AN EYELESS MUTANT IN *DROSOPHILA HYDEI*

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Received September 1, 1921

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INTRODUCTION

A new eye structure that shows marked variations in size depending upon the environmental conditions to which the culture is subjected, appeared in my stock of *Drosophila hydei* (Sturtevant) in 1917. Under certain conditions of temperature and moisture the eyes of this mutant stock appear as mere specks or are entirely missing, while the eyes of the same mutant stock under other conditions are very large, in fact indistinguishable from those of the wild type. Between these two extreme types all gradations appear. The mutant has been called "variable."

Cultures of variable subjected to warm dry conditions produce speck-eyed forms in large number; in fact the cultures at times become "pure" for speck eye. When the temperature at which the cultures are kept is reduced, the percentage of flies with large eyes increases. If the culture bottles are well supplied with moist food and kept at a temperature slightly below that of the living room the stock may appear "pure" for the wild-

type eye. Cultures kept in a fluctuating laboratory temperature, with food added at irregular intervals, give rise to a wide range from speck to normal-eyed forms with intermediate types. This was the condition under which we were studying the character for a long time after its origin, and until the key to the situation was found, the results of our crosses were most puzzling. By controlling the environmental conditions it can be demonstrated that variable is a recessive Mendelian character which seems to segregate freely from its normal allelomorph. Interest is added to this case since variable is linked with scarlet, another mutant obtained in this stock (HYDE 1915).

Before it became evident that the type of eye shown by the mutant depended upon certain environmental conditions, the results with the different crosses defied interpretation. Attempts to purify the stock by selection of the speck-eyed forms failed; for, after the process had been continued for some time and the stock bottles contained only speck-eyed flies, the next generation would apparently revert to the normal-type eye or give a range of eye sizes. The key to the situation was suggested by a comparison of the records covering a long period of time. The records showed that during the summer the speck condition of the eye was in evidence, while during the winter it was not so likely to appear. The result was explicable on the assumption that temperature was a determining factor in the realization of the character.

CONCERNING *Drosophila repleta* AND ALLIED SPECIES

It has become evident that the term *Drosophila repleta* includes more than a single species. In the American Naturalist for March 1915 STURTEVANT reported a new sex-linked mutant for *Drosophila repleta*. In the same number of the Naturalist I reported scarlet, a new mutant eye color for this same species (HYDE 1915). It is now certain that the *repleta* with which STURTEVANT worked and mine are two different species. They resemble each other so closely that despite the fact that I had bred both forms for a long time the difference was not discovered until many attempts at crossing had failed. Failure to cross is admitted to be sufficient ground for separating different species. Closer study has shown that the two differ also in certain morphological characters. In STURTEVANT'S type the lower side of the thorax including the basal segments of the legs is distinctly smoky in color, while in my type these parts are yellowish with the merest hint in some of a smoky color. In STURTEVANT'S type the yellowish segmental bands on the upper part of the abdomen are intersected by the alternating dark bands as they extend to the sides of the abdomen,

resulting in a demarkation on the side of the animal of a row of light spots. In my type these spots are only faintly in evidence. I have found STURTEVANT's type in New York and Baltimore, but not in Indiana. My type is very common about fruit stores and orchards in Indiana, but so far I have not found it in Baltimore. There is still another type of *Drosophila repleta* that differs from the two types under discussion. It is characterized by rather large light spots on the sides of the abdomen. I have taken it during two different summers in the open woods in Indiana. It is very hard to breed in captivity. There would seem then to be at least three or four different species of this fly passing under the name *Drosophila repleta*. I have found three light males, of STURTEVANT's mutant type taken at Arlington, Maryland, but have not as yet determined the inheritance of the character.

Since this was written STURTEVANT's catalog of the North American *Drosophilae* has appeared, in which these flies are described (STURTEVANT 1921). STURTEVANT's mutant is named *Drosophila repleta*. The mutant scarlet, previously reported and the "variable" of this paper belong to a new species called *Drosophila hydei*. The third form is probably a new species named by STURTEVANT, *D. mulleri*.

ORIGIN AND DESCRIPTION OF VARIABLE

Variable was first noted January 13, 1917, among the offspring from a cross of the mutant scarlet to wild stock in which the behavior of the mutant scarlet in back-crosses was to be tested (bottle 10, table III, Proceedings Indiana Academy 1917). In a total of about 100 flies, twenty were found with eyes that varied in size from mere specks (or in fact no eyes), to eyes of normal size and shape. Since both scarlet and wild-type eyes were similarly affected it is highly probable that these mutants do not represent the first mutation of the gene. It is impossible to state whether the change originated in the wild stock or in the mutated scarlet stock.

The ommatidia of the affected eyes are missing from the outer border of the eye, leaving a light brown band encircling the reduced eye. This holds for eyes down to about half size. Below this stage of reduction the eyes are often irregular, the light area is apparently carried toward the center where the few ommatidia protrude as an irregular mass from a somewhat depressed area. When reduced to a speck, this lies slightly posterior to the center of the normal eye. The small-eyed animals have an arrow-headed appearance which is in marked contrast to the wild flies with their large eyes and blunt heads.

Speck eyes were selected and inbred for a few generations as were the flies with eyes about half normal size, but both have given descendants with practically the same range of forms. The stock has apparently changed, however, in another particular, for a comparison of the descendants with the mutants that originally appeared will show that the eyes of each affected individual are more symmetrical in size and shape. The eyes of the first twenty mutants were very asymmetrical. The eye color of the mature wild-type *repleta* is very dark and will be referred to throughout the paper as mahogany.

EARLY HISTORY OF THE BEHAVIOR OF VARIABLE IN INHERITANCE

A small amount of data is given here to show the type of complicated results obtained before the key to the situation was found. The twenty flies discovered on January 13, 1917, were made up in three different cultures, and to my great surprise only normal-eyed flies appeared among the descendants until April 30 when a count yielded 2 males and 4 females with eyes about one-half normal size, 15 normal-eyed males, and 15 normal-eyed females. On May 3, there appeared 45 with normal eyes, and 15 flies with eyes one-half normal size. The small-eyed forms were selected and produced 466 normal flies and 32 with eyes that varied in size from speck to normal. The small-eyed flies were again selected, and in the summer of 1917 a count from this culture gave 147 females, and 142 males with eyes varying from one-half normal size to eyes entirely missing. Crosses were made by my students with this stock during the winter of 1917-1918. Ignorance of the fact that temperature was a determining factor in the realization of the character, led us at the time to ascribe our conflicting results to lack of purity of the stock.

Crosses between the wild stock and variable, made on March 2, 1918, gave the following results: The wild-stock ♂ mated to the scarlet variable ♀ gave more than 400 offspring with eyes like those of the wild type. These when inbred produced 1554 mahogany normal, 35 mahogany variable, 331 scarlet normal and 38 scarlet variable.

The reciprocal cross in which the scarlet variable ♂ was crossed to the wild-stock ♀ yielded about 400 sons and daughters with eyes characteristic of the wild type. These when inbred produced 390 mahogany normal, 8 mahogany variable, 81 scarlet normal and 14 scarlet variable.

These crosses give a grand total of 1944 mahogany to 464 scarlet, a ratio of 4.3 to 1. The ratio usually obtained on crossing scarlet to the wild type is 3 wild type to 1 scarlet. It seems likely that variable has in some way modified the ratio.

There are 2356 normal-eyed flies and 105 variables, a ratio of 22 to 1, a result we can understand in part when we know that the temperature can shift such a result within very wide limits.

BEHAVIOR OF VARIABLE UNDER A CONTROLLED TEMPERATURE

The study was carried forward from this point in light of the fact that eyeless flies were more likely to appear at high temperatures than at low temperatures. During the summer of 1918 the speck-eyed form had appeared in large numbers. On October 5, there appeared in a culture bottle that had been made up on May 14, 30 flies with eyes that varied from one-half the normal size to flies with mere specks for eyes. Several cultures were made from this bottle and placed in a rudely constructed warm chamber. The temperature fluctuated between 25° to 30° C. Speck-eyed flies emerged by the hundreds. In fact the cultures were pure for this character, while the flies that emerged from the control bottles, kept at a reduced room temperature during October and November, had eyes indistinguishable from the normal type. This showed that temperature was at least one deciding factor in the realization of the new character.

That moisture plays some part in the expression of the character would seem to be indicated by the fact that invariably an increasing number of flies with reduced eyes appear as the cultures become dry. Moreover the speck condition becomes intensified in dry cultures. It frequently happens that the first flies to emerge from pure variable cultures that have been kept at a relatively high temperature, have eyes larger than those that emerge later. In fact the first flies that emerge may be indistinguishable from normal while later only speck-eyed forms appear. This is shown in table 1. The obvious interpretation is that development has been accelerated by the temperature so that the plastic moment in the life of the fly is passed before the temperature has brought about any change in the moisture conditions of the culture. Many changes are taking place in a fermenting mass of banana exposed to a temperature of 25° to 30° C, so that one can not be sure from the evidence at hand that temperature exerts its influence through a change in moisture. We can only assert that the eyeless condition is realized under warm dry conditions.

LINKAGE OF VARIABLE AND SCARLET

With a stock that was pure for variable as shown by a number of tests and with the fact established that the character could be controlled by subjecting the cultures to the proper temperatures, the behavior of

scarlet and variable in the same cross was determined. Wild-stock virgin females, whose history was known, were mated to the double recessive scarlet speck-eyed males and kept at room temperature. All of the hybrids were like the wild type. These were back-crossed to the double-recessive parent stock. The cultures were kept in the warm chamber with the result shown in table 2. This table lists the results from three such tests. The data would seem to indicate that the full temperature effects were not realized, but it is evident that there is linkage between scarlet and variable. No mahogany variable flies result from this combination, which is explainable on the assumption that the characters do not cross over in the male.

TABLE 1

This table shows the history of two culture bottles of pure variable, that were well supplied with food and kept at a high temperature. Note that the first flies to hatch have larger eyes than those that hatch later

CULTURE NUMBER	DATE EX-AMINED, NOVEMBER, 1918	NUMBER OF FLIES	CONDITION OF EYE
1	9	10	Eyes normal size
	14	9	Slight reduction
	16	22	One-half size
	20	150	One-half size to mere specks
	22	100	One-half size to minimal
2	9	14	Slight reduction
	14	19	Slight deduction
	16	15	Three-fourths size
	20	100	About one-half size
	22	35	One-half size—a few minimal
	28	30	One-half size to minimal

The relation between scarlet and variable was also studied in the reciprocal cross in which the hybrid ♀ was back-crossed to the double-recessive scarlet variable ♂, under the same conditions as in the above test. From this combination all four classes appear as in table 3. This table lists the results from three separate tests. These results are consistent in showing that variable and scarlet are linked and that there is crossing over in the female and none in the male. The crosses, however, do not yield the ratios which the formula demands. This is probably due to lack of environmental control, although genetic factors may be involved. Certain difficulties are met in breeding this fly which make some of the problems here encountered hard to bring under control.

Tables 2 and 3 are compiled from records which show the sex ratio in each of the different classes to be near equality. The detailed records also show that in so far as the distribution of the characters from the back-crosses are concerned it makes no difference whether the double recessive entered the hybrid from the male or female.

TABLE 2

Back-cross. Offspring from scarlet eyeless ♀ × hybrid ♂ (Wild × scarlet eyeless). Cultures kept in warm box. The tables list the totals from three separate tests. The sex ratio for each of the different classes was near equality.

CLASSES.....	NORMAL MAHOGANY	NORMAL SCARLET	MAHOGANY VARIABLE	SCARLET VARIABLE
Test 1.....	1023	443	0	412
Test 2.....	16	3	0	2
Test 3.....	35	11	0	11
Total.....	1074	457	0	425

TABLE 3

Back-cross. Reciprocal of 2. Offspring from hybrid ♀ × scarlet eyeless ♂ (wild × scarlet eyeless). Cultures were kept in warm chamber. The sex ratio for each of the different classes was near equality. The data are compiled from three separate tests.

CLASSES.....	NORMAL MAHOGANY	NORMAL SCARLET	MAHOGANY VARIABLE	SCARLET VARIABLE
Test 1.....	876	634	103	271
Test 2.....	113	60	11	24
Test 3.....	63	22	2	7
Total.....	1052	726	116	302

STAGE IN THE LIFE CYCLE OF THE FLY AT WHICH THE ENVIRONMENTAL INFLUENCE IS EXERTED

The following experiment demonstrates that the environmental influence which determines whether the eye of the homozygous variable shall be large or small is exerted after the egg is fertilized and deposited. On January 1, 1919, 100 speck-eyed flies were taken from a pure culture of variable scarlet from the warm box. The selected flies were kept warm and were permitted to lay their eggs on filter paper to which a small piece of banana had been added. Every twenty-four hours the banana with the

eggs was placed in a separate bottle with fresh food and returned to the warm box to develop. On the eighth day of the test the eggs were divided into two lots, one lot was returned to the warm box and one was placed on the window ledge where the temperature at this time of year was rather cool.

A comparison of the flies that emerged on the corresponding dates as given in tables 4 and 5 will show that those subjected to the warm temperature had defective eyes, while the eyes of those that developed at the reduced temperature were like the wild type. These results are not to be explained in terms of viability. It is clear that temperature is a determining factor in the realization of the speck-eyed form, and that the influence is exerted after the egg is fertilized and deposited.

Table 4 brings out the fact that moisture plays a part in the realization of the speck-eyed flies. The first flies to hatch from the warm cultures have eyes larger than those that hatch later, that is after the culture begins to dry. The warm box in which the eggs were kept isolated during the first five days in January dropped somewhat in temperature due to extremely cold weather. On January 6, 1919, the eggs were transferred to a newly constructed chamber that was kept more nearly uniform at 28° C. The effect is shown in table 4, cultures 12 to 15. It would seem that when development is accelerated as a result of exposure to high temperature, the flies are likely to have large eyes, as in these cultures they approximate the normal size. If delayed, as in culture 8, until a certain drying effect is produced, the first flies to appear are likely to be of minimal size.

CROSSES INVOLVING DIFFERENT COMBINATIONS OF SCARLET AND VARIABLE
AND THEIR NORMAL ALLELOMORPHS UNDER DIFFERENT TEMPERATURE
CONDITIONS

A number of crosses have been made in order to determine whether or not the ratios are modified as a result of keeping the parents at one temperature and subjecting their offspring to another. The result is not conclusive as bearing on this point as the ratios obtained approximated those we had obtained during warm summer temperatures. The data, however, are given as substantiation of the claim as to the behavior of the character in inheritance. In some of these combinations flies genotypically eyeless but phenotypically normal were used as indicated in the table headings.

TABLE 4

*The type of eye that results on subjecting the fertilized eggs of scarlet variable to a warm temperature.
Compare with table 5.*

DATE OF ISO- LATION OF EGGS JANUARY, 1919	BOTTLE NUMBER	NUMBER OF DAYS OF INCUBATION, NUMBER OF FLIES EMERGED AND CONDITION OF EYES											
		Days	Flies	Eyes	Days	Flies	Eyes	Days	Flies	Eyes	Days	Flies	Eyes
1	1	16	35	$\frac{3}{4}$							38		
2	2	15	22	$\frac{3}{4}$							37		
3	3	14	20	$\frac{3}{4}$							36	10	m
4	4	13	10	$\frac{3}{4}$	16	7	$\frac{3}{4}$	23	4	m	35		
5	5				15	4	$\frac{1}{2}$	22	11	m	34	5	m
6	6				14	0		21	1	m	33	20	m
7	7				13	0		20	0		32	10	$\frac{3}{4}$
	7a				13	0		20	1	m	32	20	m
8	8				16	0		19	0	m	31	10	m
9	9				15	0		18	12	m	30	3	m
10	10				14	56	$\frac{1}{2}$	17	28	$\frac{1}{2}$ m	29	13	m
11	11				13	0		16	0		28	0	
12	12				12	9	$\frac{1}{2}$	15	15	$\frac{1}{2}+$	27	0	
13	13				11	0		14	25	$\frac{1}{2}$	26	25	m
14	14				10	1	$\frac{1}{2}$	13	20	$\frac{3}{4}$	25		
15	15				8	0		11	15	N-	23		

N = normal

N- = slightly less than normal

 $\frac{3}{4}$ = $\frac{3}{4}$ normal size $\frac{1}{2}$ = $\frac{1}{2}$ normal size $\frac{1}{2}$ - = less than $\frac{1}{2}$ normal size

m = minimal, i. e., mere specks

TABLE 5

The type of eye that results on subjecting the fertilized eggs of scarlet variable to a reduced temperature. Eggs laid by the same parents as in table 4. These eggs give rise to flies with normal eyes while the eggs used in table 4 give rise to defective eyes.

Date of Isolation	JANUARY, 1919									
	8	9	10	11	12	13	14	15	16	17
Number of flies emerged	21	8	13	1	1	0	50	10	30	4
Condition of eyes.	Normal	Normal	Normal	Normal	Normal	Normal	Normal*	Normal	Normal	Normal

*A few flies with eyes slightly smaller than normal.

Wild-stock ♀ × scarlet variable ♂ with normal eye

This combination made November 13, 1918, and kept warm, gave more than 100 flies like that of the wild type. Virgin F_1 flies were mated in pairs and returned to the warm box with result given in table 6.

TABLE 6

F_2 from wild-stock ♀ × scarlet normal-eye ♂ from eyeless stock. The cultures were kept in the warm chamber.

CLASSES.....	MAHOGANY NORMAL		SCARLET NORMAL		MAHOGANY VARIABLE		SCARLET VARIABLE	
	♂ ♂	♀ ♀	♂ ♂	♀ ♀	♂ ♂	♀ ♀	♂ ♂	♀ ♀
Total.....	281	301	53	84	8	4	8	7

Wild-stock ♀ × variable scarlet ♂ with very small eyes

The wild-stock ♀ crossed to the variable scarlet ♂ with very small eyes, made at the same time as the cross in the previous experiment, gave in F_1 over 100 flies all of the wild type. These inbred produced in the F_2 , classes given in table 7.

Normal-eyed ♀ from variable scarlet stock × wild-stock ♂

Normal-eyed ♀ from variable scarlet stock × wild-stock ♂ mated November 12, 1918, gave 75 wild-type flies. These inbred and kept warm

gave in F_2 the different classes as shown in table 8. The F_1 was mated December 19, 1918.

TABLE 7

F_2 from wild-stock ♀ × variable scarlet ♂ with minimal eyes. Cultures kept in warm chamber.

CLASSES.....	MAHOGANY NORMAL		SCARLET NORMAL		MAHOGANY VARIABLE		SCARLET VARIABLE		REMARKS
	♂ ♂	♀ ♀	♂ ♂	♀ ♀	♂ ♂	♀ ♀	♂ ♂	♀ ♀	
	9	28	6	3	0	0	0	0	147 normal 14 speck
	40	34	6	11	1	0	3	1	
	70	67	8	8	0	0	1	0	
Total.....	119	129	20	22	1	0	4	1	

TABLE 8

F_2 from normal-eyed variable scarlet ♀ × wild-stock ♂.

CLASSES.....	MAHOGANY NORMAL		SCARLET NORMAL		MAHOGANY VARIABLE		SCARLET VARIABLE	
	♂ ♂	♀ ♀	♂ ♂	♀ ♀	♂ ♂	♀ ♀	♂ ♂	♀ ♀
Total.....	44	41	9	10	1	1	0	1

Wild-stock ♀ × minimal-eyed scarlet ♂

The wild-stock ♀ was crossed to 6 minimal-eyed scarlet males November 12, 1918, and kept at cool room temperature. On December 31, 1918, over 100 wild-type flies appeared. These were mated in pairs and one set kept in the warm box and one in the cold.

The F_1 was mated December 31 and produced the classes shown in table 9.

TABLE 9

F_2 from wild-stock ♀ × speck-eyed scarlet ♂.

TEMPERATURE CONDITIONS	CLASSES.....	MAHOGANY NORMAL	SCARLET NORMAL	MAHOGANY VARIABLE	SCARLET VARIABLE
Warm.....	Total	801	189	9	42
Cool.....	Total	170	40	3	7

Normal-eyed scarlet ♀ from pure minimal mass culture × wild-stock ♂

This cross kept at cool room temperature gave 85 all wild-type flies. A pair of the F_1 mated January 2, 1919, produced on January 30: normal mahogany 168; normal scarlet, 12♂♂, 13♀♀; variable mahogany, 3♂♂, 1♀♀; and variable scarlet, 6♂♂, 3♀♀.

Wild-stock ♀ × normal ♂ from minimal

A wild-stock female was crossed with a normal male from minimal November 13, 1918, and kept at cool room temperature. The F_1 gave 150 all wild type. Pairs were subjected to warm and cool conditions and yielded as shown in tables 10 and 11.

TABLE 10

F₂ from wild-stock ♀ × normal ♂ from variable stock kept in warm box.

CLASSES.....	MAHOGANY NORMAL	SCARLET NORMAL	MAHOGANY VARIABLE		SCARLET VARIABLE	
	Both sexes	Both sexes	♂♂	♀♀	♂♂	♀♀
Total.....	2110	456	7	7	18	26

TABLE 11

F₂ from wild-stock ♀ × normal ♂ from variable stock kept at cool room temperature.

CLASSES.....	MAHOGANY NORMAL	SCARLET NORMAL	MAHOGANY VARIABLE	SCARLET VARIABLE
Total.....	100	22	1	0

OBSERVATIONS ON THE STOCK CULTURES OF VARIABLE

Among the normal-eyed descendants of the original bottle from which the 20 variable flies appeared there was found on April 7, 1917, a scarlet-eyed female with eyes about one-half normal size. This culture was under observation for the inheritance of a suspected wing mutation. This fly was mated to a somatically normal-eyed scarlet male from the same culture. The F_1 generation gave: 35 normal-eyed ♂♂, 40 normal-eyed ♀♀, 9 variable ♂♂ and 15 variable ♀♀.

The variable stock was established by selecting variable eye from the flies just listed. In June they produced 147 females and 142 males pure for variable. The eyes ranged from one-half the normal size to eyes almost entirely missing.

TABLE 12

Summary of the combinations made and classes realized, arranged to show that scarlet and variable are linked and that the characters do not cross over in the male.

SET OF EXPERIMENTS	P ₁ COMBINATION	F ₁	F ₂ CLASSES			
			Mahogany normal	Scarlet normal	Mahogany variable	Scarlet variable
I and III						
	Variable scarlet ♀ × normal mahogany ♂	All wild type	384 761 793 85 127 168	109 161 170 19 20 25	18 15 20 2 1 4	13 22 16 1 3 9
Total.....			2318	504	60	64
	Normal mahogany ♀ × variable scarlet ♂	All wild type	164 226 582 248 801 170 2176 100	25 56 137 42 189 40 479 22	2 6 12 1 9 3 15 1	5 9 15 5 42 7 51 0
Total.....			4567	990	49	134
II	P ₁		F ₂ CLASSES			
	Back-cross hybrid ♀ × variable scarlet ♂		876 113 63	634 60 22	103 11 2	271 24 7
Total.....			1052	716	116	302
	Back-cross variable scarlet ♀ × hybrid ♂		1023 16 35	443 3 11	0 0 0	412 2 11
Total			1074	457	0	425

The normal-eyed flies of April 30 were made up in mass culture and produced 466 normal-eyed flies and 32 with eyes varying from almost none to normal.

A female from the purified variable stock that had mere specks for eyes was mated to wild-stock males on May 28, 1917. This gave during June 21st to 24th, 27 sons and 22 daughters, all with wild-type eyes.

These inbred produced in the next generation: 384 normal mahogany, 109 normal scarlet, 18 variable mahogany, 13 variable scarlet.

During the fall and winter of 1917-1918 the inheritance of variable was studied in different combinations of back-crosses, but most disturbing ratios appeared. An examination of the stock bottles showed that they had apparently reverted to normal. I attributed this at the time to contamination and in the spring of 1918 commenced once again to purify the stock by selection. In this I was apparently successful, for in the summer only speck-eyed forms were to be found in the cultures.

October 5, 1918. From bottle made up May 14, 30 flies with eyes fairly uniform, about one-half the normal size. This bottle was kept warm and small amounts of banana added from time to time. October 14, all very small eyes. October 21, 8 very small eyes. October 28, many flies with eyes one-half size to minimal. October 30, many one-half size and larger. November 4, many one-half size and larger; 2 minimal.

The bottle was now placed near the window in the cold and on December 12 all the flies had eyes of the wild-type size. The bottle was placed again in the warm chamber and on January 9, 1919, all the flies had very small eyes. A bottle of variable produced on November 5, 1919, 2 normal, later 10 normal and 18 normal. It was then placed in the warm box and on December 7, 20 flies, with eyes one-half size and less, appeared, later 21 flies all with mere specks appeared. A bottle of minimal-eyed forms was made up October 8 and kept at cool room temperature. It produced: November 11, 36 normal. November 13, 12 normal. November 15, 27 normal. November 27, 27 normal and one slightly less than normal.

During the fall and winter of 1918-1919 experiments were carried out as recorded in tables 2 to 9. The key to the production of eyeless was evident. It could be made to appear in warm dry conditions.

A bottle made up from minimal-eyed forms on October 8, 1919, was kept at cool room temperature until November 4, 1919. It was then placed in the warm box. The larvae were good size when placed in the box. November 14, 5 normal. November 15, 10 normal. November 16, 16 normal. November 18, 13 less than normal. November 20, 4 one-half and less than

normal. November 22, 3 one-half and less than normal. November 26, 4 one-half and less than normal.

Two bottles kept at cool room temperature and dry (that is, no great excess of food was added). Made up October 19, 1919. Bottle 1 produced: November 27, 36 slightly less than normal. December 10, 25 slightly less than normal. Bottle 2 produced: November 27, 9 slightly less than normal. December 10, 40 slightly less than normal.

The stock at present is being subjected to a more exact environmental control.

RECORD OF TWO EYE MOSAICS

A mosaic male with the left eye scarlet and the right eye of wild-type color was found on March 12, 1919, from the descendants of a cross between the wild-stock male and normal scarlet variable female. The anomaly did not recur among the descendants and the inheritance was such as to show that the male was genotypically mahogany.

The second mosaic was a female that appeared October 19, 1920, with the lower third of the right eye covered with an irregular patch of scarlet; the remainder of the eye was mahogany, as was the left eye. This mosaic came from a mixed culture of mahogany and scarlet. No variables were present at this time. This fly was heterozygous; for, when mated to the scarlet male she gave 101 scarlet and 84 mahogany offspring.

DISCUSSION

A few cases in which an environmental stimulus caused marked phenotypic differences have been reported. In *Primula* BAUR (1911) showed that the plant transmitted the ability to produce red flowers at 15°C and white ones at 30°C. HOGE (1915) found that with a certain mutant of *Drosophila melanogaster*, reduplicated legs appeared in large numbers when subjected to a temperature of 9° to 10°C. ROBERTS (1918) reports that the length of the wings of vestigial is greatly modified by differences in temperature of 4° to 5°C. MORGAN (1915) has shown that the development of the abnormal abdomen in *Drosophila* is dependent upon moisture. KRAFKA (1920) in a very carefully planned series of experiments has recently shown that the number of facets that appear in the bar-eyed mutant of *Drosophila* is an expression of the temperature to which they are subjected at certain stages of development.

SUMMARY

A mutant, here called variable, of *Drosophila hydei* (Sturtevant) appeared in the same stock from which the mutant scarlet originated. These

are the only two mutants thus far reported in this species and they show linkage with no crossing over in the male.

The new character may appear in two different forms: (1) Full-eyed, indistinguishable from the normal eye, and (2) less than full-eyed, varying to mere specks.

The expression of the character, when homozygous, depends upon environmental conditions. Cultures of variable kept warm and dry produce speck-eyed forms in large numbers, while the cultures of variable kept cool and moist give rise to flies with normal-sized eyes. Temperature seems to exert its influence through its drying effect; for there is a marked tendency for dry cultures to produce speck-eyed forms. Newly made cultures of variable, subjected to a high temperature, in which the rate of development is greatly accelerated, are likely to produce eyes that approach the normal size.

There is an optimum temperature point beyond which development is so rapid that the eggs hatch while the culture is still wet even though at a high temperature. The flies that thus arise have eyes approaching normal size. On the other hand the temperature may be lowered and the culture become dry so that there is a tendency for a few small-eyed flies to appear even at a low temperature. A culture of variable kept moist and cold produces full-eyed forms, but when kept warm and dry, speck-eyed forms. It is clear that in so far as the expression of the character is concerned the influence is exerted after the egg is fertilized and deposited.

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