It is obvious on the other hand that half of the females also contain one sex chromosome that carries the lethal factor. They are saved by the other sex chromosome, but they will transmit the fatal dose to half of their sons who die and to half of their daughters who live.

The same test has been made with another sex-linked character, viz., miniature wings and the same results obtained. If, however, the lethal factor separates from the red-white factor (R — W) only once in 200 times it must be near that factor, on my hypothesis of the linear order of the factors in the chromosomes. If it does then we can calculate how often the crossing over for the wing factor should occur. In brief, we predicted the ratio of long and miniature-winged males that are expected in the back cross, *i. e.*, how many long-winged males would escape the fatal dose. The prediction was verified. For example, in F_2 there were obtained

L ♀	*L* ♂	*M* ♂
910	156	243

The number of cross-over males is 156, the number expected for the total number (399) of males is 133; this excess of long males is in the direction which the known differences in viability of long versus miniature might produce.

Similarly for the sex-linked factor for "eosin eyes." This factor lies near to the factor for red (R), hence in an experiment similar to the one with white eyes, red-eyed males should be rare. Up to the present time, 411 F_2 eosin males have emerged and one red-eyed male. The expectation is two red males to 400 eosin males.

T. H. MORGAN

COMPLETE LINKAGE IN THE SECOND CHROMOSOME OF THE MALE OF DROSOPHILA

IT has been shown recently[1] that the non-sex-linked factors that give black and wingless flies are linked to each other. In the F_2 generation (from P_1 black winged by gray wingless) there were produced:

GW	*BW*	*Gw*
2,316	1,146	737

No black, wingless flies appeared which seemed due to close linkage between the factors in question. Yet, when F_2 gray, wingless females were tested by breeding to black, winged males quite a number of black flies were obtained in the first generation (15 to 125). The explanation offered was that "crossing-over" or breaking the linkage occurred so rarely that in the production of the F_2 generation no two wingless black gametes had happened to meet.

In order to test how often crossing-over occurred, the experiment was repeated, but this time the F_1 females and males were tested for cross-overs by mating them to black wingless flies. Thus, black, winged females were mated to gray, wingless males and gave F_1 gray, winged flies. The F_1 males were tested with black wingless females and gave:

BW ♀	*BW* ♂	*Gw* ♀	*Gw* ♂
514	478	355	366

These results show that there has been no crossing-over in the F_1 heterozygous males.

The converse cross was as follows: Gray, winged females were bred to black, wingless males and produced gray, winged males and females. The F_1 males were bred, as before, to black, wingless females, and gave:

GW ♀	*GW* ♂	*Bw* ♀	*Bw* ♂
213	171	154	123

Here again the combination that went into the F_1 male remained intact.

Similar crosses in which the F_1 females were tested gave a different result: When F_1 gray, winged females (out of black, winged females by gray, wingless males) were bred to black, wingless males there were obtained:

BW ♀	*BW* ♂	*GW* ♀	*GW* ♂	*Bw* ♀	*Bw* ♂	*Gw* ♀	*Gw* ♂
696	717	305	273	180	127	606	511

The converse cross, viz., F_1, gray, winged females (out of gray, winged females by black, wingless males) were bred to black, wingless females and gave:

BW ♀	*BW* ♂	*GW* ♀	*GW* ♂	*Bw* ♀	*Bw* ♂	*Gw* ♀	*Gw* ♂
222	191	1,018	928	668	657	202	146

Adding the last two results together, it is

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[1] Morgan and Lynch, *Biol. Bull.*, Vol. XXIII., p. 174, August, 1912.

found that the percentage of "crossing-over" in the female is 21.9.

These experiments make clear, first, that *there is no crossing-over in the male* (at least for the number of cases here recorded); second, that *in the female the gametic ratio is about one to four.*

The bearing of the results on the explanation of the absence of crossing-over of sex-linked characters in the male is obvious. In that case the presence of only one sex chromosome in the male made crossing-over impossible, and this was the explanation offered. But the factors concerned with black and wingless lie in a different chromosome (in the sense that they are linked to each other and not to any sex-linked factor) which is present in duplex in both sexes, yet crossing over occurs in one sex only. Whether this second chromosome is the one to which in *Drosophila* the sex chromosome is attached can not be stated, and the question must be left unsettled until we have tested the crossing-over of other factors in this and in other chromosomes.

As Mr. A. H. Sturtevant has pointed out to me, the case here recorded offers apparently an explanation of cases in plants recently described by Bateson and others.[2] When the two dominants enter from different sides no crossing over is apparent, as seen in the first case recorded above ("complete repulsion"). When the two dominants enter from the same side there is evidence of crossing over ("partial coupling"), as shown by the following example. Gray, winged females were mated to black, wingless males, and gave gray, winged F_1 offspring. These inbred produced the following F_2 classes:

BW	*GW*	*Bw*	*Gw*
9	246	65	18

These results in the F_2 generation are of the same kind as those that Bateson and Punnett have recorded for peas, etc. Back-crossing has shown in the flies that the results are due to failure of "crossing-over" in the males. If the same tests, when applied to peas, give the same result there will be no longer any need to assume, as Bateson and Punnett have done, that there is (*A*) a system of partial coupling, (*B*) a system of complete repulsion, or "spurious allelomorphism" or to assume (*C*) a system of special dichotomous ratios for coupling, such as 3:1 and 7:1, etc.

T. H. MORGAN

THE PROBABLE RECENT EXTINCTION OF THE MUSKOX IN ALASKA

THE question of the probable recent extinction of the muskox (*Ovibos moschatus*) in northern Alaska, which has often been mooted, acquires new interest through information kindly furnished me by Mr. Vilhjálmur Stefánsson, who has just returned from four years of exploration in Arctic America in the interest of the American Museum of Natural History. Under date of New York, November 2, 1912, he writes:

Dear Dr. Allen: At your request I summarize briefly my information in regard to muskoxen in Alaska secured on the museum's arctic expedition during the years 1908–12; a full statement will in due course be prepared by Mr. R. M. Anderson, who was in charge of the zoological work of the expedition.

(*a*) Information secured from natives and white residents in Alaska: During the winter 1899–1900 there died at Cape Smythe (or near there) the Eskimo man called Mangi by the whalers (probably Mangilanna). He was the last to die of Cape Smythe (Point Barrow) natives who had seen live muskoxen in that vicinity. He was probably born between 1845 and 1850, as he was able to remember Maguire's visit to Point Barrow. A few years after Maguire's time—perhaps therefore about 1858—there was scarcity of food in winter at Cape Smythe. Mangi's father then went inland looking for caribou, and some distance up the Kunk River, which flows into Wainwright Inlet, they fell in with a band of thirteen muskoxen and killed them all. Since then no one near Point Barrow is known to have killed muskoxen or seen them.

There are many places inland from Point Barrow where muskox skulls and bones are abundant. As these are heavy and there is no market for them locally, few are brought to the coast. Our party secured one skull only.

(*b*) Information based on specimens: While dig-

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[2] *Proc. Roy. Soc.*, Vol. 84, 1911.