Per cent distribution and gene frequencies of blood potassium and hemoglobin types in the 3 sheep breeds

(A) Per cent distribution

Breed	Potassium types		Hemoglobin types		
	HK	LK	A	B	AB
Bikaneri	57.70	42.30	5.77	69.23	25.00
Mandia	66.66	33.33	0.00	93.33	6.66
Crossbred	58.82	41.18	2.94	79.41	17.65

(B) Gene frequencies

Breed	Potassium types		Hemoglobin types	
	HK	LK	A	B
Bikaneri	0.76	0.24	0.19	0.81
Mandia	0.82	0.18	0.03	0.97
Crossbred	0.77	0.23	0.12	0.88

between the gene frequencies for Hb A and HK in 33 different British breeds of sheep, and also that Hb A and HK appeared to be more common in breeds indigenous to mountain areas in Britain. The difference in these findings may be due to a different mode of adaptation to different environmental conditions. EVANS[13] and TANEJA[10] suggested that LK sheep are better adapted to arid zone conditions because of their lower water consumption. However, the very fact that results obtained by GHOSH et al.[12] and TANEJA and GHOSH[7] as well as the findings of the present study indicate a marked preponderance of HK type animals in the relatively drier parts of India, would clearly point to the comparative suitability of such animals for these tracts. Because sheep of Hb B and HK types are much more common in India and the Middle East than sheep of Hb A (and AB) and LK types, it is suggested that the Hb B and HK genotypes confer an adaptive advantage in these areas and the animals which have these genotypes thrive best. The results of TANEJA et al.[8] support this hypothesis[14].

Résumé. On a effectué la numération globulaire et déterminé la concentration du potassium dans le sang de 2 races de moutons de l'Inde et dans celui des croisements de Corriedale et de Bikaneri. La prépondérance des types Hb B et HK indique que ce sont ces individus qui s'adaptent le mieux aux zones arides de l'Inde.

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[13] J. V. EVANS, Nature *180*, 756 (1957).

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Cytological Evidence Suggestive of Crossing Over Within the Mammalian *X* Chromosome

In 1966, GALTON[1] proposed that the mammalian sex chromosomes originated from an unbalanced translocation between the members of a homologous pair of autosomes and thus produced 2 chromosomes of unequal size that are now known as *X* and *Y*. If the hypothesis is correct, the *X* chromosome should contain a large duplication.

The morphology of the *X* chromosome in testicular preparations from 4 male squirrel monkeys (*Saimiri boliviensis*), 6 male rhesus monkeys (*Macaca mulatta*), 1 male dwarf galago (*Galago demidovii*), and 1 male tarsier (*Tarsius syrichta*) suggests that chiasmata occur within the mammalian *X* chromosome (Figure).

Testicular preparations were made in the usual manner[2] but with oversquashing of the material, which produced faintly stained preparations, that, in many cases, reveal the structure of the sex chromosomes in the sex vesicle. At least 500 cells/animal were examined and a mean of 50 cells/animal photographed. The *X* chromosome is always identifiable during prophase I: it is heterochromatic; it appears close to *Y*, which is also heterochromatic; and it is the only chromosome in which chiasmata are visible at pachytene, when the autosomes still show a rod-like shape. The characteristic configuration of the *X* chromosome can be clearly seen in almost 100% of the cells in *Saimiri* and in about 20% of the cells in the other species; the remaining cells show the typical, darkly stained sex vesicle in which the structure of the sex chromosomes is not visible.

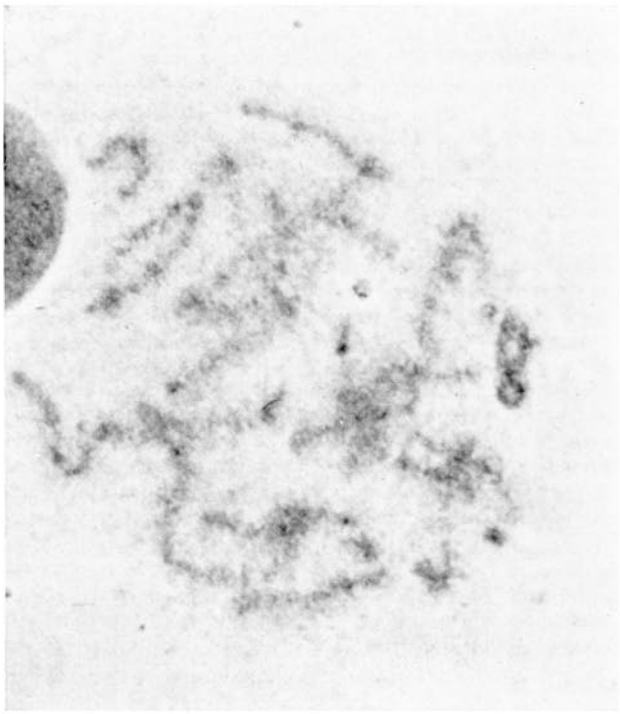
The size and morphology of the *X* chromosome suggest that it is bent at a median point; the 2 strands of the chromosome are often visible. In *S. boliviensis* and *M. mulatta*, the only species studied about which adequate information on the mitotic chromosomes is available, the *X* chromosome is the size of the longer autosomes. Nevertheless, during pachytene *X* is only about half the size of the longer autosomal bivalents; at diplotene, it is still bent at a median point in most cells.

The morphology of the *X* chromosome suggests that crossing over takes place within it. In about 50% of the cells in which the configuration of *X* is visible, actual exchanges can be seen (Figures a and b). There is now evidence[3] that when an autosome translocates into its homologous, the resulting chromosome can still undergo crossing over during meiosis. In some specimens of the rodent *Sigmodon minimus*[3], 2 acrocentric chromosomes have undergone centric fusion; meiotic studies prove

[1] M. GALTON, Lancet *2*, 1397 (1966).

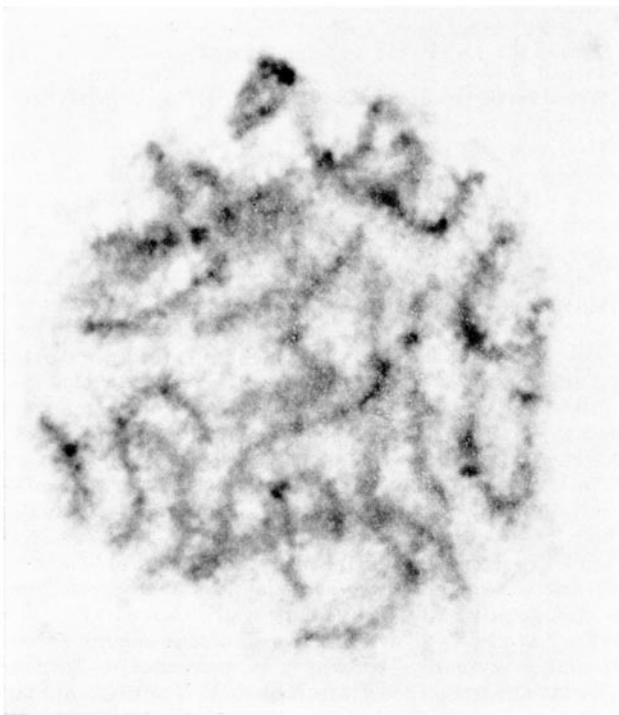
[2] B. CHIARELLI and J. EGOZCUE, Caryologia *20*, 339 (1967).

[3] T. C. HSU, personal communication.



a

c



b

Pachytene figures in male meiosis. The X chromosome is clearly identifiable. Its morphology suggests that crossing over occurs within it. Exchanges can be seen in (a) and (b).

that the fused chromosomes are homologous: the resulting metacentric bends at a median point, and during meiosis crossing over takes place within it, in a manner similar to that we describe in the X chromosome.

The chiasmata in the X chromosome appear during pachytene, before chiasmata are visible in any of the autosomal bivalents, and are terminalized by middle diplotene. Since sister chromatid crossing over is rare[4], these findings suggest that: (1) the X chromosome contains a duplication as proposed by Galton[1]. (2) The duplicated segments still behave as homologous, non-sister chromatids as they did when they were placed in different chromosomes. (3) Crossing over occurs within the X chromosome, between the segment proceeding from X and that proceeding from Y. (4) In *Saimiri* and *Macaca*, the X segment and the Y segment are in different arms of the X chromosome. (5) The process of appearance and terminalization of chiasmata in the X chromosome is asynchronous with the autosomes[5].

Résumé. La morphologie du chromosome X pendant prophase I dans le mâle de *Saimiri boliviensis*, *Macaca mulatta*, *Galago demidovii* et *Tarsius syrichta* suggère l'existence des synapses dans le chromosome X des mammifères due à la possible existence d'une duplication dans ce chromosome.

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Beaverton (Oregon 97005, USA), 4 September 1968.

[4] S. Emerson, in *Methodology in Basic Genetics* (Ed. W. J. Burdette; Holden-Day, San Francisco 1963).

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