 31, 1938.

Sincerely yours,

D. G. Langham

D. G. Langham

MAIZE GENETICS COÖPERATION
DEPARTMENT OF PLANT BREEDING
CORNELL UNIVERSITY
ITHACA, NEW YORK

March 6, 1938

To Maize Geneticists:-

The material in this letter was obtained from many sources, and has been organized under the following heads:

- I. General News Items.
- II. Seed Stocks Grown in 1937.
- III. Seed Stocks Received For Propagation in 1938.
- IV. Miscellaneous Co-op Items.
- V. Gene Index of all the Co-op letters.
- VI. Chromosome Maps of Maize.

A. Regular map: few genes, loci fairly definite.

B. Working map: many genes, loci not well established.

Most of the information in this letter is given as it was received by the Co-op, but a few changes were made in some of the tables to conform to the accepted system of arrangement.

I. General News Items

University of Minnesota, St. Paul, Minn. -

1. Zebra seedling, zb₄, has been located in chromosome 1 by the following studies.

<u>Genes</u>	<u>Phase</u>	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	<u>Total</u>	<u>% Recomb.</u>
Zb ₄ Br	RS	448	142	152	12	754	31.1
Zb ₄ F ₁	RS	455	135	158	9	757	28.0
Zb ₄ Bm ₂	RS	487	103	144	23	757	46.0
Zb ₄ P	CS	266	24	5	64	359	6.9

Progeny of 1 ear indicated that the P parent was heterozygous giving the following segregation:

CS	63	30	2	24	199	6.7
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2. A culture of ra₂ received from Dr. Brink at Wisconsin proves to be similar to the one I have studied for many years. There is some variability in type of ear, some cultures showing rudimentary male flowers on the tips of some ears, irregularity of rows on the cob but no division of the cob as in ra₁. Other cultures have a divided cob on the tip of the ear but a solid cob at the base. Ra₁ can be separated from ra₂ in the F₂ of a cross.

H. K. Hayes

3. Virescent seedling. A virescent seedling in Minn. #13 corn was found to be linked with japonica and given the symbol v_{21} . Rhoades (Co-op News Letter, March 23, 1937) has found v_{16} and v_{21} to be allelic after trisomic tests had placed v_{16} also in chromosome 8. Further linkage data of j_1 , msg and v_{16} are as follows:

Genes	Phase	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	<u>Total</u>	<u>% Recomb.</u>
$J_1 V_{16}$	RB	82	565	542	71	1260	12.1
$J_1 V_{16}$	RS	354	149	154	4	661	16.9
$J_1 Ms_g$	CS	464	39	23	135	661	9.5
$Ms_g V_{16}$	RS	337	150	171	3	661	13.9

The order of the genes appears to be $j_1 - msg - v_{16}$.

4. Zebra striped. Emerson et al list five cases of zebra striping that have been reported. There are two types, one that is expressed in the seedling stage and which may completely disappear in partly grown plants. The type reported here was obtained from an inbred line of Del Maiz sweet corn furnished by J. D. Barnard of the Minnesota Valley Canning Company. The season in 1936 was very hot and dry. Germination of sugary seeds was much lower than normal. Zebra striping could not be classified until late summer when the weather was cooler. Classification was difficult in some cultures. The results given in the summary indicate zb_6 is located in group 4.

Genes	Phase	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	<u>Total</u>	<u>% Recomb.</u>
$Zb_6 Tu$	CS	410	64	64	90	628	23.3
$Zb_6 Gl_3$	RS	326	148	135	19	628	33.9
$Tu Gl_3$	RS	314	160	147	7	628	20.5
$Zb_6 Su_1$	CS	4227	259	175	361	5022	13.3

The order of the genes appears to be $Su_1 - zb_6 - Tu - gl_3$.

H. K. Hayes and M. S. Chang

University of Missouri, Columbia, Missouri -

1. Of the unknown glossies grown in 1937, tests were completed on one which was found to be different from the other ten and has been assigned the symbol gl_{11} . This was an X-ray induced mutant. One of the ultra-violet induced glossies proved upon test to be gl_2 . Tests on three others have not been completed.

In a previous report it was stated that somewhere along the line gl₆ and gl₈ had been confused and the present stocks of these are identical. Since the symbol gl₈ has been used in print for the glossy on the 5th chromosome, this designation has been retained and a new glossy assigned the symbol gl₆.

2. Glossy 7 has been tested with j₁ msg with no indication of linkage:

Genes	Phase	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	Total	<u>% Recomb.</u>
G ₁₇ J ₁	CS	159	22	40	9	230	43
G ₁₇ Msg	CS	148	23	51	8	230	50

3. The inheritance of yellow endosperm color is more complex than has been generally believed. Evidence is available for the presence of at least one gene in addition to Y₁ and Y₃ which is concerned with the presence or absence of yellow endosperm pigment. Ratios of 3:1, 9:7, 15:1, 45:19 and others possibly more complex have been obtained.

The yellow scutellum gene sy is able to produce its effect in the presence of Y₁Y₁, but in the presence of other recessive whites the development of pigment (carotin) is completely suppressed. The factor or factors involved have not been completely identified.

G. F. Sprague

John Innes Horticultural Institution, London, England -

1. Experiments on the inheritance of quantitative characters commenced by Dr. Brieger were continued during the summers of 1936 and 1937. The ultimate aim is to produce varieties of sweet corn which are early enough for the English climate and yet satisfactory in yield. In a comparison of F₁ families and their parents it was found that the application of a pseudo-factorial method of analysis (Yates, 1936) is not warranted for field trials with maize. The efficiency of the experiment when treated as a 3 x 3 x 3 pseudo-factorial arrangement was about 60% of that when treated as a simple randomised block lay-out.

C. D. R. Dawson

Connecticut Agricultural Experiment Station, New Haven, Conn. -

1. The evidence so far obtained indicates that mosaics in maize are due to losses or rearrangements of chromosome fragments rather than to somatic crossing over as Stern finds for *Drosophila*. Paired mosaics involving different chromosomes have been found for nearly all of the easily identified endosperm characters. In seeds heterozygous for C and Pr the following results have been obtained:

	White Spots	Red Spots	Red and White Paired Spots
Number	8409	1061	37
Ratio	227	29	1

These figures indicate a more or less random exchange between the 60 chromosome arms in this triploid tissue.

The secondary paired mosaics (twin spots within the dark part of primary twin spots) can not be accounted for by somatic crossing over but are understandable on the basis of translocation followed by further breaking at other places. Variegated waxy tissue in areas that have previously lost the C gene show an unstable condition that would not be expected from somatic crossing over. Similar variegation has been found involving C, Pr, and Su.

In seeds resulting from the pollination of C wx by c Wx light and dark aleurone twin spots were found indicating a shift of one C allele. If this resulted from an exchange of homologous segments the endosperm underlying the dark part of the twin spot should be waxy. In many such twin spots examined no waxy areas were found.

D. F. Jones

Agricultural Experiment Station, College Station, Texas -

1. The most important development in Texas during the past year is the discovery that the essential differences between *Zea* and *Euchlaena* are not due to numerous genes scattered at random over all the chromosomes as we first thought, but are due to four chromosome segments which are transmitted in inheritance in almost the same manner as single genes. The fact that these segments all carry genes similar to those possessed by *Tripsacum*, and the simultaneous discovery that short segments of the chromatin are interchanged between *Zea* and *Tripsacum* in hybrids of these two genera, has led us to the conclusion that teosinte is nothing more than maize with several translocation segments from *Tripsacum* superimposed upon the maize germplasm; the product of a natural hybrid between *Zea* and *Tripsacum*.

Two of these translocation segments have been located by linkage studies. They occur at opposite ends of chromosome 4 and both show linkage with Su and Tu. These translocation segments from *Tripsacum* are probably the cause of the unpaired terminal segments which Longley has observed in his cytological studies of the hybrid of maize and teosinte. We have verified his observations on the occurrence of these segments but we are not yet certain that they occur in every case on the chromosomes which he has designated.

The differences between the various kinds of teosinte which have been collected in Guatemala and Mexico may be attributed partly to the differences in the maize to which these translocation segments have been added, and partly to a loss of portions of one or more segments as the result of repeated hybridization with maize.

These new facts reopen the entire question of the origin of

maize. With teosinte as a recent development out of the picture, it is reasonable to assume that maize originated from pod corn, which in the homozygous condition is frequently a perfect flowered plant similar to the *Andropogonae*, and which has the essential characteristics of a plant adapted to survival in the wild. The place of origin was probably in South America, either in Peru or Bolivia.

We suspect that the crossing of South American types of maize with *Tripsacum* to produce the new genus *Euchlaena*, has also resulted in some new types of maize previously not in existence, such as the pointed pop corns and the long slender flint and flour corns, neither of which are known in Peru or Bolivia. If this is the case most of our North American maize varieties, with the possible exception of the Southern Gourd-seed types, carry *Tripsacum* genes in their germplasm. It is possible that the knobs which many of our North American corn exhibit on the chromosomes have been received from *Tripsacum* via *Euchlaena*, in which case we are quite likely to find some South American varieties which are lacking in knobs.

These hypotheses suggest a number of genetic and cytological tests which will keep us well occupied for a number of years. We are having some difficulty in locating viable seed of Bolivian and Peruvian maize and if any of the readers of this letter have such seed available we should appreciate receiving some of it.

P. C. Mangelsdorf and R. G. Reeves

Iowa State College, Ames, Iowa -

1. The following linkage data were obtained from the back-cross:

		+ + Kn +													
		br	f ₁	+	bm ₂	x br f ₁ kn bm ₂									
<u>0</u>	<u>1</u>			<u>2</u>			<u>3</u>	<u>1,2</u>	<u>1,3</u>	<u>2,3</u>	<u>1,2,3</u>				
165	182	14	4	50	50	47	52	7	10	1	2	16	32	6	2
347		18		100		99		17		3		48		8	
		2.8%		15.6%		15.5%		2.7%		0.5%		7.5%		1.3%	

Recombination percentages: br-f₁ 7.2, br-Kn 26.1, br-bm₂ 35.2, f₁-Kn 27.0, Kn-bm₂ 24.1.

These data do not agree completely with the present accepted location of br and f₁. On the basis of these data Kn is located closer to br than to f₁ but it must be between f₁ and bm₂. After more extensive tests in 1937 the writer is doubtful that homozygous knotted plants can be distinguished from the heterozygous plants,

2. A tall late type of plant with about 50 per cent more nodes than the normal was discovered among the plants from an F₂ selfed

ear from the Krug variety. Plants of this type were crossed with several normal stocks in 1936 and the F_1 progenies were grown in 1937. All of the F_1 plants were normal. A similar type was found in 1936 among the plants from another F_2 selfed ear from the Krug variety.

A. A. Bryan

California Institute of Technology, Pasadena, Calif. -

1. Correlation between cytology and map position in chrom. 1.

	<u>Cytological Position</u>	<u>Linkage Map Position</u>
T1-2c	S .7	near sr
T1-9c	S .6	near P
T1-2b	S .4	P \pm 1.5
T1-6c	S .3	P-7.6 - T - br
T1-3a	S .25	P-17.3 - T - br
T1-9a		P-20.0 - T - 34 - br
T1-5b		P-25.6 - T - 32.4 - br
T1-5c		P-24.2 - T - 27.8 - br
T1-6b	L .25	P-39.0 - T - 3.8 - br
T1-6a	L .2	br - 13.4 - T
T1-3d		near br
T1-7c	L .3	near br (\pm 2.7)
T1-7a	L .4	near br
T1-10a	L .4	near br
T1-7b	L .6	near br
T1-9b	L .6	br \pm 7.0
T1-2a		near ad and an
T1-5a		br - 9.7 - T - 39. - bm ₂
T1-4a		br - 20. - T - 45. - bm ₂
T1-7d	L .8	br - 34.7 - T - 18. - bm ₂

2. Chocolate. In the distal part of long arm of chrom. 2. Homozygous long inversion gave the linkage order:

1g₁-44-v₄-32-B-25-Ch

As the inversion includes about 4/5th of the long arm, Ch must be very near the end.

E. G. Anderson

3. Ms₂₀. Backcross tests with the following chromosome alterations show no obvious linkage:

Inversion of chrom. 2 (near B and beyond v₄)

T2-4b (2 near v₄, 4 beyond g₁₃)

T2-3c (2 near sk, 3 near d₁)

T4-8a (4 near su, 8 near spindle attachment)

4. Correlation between cytology and map position in chromosome 2.

	<u>Cytological Position</u>	<u>Linkage Map Position</u>
T2-3a		near lg
T2-6b	S .75	B \pm 2.2
T2-9a	S .65	B - 2.7 - T - 23.7 - v ₄
T1-2b	S .6(?)	B - 5.3 - T - 30.9 - v ₄
T2-3c		B - 6.0 - T - 28.0 - v ₄
T2-3d		B - 13.3 - T - 12.4 - v ₄
T2-4d		B - 18.0 - T - 6.0 - v ₄
T2-9b	S .1	B - 22.5 - T - 7.2 - v ₄
T2-5a	L .1	B - 25.0 - T - 7.0 - v ₄
T2-7b	L .25	B - 28.2 - T - 4.6 - v ₄
T2-10a	L .2	B - 36.5 - T - 6.0 - v ₄
T2-6c	L .3	v ₄ \pm 1.1
T2-7a	L .3	v ₄ \pm 1
T2-4a	L .3+	v ₄ \pm 1
T2-7c	L .3	v ₄ \pm 1.6
T2-5b		v ₄ \pm 5.3
T2-4b	L .6+	v ₄ \pm 7.7
T2-4c		v ₄ \pm 35.0 - T

I. M. Clokey and E. G. Anderson

5. Linkage of sb. Slit blade is probably not on chromosome 6 where first reported:

Genes	Phase	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	Total	<u>% Recomb.</u>
Y ₁ Sb	RS	930	249	306	84	1569	50
P1 Sb	RS	478	135	154	49	816	48
Su ₂ Sb	RS	896	265	340	68	1569	43
Py Sb	RS	1165	328	352	68	1913	50

The Y was not certainly, but probably, Y₁. In any case, sb is not between Y₁ and py.

6. Sb is not on chromosome 2.

Genes	Phase	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	Total	<u>% Recomb.</u>
Lg ₁ Sb	RS	288	95	76	35	494	50
G1 ₂ Sb	RS	288	92	78	36	494	50

sb x trisome 2:

	<u>Sb</u>	<u>sb</u>
Culture 1	6	3
Culture 2	187	63
Culture 3	126	20
	<u>319</u>	<u>86</u>

If sb were on chromosome 2 there should be about 30 sb plants; if on some other chromosome, about 100.

Notes: Sb is generally readily classifiable, though quite variable. Many of the plants are fully fertile. Usually the ratio is about as expected, though in two of my cultures the ratio was about 3:1 (F_2 seed). This was not due to lethality of sb, for nearly all of the seeds grew. In A B Pl plants the slitting of the blades seemed less developed than in green plants.

J. Shafer

University of Wisconsin, Madison, Wisconsin -

1. Linkage of ra₂.

Genes	Phase	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	Total	% Recomb.
<u>Cr₁ Ra₂</u>	RB	14	26	22	3	65	26.1

This is further evidence indicating that the ra₂ locus may be near that of d₁.

R. A. Brink

Arlington Experiment Farm, Arlington, Virginia -

1. The dominant Dt gene has been reported (1936) to produce dots of aleurone color on a₁-tester seeds. The nature of the interaction between Dt and a₁ was unknown at that time. It has now been established that Dt causes a₁ to become unstable and to mutate at a rate thousands of times greater than normal. Mutations of a₁ in the presence of Dt can be detected in aleurone, husks, and leaves i.e. plant color, and pericarp tissue. Recessive a₁ mutates to the A₁ allele a thousand times as frequently as to the a₁^p allele. There is no chromosome abnormality present in the Dt line. The a₁ gene is in chromosome 3 while Dt may belong to chromosome 9. Mutations of a₁ to A₁ or a₁^p occur late in development in all tissues. It is not possible, at least by the writer, to reconcile these data with any of the hypotheses advanced by Schultz, Stern or Patterson to explain variegation. They seem, however, to agree with Demerec's conception of increased mutability being caused by a chemical or physiological condition produced in the cell. Recessive a₁ is highly stable in the presence of dt. The Dt gene is specific in its effect on a₁. No other recessive locus including a₂, c, r, lg₁, wx and su is affected. A dominant modifying gene reducing the frequency or rate of mutation has been isolated. There is some evidence of a recessive gene affecting the time of mutation.

2. The following data on the location of ws₃ show the order to be as follows:

<u>ws₃</u>	<u>lg₁</u>	<u>gl₂</u>	<u>B</u>
0	11	30	49

These four genes are all located in the short arm of chromosome 2 and if the R^g or r^g alleles are used with B all of them can be classified in the seedling stage.

$\frac{ws_3 lg_1 +}{+ + gl_2}$ selfed	$ws_3 lg_1 + -$	415	$ws_3 lg_1 gl_2 -$	16
	$+ + gl_2 -$	525	$+ + + -$	1068
	$ws_3 + gl_2 -$	24	$ws_3 + + -$	90
	$+ lg_1 + -$	99	$+ lg_1 gl_2 -$	4
Total = 2241				

$$ws_3 - lg_1 = 11\% \quad ws_3 - gl_2 = 27\% \quad lg_1 - gl_2 = 19\%$$

3. Trisomic tests show y_{10} is in chromosome 6. Since y_{10} gave 43% recombination with Y_1 it will fall near the end of either the long or short arm. Tests with py will be made this spring.

4. Preliminary results indicate that the pollen tube is not parasitic but is dependent for its growth in the silk upon the starch stored in the pollen grain.

5. There is a highly significant increase in crossing over in the A_2-Bt and Bm_1-Pr regions of chromosome 5 in microsporocytes as compared with megasporocytes. In a "low" line there was 7.6% recombination between A_2-Bt in the female gametes contrasted with 12.2% in the male gametes. Similar differences between the frequency of crossing over in the two sexes is the explanation of the inexplicable difference found by the writer (1936) in crossing over for the Bm_1-Pr region in plants hyperploid for the short arm of chromosome 5 as compared with diploid sibs. The hyperploid individuals had been used as the male parent while the diploid sibs had been used as the female.

M. M. Rhoades

Cornell University, Ithaca, New York -

1. In the News Letter of March 23, 1937, pp. 1, 2, it was shown by means of three-point tests involving the genes sr , P , and br and the translocations T1-5a and T1-5c, that the order of the genes is $sr - P - br$ with the translocation breaks between P and br . Backcross data from 476 individuals were also presented suggesting that ts_2 is between P and what was then called T1-10b but now designated T1-2c.

Records of the past summer presented below show that T1-2c is to the left of P very near sr , that ts_2 is to the left of P with ms_{17} presumably to the left of ts_2 , and that T1-3a and T1-9c are probably to the right of P . The data are as follows:

Genes	Phase	XY	Xy	xY	xy	Total	% Recomb.
Sr T1-2c	CB	151	1	1	144	297	0.7

F ₁ genotype	0		1		2		1, 2		Total
$\frac{ts_2 P +}{+ + Tl-5b}$	76	93	1	2	17	22	0	0	211
	169		3		39		0		
			1.4%		13.7%				
$\frac{ms_{17} P +}{+ + Tl-5b}$	26	25	3	2	15	13	2	1	87
	51		5		28		3		
			5.7%		32.2%		3.4%		
$\frac{ts_2 P +}{+ + Tl-3a}$	106	140	3	1	29	36	0	0	315
	246		4		65		0		
			1.3%		20.6%				
$\frac{ms_{17} P +}{+ + Tl-3a}$	54	33	2	0	7	5	0	0	101
	87		2		12		0		
			2.0%		11.9%				
$\frac{sr P +}{+ + Tl-9c}$	38	32	24	17	0	5	0	1	117
	70		41		5		1		
			35.0%		4.3%		0.9%		
From '37 News Letter	97		24		5		3		129
	167		65		10		4		246
			26.4%		4.1%		1.6%		
$\frac{Tl-2c + P}{+ ts_2 +}$	156	138	51	29	2	1	0	0	377
	294		80		3		0		
$\frac{+ ts_2 P}{Tl-2c + +}$	204	276	50	49	3	0	0	1	583
	480		99		3		1		960
	774		179		6		1		
			18.7%		0.6%		0.1%		
From '37 News Letter	401		70		5		0		476
	1175		249		11		1		1436
			17.4%		0.8%		0.1%		
$\frac{+ ms_{17} P}{Tl-2c + +}$	152	157	29	31	3	5	0	4	381
	309		60		8		4		
			15.7%		2.0%		1.0%		

Two of the cultures reported above involving Tl-2c with B of chromosome 2 and P and ts_2 of chromosome 1, gave the following data from B Tl-2c + P

		+		+		ts ₂		+						Total	
0		1		2		3		1,2		1,3		2,3		1,2,3	
122	111	27	34	30	21	2	0	8	21	1	0	0	0	0	0
233		61		51		2		29		1		0		0	
		16.2%		13.5%		0.5%		7.7%		0.3%		0		0	

One of these cultures also segregated lg_1 as in F₂. Using only lg_1 plants, the records for lg_1 B Tl-2c + P are:

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1,2</u>	<u>1,3</u>	<u>2,3</u>	<u>1,2,3</u>	<u>Total</u>
28	15 19.0%	12 15.2%	10 12.7%	0	6 7.6%	3 3.8%	1 1.3%	4 5.1%	79

One of the cultures reported above to show close linkage between Tl-2c and sr also involved B of chromosome 2 but no marker other than sr of chromosome 1. The data are:

<u>F₁ genotype</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>1,2</u>	<u>Total</u>
<u>B Tl-2c +</u> <u>+ + sr</u>	63 44 107	28 9 37 25.7%	0 0 0 0	0 0 0 0	144

Since no crossover between Tl-2c and sr appeared in this culture, the orientation of these two markers with respect to the rest of chromosome 1 cannot be told.

2. Among 2052 F₂ plants of crosses of ad₁ with an₁, no double recessive appeared, but F₃ cultures from 220 F₂ an₁ and ad₁ plants indicated a crossover value of 4.1% (Linkage Summary, 1935, p. 32). Backcross cultures of last summer gave the following results:

<u>Genes</u>	<u>Phase</u>	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	<u>Total</u>	<u>% Recomb.</u>
<u>Ad₁ An₁</u>	CB	247	7	10	199	463	
<u>Ad₁ An₁</u>	RB	4	36	31	1	<u>72</u> 535	4.1

R. A. Emerson

3. Chromosome 7.

<u>F₁ genotype</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>1,2</u>	<u>Total</u>
<u>in + +</u> <u>+ v₅ gl₁</u>	880	30 3.4%	99 11.3%	8 0.9%	1017
	in - 4.3 - v ₅ - 12.2 - gl ₁				
<u>in gl₁ +</u> <u>+ + ij</u>	81	12 9.8%	23 18.7%	7 5.7%	123
	in - 15.5 - gl ₁ - 24.4 - ij				

A number of seedlings in the latter cross were destroyed by mice in early stages. Counts are not dependable for distances but they are consistent with the order in the first cross.

A. C. Fraser

4. Doubling the number of chromosomes in yellow corn increased the carotinoid content 43 per cent as determined by chemical analysis of 2N and 4N stocks having a common origin. The volume of the endosperm cells of the tetraploid was more than 3.5 times as great as that of the diploid. Thus the individual endosperm cells of the tetraploid contained more than 5 times as much carotinoid as did those of the diploid and in terms of gene concentration within the endosperm tissue the amount of carotinoid was increased 2.5 times as a result of chromosome doubling. Chemical analyses by D. B. Hand.

5. The following results have been obtained to date on haploid frequencies in seedling progenies from untreated and x-rayed (1500 r-units) pollen:

	<u>N</u>	<u>2N</u>	<u>N/1000</u>
From untreated pollen	66	126,308	.53/1000
From x-rayed pollen	31	24,619	1.25/1000

The haploids were identified with the aid of recessive seedling genes, stomate examination and root-tip chromosome counts.

L. F. Randolph

6. The following characters have appeared in inbred lines:

- co -Corrugated leaf. Raised striations of tissue in seedling and mature leaves. Classification good. Viability normal.
- bk_x-Brittle stalk. Similar to brittle stalk-1. Classification good. Viability normal.
- de_a-Defective endosperm. Seed similar to de₁.
- de_b-Defective endosperm. Seed similar to de₁.
- de_c-Defective endosperm. May be a new sugary. Classification good. Viability good in germinator, but hasn't been tested under field conditions.
- f_x-Fine stripe. Plant striped in seedling stage and throughout development. Classification good. Viability normal.
- Pu_x-Purple plumule. Similar to Pu₁.
- w_x-White seedling. Similar to w₁.
- ws_x-White sheath. Similar to ws₃.

R. G. Wiggins

7. White seedling-1 (w₁) has been known to be loosely linked with the Y₁ gene of the sixth chromosome (Linkage Summary, 1935). To place w₁ more accurately in the chromosome seedling counts were made of the F₂ cross between w₁ and pigmy (py). Seeds were taken from the Co-op stocks. The results indicate a very close linkage between py and w₁.

<u>Genes</u>	<u>Phase</u>	<u>XY</u>	<u>Xy</u>	<u>xY</u>	<u>xy</u>	<u>Total</u>	<u>% Recomb.</u>
Py W ₁	RS	867	416	443	0	1726	4.8 (if one xy)

G. A. Lebedeff

8. Segregation in autotetraploid maize. To determine the nature of segregation of some genes in autotetraploid maize, backcrosses were made involving the genes B (plant color booster) and Su (sugary endosperm).

<u>Cross</u>	<u>B</u>	<u>b</u>	<u>No. of Plants</u>	<u>Ratio</u>
BBbb x bbbb	437	135	572	3.25 : 1

Some difficulty was encountered in classifying the progeny of the backcross, sun red (BBbb) x green (bbbb), since there was a great deal of variation in degree of coloration. Some plants were distinctly sun red, others resembled dilute sun red, while still others showed a tinge of color on and around the ligules. Undoubtedly errors were made in classification, there being an excess of green plants. However, the backcross ratio approaches 3.67 : 1. Since the type of segregation is a function of cross over distance between the gene locus and the spindle fiber attachment region, this would indicate that the gene B is located fifty or more units from the spindle fiber attachment region and that chromatid segregation had occurred.

<u>Cross</u>	<u>Su</u>	<u>su</u>	<u>No. of plants</u>	<u>Ratio</u>
Su Su su su x su su su su	2877	645	3522	4.46 : 1
su su su su x Su Su su su	$\frac{369}{3246}$	$\frac{87}{732}$	$\frac{456}{3978}$	$\frac{4.24}{4.43} : 1$

There was no difficulty in classifying sugary segregates in a backcross of autotetraploids. The ratio of 4.43 Su : 1 su indicates that this gene has segregated on a basis intermediate between the random distribution of four chromosomes and random distribution of eight chromatids, and suggests that the gene Su is located about 20 cross over units from the spindle fiber attachment region.

H. E. Fischer

9. It has been observed by many investigators that the F₁ ears of maize-teosinte hybrids are 4-rowed (paired spikelets, two-ranked). This indicates that the paired spikelet condition

of the maize ear is dominant to the single spikelets of teosinte. Collins and Kempton, 1920, showed that in an F_2 population, paired and single spikelets segregated 3:1. Data obtained by the writer in the summer of 1937 have confirmed their findings.

It has not been pointed out, however, that the two-ranked condition of teosinte, which appears in the F_1 of maize-teosinte hybrids, segregates as a unit character in the F_2 population. The combined 3:1 segregation of the dominant two-ranked condition of teosinte (as contrasted with the many-ranked condition of maize) and the 3:1 segregation of paired vs single spikelets, gave a 9:3:3:1 ratio, indicating that these two genes are independent of each other. This independence makes possible the combination of the recessive many-ranked condition of maize with the recessive single spikelets of teosinte, giving two kinds of ears: some with an even number of rows and others with an odd number of rows. Thus, 3-, 4-, and 5-rowed ears with single spikelets have been found. With paired spikelets these would presumably have been 6-, 8-, and 10-rowed ears, respectively.

10. Preliminary F_2 and reciprocal backcross data on maize-teosinte hybrids indicate that response to short-day may be due to one, or a few, genetic factors.

11. New characters.

gc_2 - Glucostacious-2. Seedlings pale green in very early stages. Then brown blotches appear and the plants die. Chrom. unknown.

cz_x - Cuzcoid. Plant too late to shed pollen under field conditions at Ithaca.

la_t - Lazy teosinte. Similar to la_1 in maize. Has not been tested for allelism.

D. G. Langham

II. Seed Stocks Grown, 1937

1. Testers.

Chromosome 1:

$p ad_1 seg. an_1$ $P/ + f_1 bm_2 seg. br$

$(p ad_1 x p ad_1 an_1)self$ $sr an_1 bm_2$

$br f_1 bm_2 x (Kn x br f_1 bm_2)$

Chromosome 2:

$lg_1 gl_2 B ts_1 v_4 A Pl x lg_1 +/gl_2 B +/ts_1 v_4 A Pl$

$lg_1 b gs_2 V_4/? Gl_2/? x Inbred II$

$lg_1 Gl_2/? b v_4 gs_2 x Inbred I$

Chromosome 2 (con't):

Inbred x lg₁ gl₂ b v₄ A pllg₁ gl₂ b v₄ A₁ Yb gs₂ lg₁

trisome #2

Chromosome 3:

a₁ lg₂ Dt/?a₁ Dt/?a₁ +/na +/lg₂ +/ts₄ x a₁ na +/lg₂ +/ts₂a₁ lg₂ d₁ x A₁ lg₂ d₁ ts₄a₁ lg₂ ra₂a₁ yt seg. naa₁ ts₄ +/na Dt/? x a₁ +/ts₄ na Dt/? Trisome #3a₁ na cr gl₁ v₅ Ya₁ Dt/? seg. lg₂A₁ lg₂ +/d₁ x A₁ lg₂ ts₄ d₁a₁ lg₂ Dt/? y₁ seg. nana ts₄ x na +/ts₄

Chromosome 4:

(su₁ x d_H) x (Tu su₁ x d_H)su^{am} du(+/w₄ +/su₁)self(Ts₅ su₁ x w₁)self(Ts₅ su₁ x la) x la su₁(gl₃ x su₁ j₂)self(Ga x su₁)self(su₁ gl₃ x w₁)self(Ts₅ su₁ x la su₁)self

Trisome #4

Chromosome 5:

Homo. A₁ C R a₂ bt bv pr₁v₂ a₂ A₁ C R b pl

Trisome #5

Homo. A₁ C R a₂ bt bv pr₁ seg. v₂Homo. A₁ C R A₂ bt bv pr₁

Chromosome 6:

Pl sm +/py A b x Pl py A b

Y₁ Pl sm seg. pyPl sm x pb_x(Lebedeff)

Chromosome 7:

Inbred x ra₁ gl₁ ij bl_xra₁ gl₁ ij x gl₁ ij fr₁ +/fr₂v₅ gl₁ Tp seg. ra₁ tpra₁ gl₁ v₅ x Tp gl₁ v₅ra₁ gl₁ ij x bd₁ra₁ gl₁ ij(bd₁ x gl₁ ij) x gl₁ ij bd₁

Trisome #7

Chromosome 8:

 $v_{16} ms_8 j_1 \times (ms_8 j_1 \times v_{16})$
 $ms_8 \times ms_8/+$
 $ms_8 j_1 \times ms_8/+ j_1$

Trisome #8

Chromosome 9:

Inbred I \times $g_4 wx$
 $g_4 wx \times (g_{14} \times y_{g_2} c sh wx)$
 $au_1 au_2 sh$
 $wx da ar sa_1$

Trisome #9

Inbred I \times ar wx

c sh wx bp

 $ms_2 \times ms_2/+$
 $(g_{14} \times y_{g_2} c sh wx)self$

Chromosome 10:

 $r zb_5 seg. nl_1$
 $Og/+ Y P^{WR}$
Inbred \times OgOg
 $r A_1 C y_1 seg. g_1$
 $l_1 seg. w_1$

Og Og

seg. l_1

Trisome #10

2. Miscellaneous

U. S. 204 (Inbred I)

Inbred I \times bm_3
 $A_1 C R Pl B Y_1 a_2$
 $g_2 A_1 b Pl$
seg. v_{12} v_{13}
 $va_2 \times va_2/+$
 $wa \times wa/+$
 $ms_5 \times ms_5/+$
 $ms_6 \times ms_6/+$
 $ms_7 \times ms_7/+$
 $ms_9 \times ms_9/+$
 $ms_{10} \times ms_{10}/+$
 $ms_{12} \times ms_{12}/+$

West Branch (Inbred II)

seg. hf

 $Kn A_1 +/b Pl \times A_1 +/b Pl$
 $A_1 C R A_2 Pr_1$
 $(bm_3 \times y_{g_3})self$
 $A_1 C R A_2 pr_1 i$
 $Vg/+ \times vg$
 $an_2 \times$ Inbred

 $+/na_2 \times na_2$
 $r pr_1 \times A_1 C R^{st} B$
 $A_1 B pl R^{st} \times r pr_1$
 $+/bk_1 \times bk_2$
 $(+/bk_1)self$
 $+/de +/mi \times de mi$

ms ₁₃ x ms ₁₃ /+	+/an ₂ x +/an ₂
ms ₁₄ x ms ₁₄ /+	Inbred x mi
ms ₃₇ x ms ₃₇ /+	Wc Y ₁
ms ₃₉ x ms ₃₉ /+	f _x (Wiggans)
ms ₄₂ x ms ₄₂ /+	de _a "
v ₁₂ x v ₁₂ pr ₁	de _b "
seg. gl ₁₀	de _c "
(sb x A ₁ b pl +/y ₁ su ₂)sib	co "
y ₁ su ₂ seg sb	ws _x "
pb ₄	Chlorophyll types-
S _x	Yellowish green
sy	rather lt. green
Pc _x	medium to lt. green
Ch/? seg. gl ₁	dark green
Ts ₃ /+ v ₄ /+ x Rg/+	nl ₂
Ts ₃ /+ v ₄ /+ x R gl C sh wx	gc ₂

Seed stocks from Australia grown by Shafer in Calif. for the Co-op:

3 different stocks of yellow-striped seedling.

5 different stocks of virescent seedling.

crinkly.

3. Stocks too late to mature at Ithaca.

From Krug:

brown pericarp	black pericarp
branched ear	seg. tassel seed
seg. dwarf	bract in tassel
oily spots	seg. defective endosperm
seg. mealy	rolled leaf
variegated pericarp	semi-dwarf
ragged	striped leaves
seg. zebra seedling	ms x ms/+
crinkly	zebra leaves

From Mangelsdorf

mottled dwarf

seg. vp_x

4. No germination.

sr an₁ bm₂

J_{33a} x A c R sh wx B Pl

da au₁ au₂ sh

+/v₁₅ x +/v₁₅

ms₄ x ms₄/+

ms₁₅ x ms₁₅/+

ms₂₇ x ms₂₇/+

g₄ ar sa₁ pk₁

III. Seed Stocks Received For Propagation in 1938

1. J. Shafer, Ithaca, N. Y.:—

v₁₉

T 1-2b x T 1-2b

T 2-4b

2. R. A. Brink, Madison, Wisconsin:—

(pm x lg₂ d₁) sib

(A₁ pm x a₁ lg₂) sib

3. J. H. Kempton, Washington, D. C.:—

fs

4. A. Tavcar, Zagreb, Yugoslavia:—

Hs

5. M. M. Rhoades, Arlington, Virginia:—

(ws₃ lg₁ B A₁ pl x gl₂) x (ws₃ lg₁ b A₁ pl x gl₂)

6. W. R. Singleton, New Haven, Connecticut:—

ra₂?

zb_x f x ys

su₁ x +/lo

+/ba_x

v₅?

gl₃ v₄ x lg₁ gl₂ b v₄ r^gACYSu

yellow x yellow

ys_x (7 cultures)

7. R. G. Wiggans, Ithaca, N. Y.:—

de_c

Pu_x

f_x

IV. Miscellaneous Co-op Items

1. Seed stock inventory. In March, 1937, an inventory of the genetic seed stocks in the Co-op collection showed that 148 of the genes reported in the Linkage Summary, 1935, were not in the seed trays here. A list of those 148 genes was included in the News Letter, March 23, '37, and several maize geneticists responded by sending in 16 genetic stocks.

In January, 1938, personal requests were sent to each of the 25 geneticists who, collectively, had first reported the remaining 132 stocks. We have learned that about 75% of those genes have been lost due to inviability of seed stocks.

2. Assignment of linkage groups. One of the topics discussed at a special meeting of maize geneticists at the A A A S meetings in Indianapolis, was the problem of linking workable genes and developing more desirable tester stocks. This is an important question because there are more than 50 suitable genes that haven't been linked and some of the chromosomes are poorly marked.

The plan previously outlined for linking new genes has not been fundamentally changed, but it may well be reviewed here. Each of the ten linkage groups in maize has been assigned to one, or more, cooperator who is charged with testing unplaced characters with his particular chromosome and building up suitable tester stocks. The following assignments have been made:

- Chromosome 1. Emerson.
- Chromosome 2. Rhoades and Clokey.
- Chromosome 3. Brink and Woodworth.
- Chromosome 4. Singleton and Brunson.
- Chromosome 5. Burnham.
- Chromosome 6. Stadler and Lebedeff.
- Chromosome 7. Jenkins and Fraser.
- Chromosome 8. Sprague and Perry.
- Chromosome 9. Eyster and Shafer.
- Chromosome 10. Lindstrom, Wentz, and Bryan.

When a new gene is found, a few seeds involving it should be sent to the secretary of the Maize Genetics Cooperation who will grow them in an increase block and obtain a liberal supply of seed for the central repository. Then the secretary will send a few seeds to each of the above geneticists who will test for linkage in his particular chromosome.

This system has been devised not to limit the number of workers who are trying to link new genes, but rather to insure the linkage of every workable gene.

3. More vigorous genetic stocks. During the summers of 1935 and 1936, a number of maize geneticists tested a group of inbred strains for disease resistance and general desirability. The two inbreds, U.S. #204 and West Branch Sweepstakes, seemed best suited to Ithaca conditions and have been selected for use in the Co-op. They have been designated as Inbred I and Inbred II, respectively, and are being used in crosses with weak genetic stocks to increase vigor and, by repeated backcrossing of the segregates to the

inbreds, to obtain a more nearly homozygous chromosome complement. Later, the segregates from each inbred line may be crossed to get hybrid vigor.

Last summer 17 genetic stocks were crossed with both Inbred I and Inbred II.

4. Linkage maps. The linkage maps attached to this Letter were prepared from the data in the Linkage Summary and the data which appeared in the Co-op News Letters since the Linkage Summary was published.

Sincerely yours,

D. G. Langham

D. G. Langham
Secretary

V. Gene Index of Co-op News Letters

This gene index of the Co-op News Letters was made so that the information in the Letters which might be of value in connection with linkage studies could be more readily found. It includes mainly those genes about which some statement of linkage has been made in the Letters, and does not include those that are merely mentioned without any supplementary information. John Shafer.

- a₁:
- 1-25-34, p. 5
(January 25, 1934, page 5)
 - 11-24-34, pp. 13, 18, 11
 - 1-23-33, pp. 3, 6
 - 3-6-35, p. 3
 - 3-4-36, pp. 7, 10, 11
 - 3-23-37, pp. 8, 13, 14
 - 3-6-38, pp. 8, 15
- a₂:
- 12-18-33, p. 5
 - 1-25-34, p. 6
 - 11-24-34, pp. 2, 14
 - 1-23-33, p. 6
 - 3-4-36, pp. 7, 17
 - 3-6-38, pp. 9, 15
- a₃:
- 11-24-34, p. 10
- ad₁:
- 1-23-33, p. 6
 - 1-25-34, p. 4
 - 3-6-35, pp. 3, 15
 - 3-4-36, p. 9
 - 3-6-38, pp. 6, 11, 14
- ad₂ (= ad₁):
- 3-6-35, p. 3
- ad₂ (first called ad₃):
- 3-6-35, pp. 3, 15
- ad₃ (now ad₂):
- 3-6-35, p. 3
- ag (=ij):
- 12-18-33, p. 6
 - 9-13-34, p. 8
 - 1-23-33, p. 6
- al:
- 12-18-33, pp. 3, 5
 - 1-23-33, pp. 3, 6
 - 3-6-35, pp. 3, 5
 - 3-4-36, pp. 15, 16
 - 3-23-37, pp. 8, 15
- an:
- 1-25-34, p. 4
 - 11-24-34, p. 5
 - 1-23-33, p. 6
 - 3-6-35, p. 1
 - 3-36-38, pp. 6, 11, 14
- ar_a:
- 9-13-34, p. 2
- ar:
- 12-18-33, p. 2
 - 1-25-34, p. 8
 - 1-23-33, p. 3
 - 3-6-38, p. 16
- as:
- 1-23-33, p. 6
- an₁:
- 12-18-33, p. 2
 - 1-25-34, p. 8
 - 1-23-33, p. 3
 - 3-6-38, p. 16

an₂:

1-25-34, p. 8
3-6-38, p. 16

B:

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1-25-34, p. 4
11-24-34, p. 5
1-23-33, pp. 3, 6
3-6-35, pp. 1, 3, 4
3-4-36, pp. 11, 15
3-23-37, pp. 14, 15
3-6-38, pp. 6, 7, 8, 10, 11, 13, 14

ba₁:

1-25-34, p. 5
11-24-34, p. 13
1-23-33, p. 3

ba₂:

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1-23-33, p. 6
3-23-37, p. 1

bd:

9-13-34, pp. 6, 8
11-24-34, p. 10
3-4-36, pp. 7, 16
3-23-37, pp. 1, 9
3-6-38, p. 15

be (=bd):

9-13-34, p. 8

Bh:

1-25-34, p. 6
1-23-33, p. 6

bk₁:

3-23-37, p. 1

bm₁:

12-18-33, pp. 2, 5
1-25-34, p. 6
11-24-34, pp. 2, 4, 5, 6, 7
1-23-33, pp. 3, 6

bm₁ (con't.):

3-6-35, pp. 1, 4, 9, 10, 11
3-4-36, pp. 3, 7
3-6-38, p. 9

bm₂:

1-25-34, p. 4
11-24-34, p. 5
1-23-33, pp. 3, 6
3-6-35, pp. 1, 3
3-4-36, p. 10
3-23-37, pp. 3, 5
3-6-38, pp. 1, 5, 6, 14

bm₃:

12-18-33, p. 5
11-24-34, p. 6

Bn₁:

1-25-34, p. 7
11-24-34, pp. 6, 7
1-23-33, pp. 3, 7
3-4-36, p. 7

bn₂:

9-13-34, p. 8

bp:

1-25-34, p. 8
1-23-33, p. 7
3-6-38, p. 16

br:

1-25-34, p. 4
11-24-34, p. 5
1-23-33, pp. 3, 7
3-6-35, p. 3
3-4-36, p. 10
3-23-37, pp. 1, 2, 5
3-6-38, pp. 1, 5, 6, 9, 14

bt₁:

12-18-33, pp. 3, 5
1-25-34, p. 6
11-24-34, pp. 2, 4, 4, 6
1-23-33, p. 7
3-6-35, p. 3

bt₁ (con't):

3-4-36, pp. 7, 14
 3-23-37, p. 10
 3-6-38, pp. 9, 15

bt₄(= bt₁):

3-6-35, p. 3

bv:

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 1-25-34, p. 6
 11-24-34, p. 4
 1-23-33, p. 7
 3-6-38, p. 15

c:

12-18-33, pp. 2, 6
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 9-13-34, p. 8
 1-23-33, pp. 3, 7
 3-6-35, pp. 12, 14
 3-4-36, pp. 11, 15
 3-6-38, p. 16

cb:

1-23-33, p. 7

Ch:

12-18-33, p. 3
 11-24-34, pp. 6, 7
 3-4-36, pp. 3, 17
 3-23-37, p. 5
 3-6-38, p. 6

co:

3-6-35, p. 15

cr₁:

1-25-34, p. 5
 1-23-33, pp. 3, 7
 3-4-36, p. 7
 3-23-37, p. 14
 3-6-38, pp. 8, 15

cr₂:

1-23-33, p. 7

d_a:

9-13-34, p. 2

d_b:

9-13-34, p. 2

d_H:

3-6-38, p. 15

d₇:

3-23-37

d₁:

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 11-24-34, p. 12
 1-23-33, p. 7
 3-6-35, p. 5
 3-4-36, p. 9
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d₂:

12-18-33, p. 1
 1-25-34, p. 5

d₃:

1-25-34, p. 8
 1-23-33, p. 7

d₅:

1-23-33, p. 7

d₆:

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~~3-6-35~~, p. 1
~~3-23-37~~, pp. 1, 2, 3, 9
~~3-6-38~~, pp. 9, 10

ts₄:

~~1-23-33~~, p. 14

ts₄ (con't.):

~~1-25-34~~, p. 5
~~11-24-34~~, p. 11
~~3-6-35~~, p. 3
~~3-4-36~~, p. 10
~~3-6-38~~, p. 15

Ts₅:

~~1-23-33~~, p. 14
~~1-25-34~~, p. 5
~~11-24-34~~, p. 8
~~3-6-35~~, p. 1
~~3-23-37~~, p. 6
~~3-6-38~~, p. 15

Ts₆:

~~3-23-37~~, p. 6

Tu:

~~1-23-33~~, pp. 3, 14
~~12-18-33~~, pp. 5, 6
~~1-25-34~~, p. 5
~~11-24-34~~, pp. 8, 10
~~3-6-35~~, pp. 1, 2, 3
~~3-23-37~~, p. 14
~~3-6-38~~, pp. 2, 4, 15

va:

~~9-13-34~~, p. 3

v₁:

~~1-23-33~~, p. 14
~~12-18-33~~, pp. 2, 6
~~1-25-34~~, p. 8
~~3-4-36~~, p. 3

v₂:

~~1-23-33~~, pp. 3, 14
~~12-18-33~~, p. 5
~~1-25-34~~, p. 6
~~11-24-34~~, pp. 2, 6, 7
~~3-6-35~~, p. 1
~~3-4-36~~, p. 7
~~3-6-38~~, p. 15

v₃:

1-23-33, p. 14
 1-25-34, p. 6
 11-24-34, p. 4
 3-4-36, p. 7

v₄:

1-23-33, pp. 3, 14
 1-25-34, p. 4
 3-6-35, pp. 1, 4
 3-4-36, pp. 11, 15, 17
 3-6-38, pp. 6, 7, 14

v₅:

1-23-33, pp. 3, 14
 12-18-33, pp. 2, 5
 1-25-34, p. 7
 11-24-34, pp. 7, 18
 3-6-35, p. 1
 3-4-36, pp. 9, 16
 3-23-37, p. 4
 3-6-38, p. 15

v₆:

1-23-33, p. 14
 1-25-34, p. 6

v₇:

1-23-33, p. 14
 1-25-34, p. 6

v₈:

1-23-33, p. 14

v₁₀:

3-23-37, p. 7
 3-6-38, p. 9

v₁₂:

1-23-33, p. 14
 1-25-34, p. 6
 3-4-36, p. 7
 3-23-37, p. 10

v₁₄(=v_{g2}):

1-23-33, p. 14

v₁₅:

1-23-33, p. 14
 1-25-34, p. 8

v₁₆:

3-23-37, p. 7
 3-6-38, pp. 2, 15

v₁₈:

1-23-33, p. 15

v₂₀:

1-23-33, p. 15

v₂₁ (=v₁₆):

3-4-36, p. 17
 3-23-37, p. 7

va₁:

1-23-33, p. 15
 1-25-34, p. 7

vp₁:

1-23-33, p. 15

vp₂:

1-23-33, p. 15
 11-24-34, pp. 6, 7
 3-6-35, p. 10

vp₃:

1-25-34, p. 5

vp₄:

1-23-33, p. 15
 3-6-35, p. 13

w₁:

1-23-33, p. 15
 3-6-38, pp. 12, 13

w₂:

1-23-33, p. 15

w₄(=v₁₂?):

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 3-4-36, p. 3
 3-23-37, pp. 6, 15

w₅:

1-23-33, p. 15

w₆:

1-23-33, p. 15

w₁₁:

1-23-33, p. 15
 1-25-34, p. 8

w₁₂:

9-13-34, p. 9

w_h:

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w_l:

1-23-33, p. 15
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w_{s3}:

11-24-34, p. 2
 3-6-35, p. 2
 3-23-37, pp. 7, 8
 3-6-38, pp. 8, 9

w_x:

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 1-25-34, p. 8
 9-13-34, p. 8
 3-6-35, pp. 4, 12, 13, 14
 3-4-36, pp. 3, 10, 11
 3-23-37, pp. 7, 10, 11, 14
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xn₁:

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Y_x(=Y₃):

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 3-4-36, p. 16

Y₁:

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Y₄:

3-4-36, p. 9

yd:

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yf:

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Y_G?

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Y_{Ga}:

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Y_{G1}:

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Y_{G2}(=v₁₄):

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 12-18-33, p. 2
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 3-6-38, p. 16

y_{g3}:

12-18-33, p. 5

y_{s1}:

1-23-33, pp. 3, 16

12-18-33, p. 5

1-25-34, p. 6

11-24-34, pp. 2, 6, 7

3-4-36, p. 7

y_{s2}:

1-23-33, p. 16

yt:

1-23-33, p. 16

3-6-38, p. 15

z_{b4}:

3-6-38, p. 1

z_{b5}:

11-24-34, p. 1

3-6-38, p. 16

z_{b6}:

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z (=z_{g1}):

1-23-33, p. 16

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z_{g1} (=z_{g2}):

1-23-33, p. 16

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z_{g2} (=z_{g3}):

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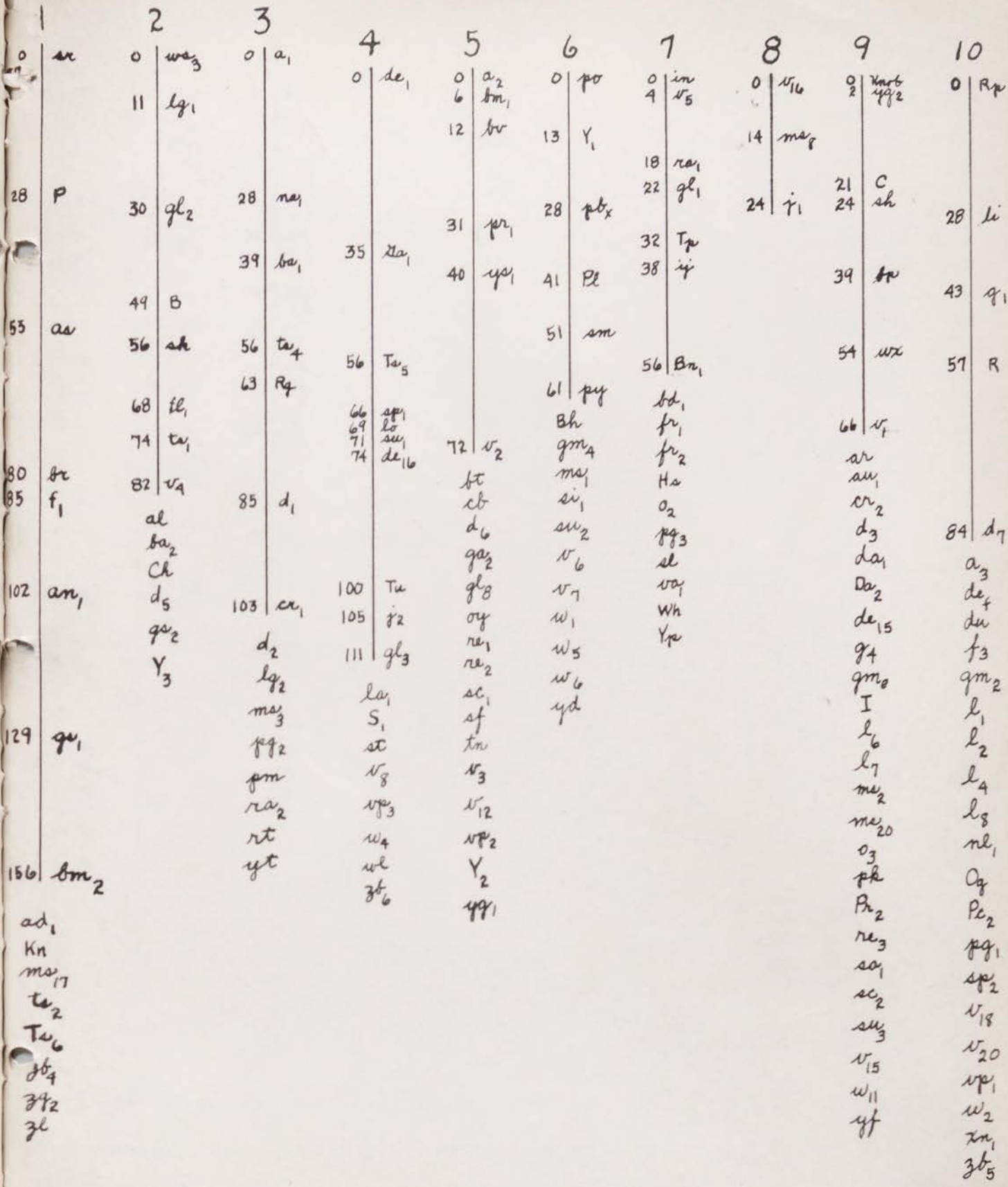
z_{g3}:

3-6-35, p. 3

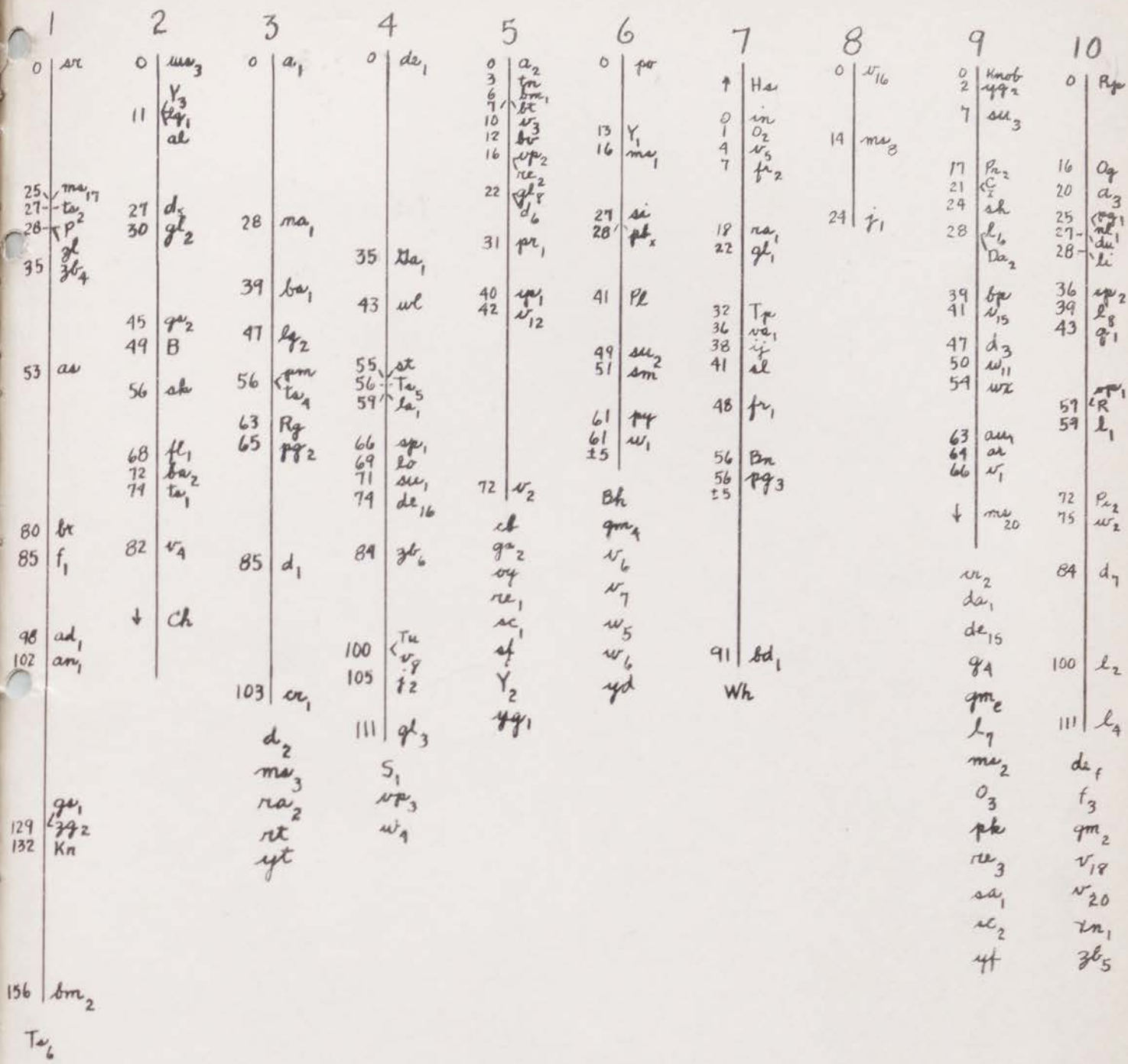
z₁:

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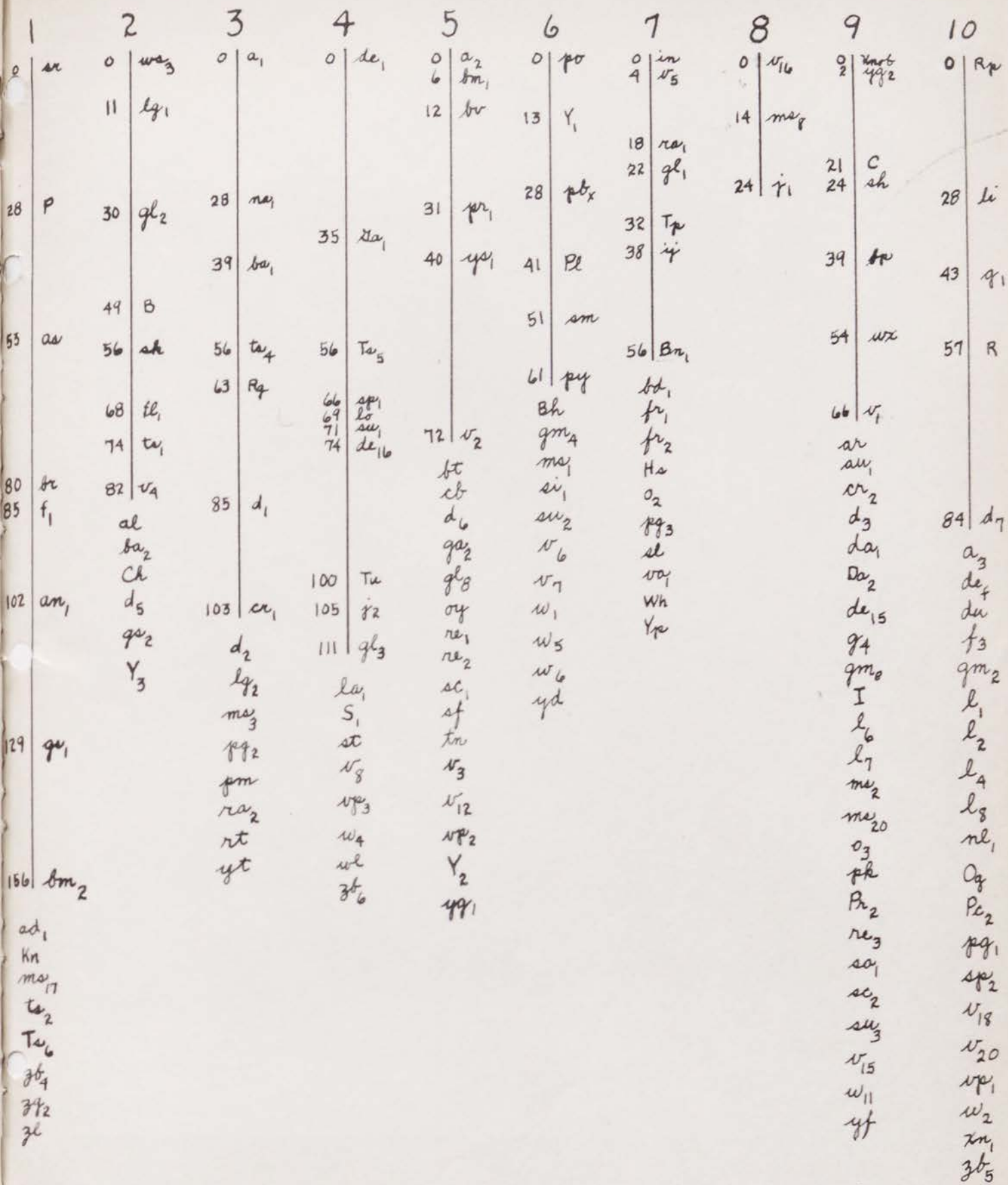
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Linkage map of the ten chromosomes of *Zea mays* showing the loci of those genes whose position can be determined with reasonable certainty.



Linkage map of the ten chromosomes of *Zea mays* showing the approximate loci of many genes. (Working map. More 3-point tests needed to establish exact loci of genes).



Linkage map of the ten chromosomes of *Zea mays* showing the loci of those genes whose position can be determined with reasonable certainty.