**60. Association of the X and Y Chromosomes in
the First Meiotic Division of the Black
and the Norway Rats**

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A number of reports on the chromosomes of the somatic cells in rodents are presented by the development of the technique, but are not enough in the chromosomes of the meiosis in these animals. In the mouse some studies on the meiosis have been carried out by some investigators (Solari 1974; Oshimura and Takagi 1975; Kanda and Kato 1980; Hsu 1982; Imai and Moriwaki 1982), but in the rat such a study is quite a few. It may be depending on the difficulty of the demonstration of clear meiotic chromosomes in the latter species. In the mouse the X and Y chromosomes are associated by the form of end to end or terminal to terminal (Kofman-Alfaro and Chandley 1970; Hsu *et al.* 1971; Polani 1972), but in the rat there is no clear evidence whether, or not, the X chromosome associates with the Y in the same manner as the mouse. In the present paper, some findings of the X and Y association in meiosis of the black and the Norway rats will be described with a special note on the configuration of the X and Y association in these animals.

Materials and methods. The male Japanese black rats (*Rattus rattus tanezumii*) collected in Amagi-yugashima, Shizuoka-Pref., Japan and the male Hong-Kong black rats (*R. rattus flavipectus*) collected in Hong-Kong and bred in the National Institute of Genetics, Misima (N.I.G.) for several years were used. In the Norway rat (*R. norvegicus*), the male Wistar-Imamichi strain rats maintained in the Department of Physiology, Nippon Veterinary and Zootechnical College, and the male Lewis strain (LEW) rats maintained in N.I.G. were used. Slides for the observation of the meiotic chromosomes of the rat were made by following the Adler's technique (1982). The slides were stained first by conventional Giemsa and then they were re-stained by C-banding by the sequential staining technique (Yosida and Sagai 1975) to the confirmation of the centromeric regions of chromosomes.

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Results and discussion. 1) Condensation of the X chromosome in the prophase of the first meiotic division. The X-Y pair becomes clear gradually from the diplotene stage in the first meiotic division in the Norway and black rats. The X chromosome in the Norway rat was progressively condensed and the sister chromatid can be observed with the advance of the stage (Fig. 2). This situation was similar to the mouse (Solari 1974). On the other hand in the black rat the condensation of the X chromosome in the meiotic prophase delayed and retained as a long thread through the diplotene to MI (Fig. 1).

Figs. 1-2. First meiotic division of the black rat and the Norway rat. 1: The black rat (*Rattus rattus tanezumi*). 2: The Norway rat (*R. norvegicus*). A, diplotene. B, diakinesis. C, metaphase. Arrows indicate the X-Y association.

The Y chromosome condensed progressively as seen in the Norway rat. This feature of the retention of the condensation in the X chromosome was remarkable in *R. rattus tanezumi*, but it was observed in *R. rattus flavipectus* although the X was condensed faster than *tanezumi*. In the second meiotic division, the X chromosome condensed commonly in the black and the Norway rats.

2) Association of the X and Y chromosomes. In the mouse, it was observed that the distal end of the X chromosome was associated to the distal end of the Y chromosome. Such the end-to-end association of the X-Y pair was clearly demonstrated by the C-banding technique (Hsu *et al.* 1971; Polani 1972), and by the autoradiographical technique (Kofman-Alfaro and Chandley 1970). The X-Y pair of the black rat during the diplotene to MI stages was observed by

the use of the C-banding technique. In this study the Hong-Kong subspecies (*R. rattus flavipectus*) was used, because the large C-bands were demonstrated (Yosida 1980). In the X-Y conjunction, the C-banding was clearly observed at the conjunctive end of the X chromosome (Fig. 3). On the other hand the free or distal end of the Y chromosome was associated to the X. The morphology of the Y was demonstrated by the conventional Giemsa staining. In the Norway rat, a similar association of X and Y to the black rat was observed (Fig. 4). According to Yosida (1979), the X chromosome of

Figs. 3-4. The X-Y association of the black rat and the Norway rat at the first meiotic division. 3: The black rat (*R. rattus flavipectus*). A, conventional Giemsa staining of the meiotic X-Y. B, C-banding of the meiotic X-Y. C, C-banding of the somatic X and Y chromosomes. D, G-Banding of the somatic X and Y chromosomes. 4: The Norway rat (*R. norvegicus*). A, conventional Giemsa staining of the meiotic X-Y. Arrow denotes the centromeric position of the X chromosome. B, conventional staining of the somatic X and Y chromosomes. C, G-banding pattern of the somatic X and Y chromosomes.

Fig. 5. Diagrammatical illustration of the X and Y association in the first meiosis of the black and the Norway rats. Centromeres of the X and Y chromosomes are denoted by black and white circles.

the Norway rat was polymorphic and that of the Lewis strain was subtelocentric in nature. As seen in Fig. 4, the free end of the Y chromosome was associated to the short arm of the X chromosome. In both of the black and the Norway rats, the association of the X and Y during diplotene to MI was the top(X)-to-end(Y), but not the end(X)-to-end(Y) as seen in the mouse. In the former group, however, one question is arised whether, or not, the centromere of the X was associated directly to the distal end of the Y. The X chromosomes of several subspecies of the black rat and several strains of the Norway rat were known to be acrocentric in nature. We suggest that the top(X)-to-end(Y) association in the rats is only perfunctory, and the distal end of the short arm of the acrocentric X would be associated to the distal end of the Y. Although the short arm of the X chromosome

is sometimes difficult to observe in the meiotic division, the chiasma between the X and Y would be existent. However, it was not demonstrated under the light microscopy. A supposed figure of the X-Y association in the meiotic metaphase (I) was as shown by a diagram (Fig. 5).

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