From a practical point of view this lack of correlation is of special interest. It simply means that it is not possible to judge the quality and value of the plants from the quality of the seed they produce. This might seem very discouraging at first glance, but as a matter of fact it is really quite the contrary. Thus it must serve to induce the plant breeder to produce strains which are not only of superior quality, but which can also easily be checked by means of distinct morphological characters possessed by their seed.

The possibility of fixing the different seed characters by breeding.—It is evident that only conclusions of probability as to the hereditary quality of the different seed characters can be made from the observations of the past summer on the said seed types. Whether or not such characters as color, shape, etc., can be hereditarily transmitted to the progeny, is a question that can be solved only by direct experiments. Very few experiments in the said respect have been carried out up to the present time. Martinet* has made a few observations which seem to indicate that the color of clover seed is a hereditary unit. He concludes: "Dans douze plantes egrenées en 1900, 9 ont reproduit des graines de même nuance et 3 seulement des graines de coloration mixte; sur les 26 plantes observées en 1902, 23 présentent une coloration des graines semblable à la plante mère, tandis que 3 plantes seulement ont donné des graines d'une autre nuance."

The practical meaning of these observations of Martinet's is likely that it might be possible to produce, by proper breeding, varieties of clover with a special color of seed, and there is very little doubt that it will also be possible to fix the other seed characters by breeding so as to obtain strains having a certain distinct type of seed.

THE ORIGIN OF AN EARLY VARIETY OF MATTHIOLA BY MUTATION

H. B. FROST

Ithaca, N. Y.

Two problems, primarily, interest the breeder of plants or animals. One, that of the transmission of characters, is far on the way to solution in detail, a solution at least proximate and practically usable. The other, that of the origin of new characteristics, has been restated for us by Mendelism and the related theories, which have sharply challenged the old hypothesis of gradual hereditary change.

* *Annuaire agricole de la Suisse*, 1903.

Only extended experimentation under carefully controlled conditions can with reasonable certainty prove or disprove the absolute stability of genotypes in the absence of crossing. Mutation, or the apparent sudden origin of new genotypes, is plainly a widespread phenomenon, but its significance, especially in relation to "progressive" variation, is still in question. The mutative origin of types showing normal development and vigor, and the behavior of these types when crossed with the parental form, are matters of especial interest.

It is probably easy to attach too much importance to the appearance of "degenerate" mutants. If mutation consists of a qualitative change in a definite hereditary substance, it is to be expected that the resulting form will often be biologically inferior, under certain conditions or under any possible conditions, to the parental form. We should consider it probable that many such changes even produce non-viable gametes or zygotes, i.e., types of gametic constitution that either preclude any formation of zygotes or insure early cessation of development through lack of adjustment to the conditions of life. Bateson and Saunders suggested^a in 1902 that there may be biotypes incapable of development to maturity as homozygotes, and the prediction has been verified in the case of certain chlorotic forms. We are not yet justified in assuming that the general nature of the unknown mutative process in such cases differs from that which prevails where "normal" biotypes result.

Further, if a mutant form differs only slightly from the parental type, the occurrence of the mutation may defy detection by the most refined and laborious methods. Some bizarre mutants are to be expected, and these are readily found, while "normal" mutants, if they occur, must often fail of detection.

The evidence tends more and more to prove that there is genetic continuity of the chromosomes, and that a full haploid complement of chromosomes is necessary to development. Further, a mutant type and its parent form, and related forms in general, commonly agree in their number of chromosomes. All this tends to make it more probable that mutation usually, at least, depends upon a change in the nature of an essential substance or substances, perhaps in the essential constitution of one or more chromosomes, rather than upon mere physical abnormalities in mitosis.

In the writer's cultures of ten-weeks stock (*Matthiola*), a remarkable series of variant types has appeared. Some of these forms have

^a *Evol. Com. Roy. Soc., Report 1, p. 133.*

occurred repeatedly among the progeny of ordinary plants, and in several lines of descent, always in very small numbers. Four at least of these forms definitely transmit the new character to part of their progeny, the rest of their progeny conforming to the usual type of the variety. Apparently the mutating germ-cell usually meets a normal one, forming a heterozygote, and segregation takes place when this hybrid mutant forms its gametes.

The extracted "normals" are evidently pure, but in three cases out of the four the dominant mutant type falls far short, in unselected cultures, of the expected 75 per cent, and pure dominants are rare or absent. In one case there is apparently partial gametic coupling with singleness and doubleness, which would partially explain the deficiency; in one case *two* new factors are perhaps concerned, but usually with a great excess of normals; in a third case, there may be simply severe selective elimination of the weak-growing mutant type during embryonic development.

In the remaining case, of the four mentioned, the second generation indicates that the plants of the first generation were the progeny of a monohybrid, with an approximation to the ordinary ratio. The original mutant, an early dwarf plant, is WG9-C10 of Chart 1 in the writer's paper in A. B. A. Report 6, which shows that the progeny of this plant had a lower average number of main-stem internodes than the progeny of any other parent tested. Means for time of flowering show a similar though less marked tendency to earliness. The real condition of the progeny of the mutant, however, is shown much better by the actual frequency-distributions for number of internodes and time of flowering, as presented in tables 1 and 2 herewith. Part of the progeny are early, with few nodes, and part are ordinary. The variability is evidently greatly increased, and the distribution plainly suggests that WG9-C10 was a monohybrid, the ordinary type of the variety being recessive.

All the singles of this generation were tested in 1910-11, in comparison with plants of the same and another line but of ordinary ancestry, and apparently conclusive evidence was obtained that WG9-C10 was a monohybrid, earliness (and the correlated few-nodedness) being definitely and perhaps almost completely dominant. Fifteen-seed cultures from selected parents, with germination usually perfect,^b were grown in the greenhouse under fairly uniform conditions,

^b Because of lack of space, one plant of each lot was not repotted, and is not included here. The results, however, are not prejudiced, since the plants were selected by number; No. 5 or No. 10, whichever was at the back of the bench in the rows of 10 pots each, was always omitted.

TABLE 1.—*Matthiola*, 1908-09. Frequency distributions for number of internodes below first flower.¹

P ₁	Singles.						Doubles.					
	House C.		House M.		House W.		House C.		House M.		House W.	
	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.
<i>Internodes</i>												
16	1											
17												
18												
19	1											
20	1						1					
21			2									
22			1				1		1			
23									1			
24							9					
25	1	2	1	1			2	25				
26								29		1		
27	1	7		1			1	22		2		
28		17						6		9	1	
29		24		1						14		
30		13		1				1	2	22		1
31		8		2						27		
32		2		7						5		
33		1		15	1					3		
34			1	16						4		1
35		2		19	1							5
36				4	1				1			6
37				1	1							8
38				8								5
39				3								13
40				1								6
41			1	1								8
42		1			1							6
43						1						12
44												9
45					1							6
46						4						3
47						3						3
48						4						
49					1	3						1
50						6						
51					1	3						2
52						10						1
53						6						
54						2						2
55					1	3						
56						7						1
57						8						
58						1						
59						1						1
60						3						
61												
62						1						

¹ The distributions given in tables 1 and 2 are those from which were calculated part of the statistical constants presented in the writer's paper in A. B. A. Report No. 6, except that the progeny of WG9-C10 are here given separately from the rest. The letter "G" in "WG9" refers to a soil factor in the first year's cultures.

TABLE 2.—*Matthiola*, 1908-09. Frequency distributions for number of days to flowering.¹

P ₁	Singles.						Doubles.					
	House C.		House M.		House W.		House C.		House M.		House W.	
	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.
Days. ²												
110			1									
111			1									
112												
113												
114												
115												
116				1					1			
117					1							
118			1	2								
119				3								
120	1			4								
121			1	2						1		1
122				3								2
123				8	1				1	1		2
124			1	4								2
125				7	1				5		1	3
126				16					7			7
127				3	1	2			9			2
128				4		3			8			5
129				7	1	4			8			7
130				1	1	3			12			4
131		1		2		4			2	12		3
132	1			1		2				7		8
133	1			1	1					4		7
134	1	2		2		1			2			7
135		4		4		4			6			6
136			1	1		3	1					4
137		7		2		3		3		1		2
138		10		1		9		4		1		1
139		18		1	1	2		8		1		3
140	1	7		1		4		13				3
141		10				1	1	9		1		3
142		4				6		15		1		1
143		4			1	5	2	10				2
144		4				2		9				2
145						3		6				3
146							1	5				2
147								4				
148					2			1				1
149					2			1				
150		1			1			2				
151		1						1				1
152												2

¹ From time of planting to time of emergence of corolla of earliest flower from calyx. See A. B. A. Report, vol. 6, p. 386. The means given in vol. 6 for time of flowering were calculated from the times of observation (i.e., from the upper class limits), without correction for this fact, and therefore are uniformly too high by one-half day.

² To time of observation (upper class limit).

TABLE 2.—Continued.

P ₁	Singles.						Doubles.					
	House C.		House M.		House W.		House C.		House M.		House W.	
	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.	WG9-C10.	Rest.
<i>Days.</i> ¹												
153		1										1
154												
155		1						1				1
156												
157												
158												
159												
160												
161												1
162												
163												
164												
165												
166												
167												1
168												
169												
170												
171												
172												
173		1										

¹ To time of observation (upper class limit).

and larger cultures from all parents in the field. Unfavorable weather conditions made the field results less definite than the others, and incapable of brief presentation; so figures will be given here only for the greenhouse.

The parents (from the mutant line) that were used for the greenhouse were selected as follows. The selection was based on number of internodes, and on earliness also where two plants had the same number of internodes. Three parents were taken for each of the three parental environments (cool, medium temperature, warm = "C," "M," "W," in pedigree numbers)—the plant with most nodes, the one with fewest, and an intermediate one.

Tables 3 and 4 show the frequency-distributions for number of internodes in the progeny-lots and table 5 gives the ordinary statistical constants corresponding to table 3. Plainly the three late or many-noded progeny of the supposed hybrid mutant were pure extracted recessives, and five of the rest were probably heterozygous, while one, WG9-C10-M4, seems to be a pure dominant.

TABLE 3.—*Matthiola*, 1910-11. Singles. Frequency distributions for number of internodes below first flower.¹

P ₁	WG9																				
P ₂	C1		C10			C5			C10			C9		C10			C9		C10	C10	Late.
P ₁	M3	M9	C2	C5	C1	M6	M9	M4	M2	M7	C3	C7	W6	W5	W10	M5	M8	C10	Not Late.	Late.	Late.
Inter-nodes.																					
16														1					1		
17			1	1									1						3		
18			1					2					1	1					5		
19			2	1				2	1				2	2					10		
20			1	1				1					1						4		
21														1	1			1	2	1	
22									1				1					1	3		
23				1									1						2		
24			1					1						1					3		
25									1										1		
26		1							2			1					1		2		3
27							1				1			1			2		1		4
28						2			1		2				1	3	2		1	1	9
29		4	1	1	6	3	2			2	4	3	1		1	2	1		3	9	19
30	1		1			2					2					1	1	1	2		7
31	2	3		2			1			1					2				2	3	6
32	1				1															1	1
33																					
34	1																				1
35	1																				1
36													1								1
37																					
38		1																			1
39																					
40																					
41																					
42																					
43																					
44																					
45																					
46																					
47																					
48																					
49	1				1															1	1

¹ The plants of all progeny-lots reported in tables 3 and 4 stood on the same bench in the greenhouse in the order here given, all lots but the last given constituting together one solid block of plants. Under the grandparent, WG9-C10 (P₂ generation), its early progeny used as parent is always at the left, and its late progeny at the right in Tables 3 and 4.

In the three columns at the right in tables 3 and 4, the progeny-lots are combined. The correspondence of the distribution of the extracted late or many-noded progeny with that of the lates of ordinary ancestry is surprisingly close, when the smallness of the numbers is considered.

TABLE 4.—*Matthiola*, 1910-11. Doubles. Frequency distributions for number of internodes below first flower.

P ₁		WG9																				
P ₂	C1		C10				C5			C10			C9		C10			C9		C10	C10	Late.
P ₁	M3	M9	C2	C5	C1	M6	M9	M4	M2	M7	C3	C7	W6	W5	W10	M5	M8	C10	Not Late.	Late.	Late.	
Inter-nodes.																						
14													1							1		
15														3						3		
16									2					1					1	4		
17								2	2										2	6		
18			1					3					1							5		
19				1				1						1						3		
20														1						1		
21								1									1		3	4		1
22			1	1	1			1	1		1							1	2	6	1	2
23										1					1				1	1	1	1
24			2										1				1		3			1
25	1			2	1		1		1	2	2	1	1		1		1	2	2	6	4	9
26		2			3	2	7		1	1	1	5			3	1	1		1	7	19	
27	2	2		1	2	4	1		1	5	1	2			3	3			2	10	15	
28	1		1			1														1		2
29	1			1																1		1
30															1					1		
31																						
32	1																					1
33			1																	1		
34										1											1	
35																						
36																						
37																						
38																						
39		1					1															2

These very small-scale results are confirmed by study in the field of larger lots, usually of from 70 to 80 plants each, of progeny of all but one of the first-generation singles. The habit of the plants in the field made accurate determination of the number of internodes evidently impracticable, but observation of the time of flowering leads to the conclusion that the following classification of the parents is probably correct:

Class.	Cool house.	Medium house.	Warm house.	Total.
Pure early.....	0	3	1	4
Heterozygous.....	3	1	5	9
Pure late.....	2	2	3	7

There is practically no doubt about the number of pure late parents, unless possibly one more should be classed here, but there is some uncertainty with reference to the separation of the other two classes.

It is interesting to note that the only apparent mutant, of those so far tested, to give this regular result, is also the only one that seems to differ from the parent variety only in size and earliness; the others differ in leaf-characters, and are usually deficient in vigor. The case is also of special interest as an instance of apparently nearly complete dominance of a size-character, and as showing dominance of dwarfness over tallness.

East^c reports for *Nicotiana*, and East and Hayes^c for maize, that various "abnormal" mutant types have proved dominant to the parental form. The results of the writer are entirely in agreement with these on this point, as no mutant yet tested has proved to be a pure recessive. Possibly the factorial basis is not always simple, if indeed normal segregation occurs at all, but no hypothesis of *absence*

TABLE 5.—*Statistical constants for distributions given in Table 3.*¹

Parents	n	Mean	Standard deviation	Coefficient of variability
"Pure-bred" late.....	53	29.434 $\pm$ 0.205	2.215 $\pm$ 0.145	7.525 $\pm$ 0.496
Extracted late.....	15	29.000 $\pm$ 0.417	2.394 $\pm$ 0.295	8.257 $\pm$ 1.024
Early (simplex and duplex)....	42	21.929 $\pm$ 0.450	4.328 $\pm$ 0.319	19.738 $\pm$ 1.508

¹ Omitting the two variates at 49, and also all the progeny of WG9-C10-C10, which, with part of its progeny, belonged to another "mutant" type as well, and thus might introduce other factors of genetic internode-variation if included.

of factors seems adequate, at least unless absence in *one* gamete profoundly modifies the resulting zygote.

With two or three of these forms, low general vigor, small seed-production, and to some extent poor germination of the seed produced are associated with the aberrant ratios. Perhaps the mutant character is regularly carried by half the gametes but undergoes selective elimination, either while within the ovary or later, because of the low vigor of the mutant form. Field cultures, with a relatively low rate of germination, have given evidence of a high rate of selective elimination of three of these types at or soon after germination. This suggests that the percentage of mutants in the general population may be much below the percentage of mutating gametes.

The early mutant was apparently unique among about 151^d

^c Conn. Agr. Exp. Sta. (New Haven) Bulletin 167, p. 135.

^d One hundred and sixteen of these absolutely unselected, except for the rejection of one diseased plant that probably would have died in any case.

progeny of plant WG9; this fact and the apparently simple (monohybrid) dominant inheritance of the character seem to preclude explanation on the basis of heterozygosis of WG9. The flowers of this plant were not bagged, but the only other single-flowering plants in the same house have given progeny usually normal, and there is no evidence, with the possible exception of the case of one double, that the early character has appeared at all in the cultures aside from WG9-C10 and its progeny. We evidently have a new dominant character arising *de novo*—and this a character of possible practical value, since the new type flowered much more successfully than the parental type during the hot dry summer of 1911.

These results have some bearing on the question of the possible value in breeding of non-economic morphological characters correlated with characters of practical value. The early type differs more decidedly from the ordinary type of the variety in the number of internodes than it does in earliness, and the former feature is, at least with normally developed plants, much the easier to determine with accuracy. A single examination of the mature plants for number of internodes is evidently of more value than flowering data requiring frequent examinations for several weeks.

INHERITANCE OF MAMMÆ IN SWINE

E. N. WENTWORTH

Ames, Iowa

So many theories and misconceptions are prevalent in regard to the inheritance of mammæ in swine, the functioning of the same, and the relation of functional mammæ to the number of pigs, that a careful investigation should prove of lasting benefit. The practical value of the same since the discovery of the effect of ration on functional mammæ is most important.

It has long been believed by most farmers that only as many mammæ function as there are pigs in the litter, and it has also been believed by some that a sow will not have a numerically larger litter than she has nipples. In order to investigate these points, and allied questions, records on 31 gilts with their living pigs were taken. The boar which was the sire of all the litters had 11 nipples, the following pattern being present: the forward pair were located under the last rib, the odd teat was next, then the 4 remaining pairs occurred in normal position. As a matter of interest it may be well to note that in every