NOTE ON A TRI-COLOUR (MOSAIC) MOUSE.

By R. A. FISHER, Sc.D., F.R.S.

(*Rothamsted Experimental Station, Harpenden, Herts.*)

The occurrence of rats and mice having skin areas of two different colours in addition to white is sufficiently uncommon to deserve record. In the following note I have endeavoured to put together all information likely to be useful to other workers, on a case which occurred in my stock during the spring of 1929.

A pair of litter-mates, born 23 February, 1928, were mated to carry on a stock line segregating in the two factors: **Bb**, black *v.* chocolate, and **Ww**, white *v.* recessive pied. Of their eleven litters one was lost by incursions of wild mice, and the young recorded from the remainder are shown below in Table I.

TABLE I.

	Pied		White		
	Black	Chocolate	Black	Chocolate	Uncertain
♀	5	7	7	2	0
♂	7	4	1	11	2
Total	12	11	8	13	2

In the eleventh litter, born 5 February, 1929, occurred the exceptional doe, classified above as a black white, having small black patches on either side of the rump and a distinct chocolate dot between the right eye and ear. The eyes, which, in certain lights, appear distinctly brown in chocolate mice, have always appeared to be both black, and since the chocolate spot is close to the right eye it is probable that the area affected is small. It will be noticed that the parents were at the time near the end of their reproductive period, being nearly a year old.

No comparable case has hitherto occurred in this stock out of some 7000 mice bred in the last few years, of which about 1500 were heterozygous, **Bb**, and the effect not masked by dilution.

In mating her it was desirable in the first place to test if she were genetically **bb** or **Bb**, which could best be done by back-crossing to chocolate; in the second place, to test the possibility that the condition was favoured by her particular genetic constitution by mating to one of her own sons, and thirdly, in view of the possibility that chocolate areas

are more readily formed on the edge between black and white areas, to make sure that such boundaries were available over as much of the body as possible, as in the whiter strains of dominant pied. Her first litter was therefore from a chocolate buck, **bbWwSs**, from such a strain, and consisted of two self does, black and chocolate respectively, three pied bucks, two blacks and one chocolate, and three white bucks, one of which was certainly chocolate. The chocolate pied buck was certainly dominant pied, **WwSs**, but either or both of the black pied males may have been recessive pied **wwss**, since the cross was segregating heavily for modifiers and they were not subsequently tested.

For further matings the chocolate dominant pied son has been used and nine further litters obtained. These are shown in Table II.

TABLE II.

	Black				
	Self	Dominant pied	Recessive pied	White	Total
♀	1	5	2	2	10
♂	0	4	0	2	6
Total	1	9	2	4	16

	Chocolate				
	Self	Dominant pied	Recessive pied	White	Total
♀	2	6	3	4	15
♂	0	6	2	7	15
Total	2	12	5	11	30

All the whites could be classified by skin spots except one black male and one brown female, which were classified by the eyes. There were thus fifteen blacks which might have, but did not show tri-colour spotting. This is sufficient to exclude any hypothesis which requires that half the young should be tri-colour, but not to exclude a quarter or smaller fractions. It may be inferred either that the tri-colour coat is not genetically conditioned, or that it frequently fails to appear in mice of suitable genetic constitution. On the former view the present case may reasonably be regarded as a mosaic from part of whose body the **B** gene has been lost during cell division.

It will be noticed that in the second mating there is an excess of chocolate young. Taking the two matings together, there are thirty-three chocolate to nineteen black, an excess which, while scarcely differing significantly from the 1 to 1 expectation, lends some colour to the

suggestion that the black gene may have been lost also from some part of her germinal tissue, as in the case of the mosaic guinea-pig reported by Wright and Eaton.

DISCUSSION.

The closest parallel with the tri-colour here described is provided by three individuals reported by Pincus(1) in February 1929. His cases concern not only the same species, but the same factor, and consist of three pied mice showing both black and chocolate areas. I presume from Pincus' description that all were recessive pied, being in this unlike the doe here reported. Pincus describes all three as genetically heterozygous, **Bb**, but in the case of his doe the evidence consists only of a single litter by a black brother, yielding two black and one chocolate. She may therefore have been homozygous chocolate in the germinal tissue. The two bucks were tested extensively by mating to chocolate and both of these gave a slight but apparently insignificant excess of blacks, none of which were tri-colour. In both of these the chocolate area was on the back, and Pincus emphasises the fact that this area is in other mice of the same stock often occupied by white spotting. This leads him to suggest an alternative to the view that the **B** gene has been lost by somatic non-disjunction, namely that in the border areas which in mice of the same strain are sometimes pigmented, sometimes white, and which may be designated "critical for pigmentation," a recessive gene may exercise a controlling effect. This view is supported by the fact that the chocolate areas in the two bucks, though of different sizes, were in the same place. The two bucks were not, however, nearly related and the tri-colour character did not appear in about 150 black offspring. It is not stated that the mates were chosen from near relatives of the tri-colours.

An extremely interesting case in rabbits was reported at the same time by Castle(2), involving the dilution factor, which changes black to blue. A buck, which was subsequently shown to be heterozygous in this factor, had a large blue spot on the left shoulder extending to the white areas on the foot and neck. With blue does he produced forty-one blue, forty-four black and two tri-colours, black Dutch with areas of blue, though smaller than those on the father. In one case the patch was on the forehead where a Dutch rabbit would normally show white, and in the other it was a transverse belt on the right side, from the mid-ventral line adjacent to the white belt to the middle of the back.

The original tri-colour when mated with yellow, for which he was also heterozygous, produced one tri-colour out of eleven not-yellow offspring, this being a black Dutch doe having a blue spot in the position of the

usual white blaze. Mated to his mother who was homozygous black, he had, besides yellow offspring, twenty-two black ones, none of which were tri-colour. No tri-colours again were produced from his heterozygous sisters and daughters, one of whom was herself a tri-colour. Castle concludes that he "transmitted the tri-colour condition in a small percentage only of his gametes, which we can estimate at 3 or 4 per cent. of his intensity-transmitting gametes." The absence of tri-colours among the six black young by his tri-coloured daughter does not, however, support the view that the difference between his black and his tri-colour offspring was wholly gametic. That it is partially so is suggested by the record of one of his tri-colour sons, who by blue females has produced sixty-six blacks, seventy-one blues and three tri-colours. In his case also mating with his tri-colour sister has produced no tri-colours, there being five blacks each of which has a two-thirds probability of being heterozygous.

There can be little doubt in this case that the tri-colour condition is determined, at least in part, genetically, and its low incidence among the heterozygous offspring shows how easily its genetic nature might escape observation in cases in which few offspring can be produced.

A well-established example of a non-transmitted mosaic was reported by Wright and Eaton in 1926 (3). This was a buck guinea-pig who was apparently a mutant from albino dilution, $\mathbf{c^d}$, to the wild type, **C**. His coat showed both $\mathbf{c^d}$ and **C**, and as he lived to sire 228 young it was possible to establish two important facts, (i) that he failed to transmit the mosaic appearance to any of the seventy-nine offspring which received **C** (intense coloration), and (ii) that he must have been a mosaic in the germinal tissue, since much more than half of his offspring were dilute. Wright and Eaton suggest that his germinal epithelium was 70 per cent. heterozygous and 30 per cent. homozygous dilute. In spite of some appearance to the contrary, the proportion of the two kinds of offspring does not seem to have varied significantly during his lifetime.

With the exception of Castle's case there is no reason to go beyond the hypothesis that we are dealing with simple mosaics caused by the loss of a greater or smaller fragment of chromatin; on the other hand this one example, where the peculiarity was unquestionably inherited, must make us hesitate in other cases also to assume that the genetic constitution has not influenced the "mosaic" appearance. A somewhat lower incidence among the offspring than that observed by Castle would have escaped observation even in the large progenies obtained by Pincus and by Wright and Eaton, especially if inbreeding were not practised. In the case of the guinea-pig, the view that we have to do with a somatic mosaic is

strongly supported by the anomalous frequency ratio of the offspring, and the same is true in less degree of the mouse here reported. The association with white areas in Pincus' mice, as in Castle's rabbits, is, however, suggestive of the view that in certain exceptional genetic combinations an abnormal pigmentation in these areas may be induced without non-disjunction. Finally, it is not impossible that the frequency of somatic non-disjunction may itself be influenced by the genetic composition.

REFERENCES.

(1) PINCUS, G. (1929). "A mosaic (black brown) coat pattern in the mouse." *Journ. Exp. Zool.* LII, 439–41.

(2) CASTLE, W. E. (1929). "A mosaic (intense dilute) coat pattern in the rabbit." *Ibid.* LII, 471–80.

(3) WRIGHT, S. and EATON, O. N. (1926). "Mutational mosaic coat patterns in the guinea-pig." *Genetics*, XI, 333–51.