91. Studies on the Karyotype Differentiation of the Norway Rat. XII

Morphological Characteristics of the Tetravalent formed in the First Meiotic Division of the 11-Y Translocation Heterozygotes in the NIG-III Strain Rat, with special regard to the Analysis of the Precocious Dissociation of the Dot-Y Element

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In the previous paper (Yosida 1984), the translocation between the autosome no. 11 and the Y chromosome occurring in the NIG-III strain rat after the γ-irradiation has been described with a note on its transmission to the offspring. A major part of the Y chromosome was broken near the centromere, and the broken end was translocated to the short arm of one of the acrocentric pair no. 11. By such a translocation one of the pair no. 11 was transformed to a metacentric shape, and the remained Y to the small element like a dot. By the genetic examination it was strongly suggested that the male determining gene should be located on the dot-Y, because if it was not included in the karyotype, even though the translocated large part of the Y element was presented, it always developed to a female. The translocated 11-Y and the dot-Y were transmitted to the offspring just as the normal chromosomes. From these behaviours it was suggested that the translocation was reciprocal, and the 11-Y should have the functional centromere and telomere. The Y-element translocated to the no. 11 autosome was clearly demonstrated by the C-banding staining, by which the translocated Y element was stained heavily. From the dot-Y, however, the no. 11 is difficult to be demonstrated, because it was so small. If the translocation would be reciprocal between the autosome no. 11 and the Y-element, a tetravalent consisting of the four elements, such as the normal 11, 11-Y translocation, X and dot-Y chromosomes, would be formed in the meiotic division of the heterozygous male. The present paper deals with the prophase and metaphase of the first meiotic division in the translocation heterozygous male, with special regard to the analysis of the

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precocious segregation of the dot-Y in the first spermatocytes.

Material and methods. NIG-III strain rat with a translocation between the autosome 11 and the Y chromosome was obtained after the γ-irradiation (Yosida 1984). The translocation heterozygous rats from the offspring of the above rat were used in the present study. The Adler's technique (1982) for the observation of the meiotic chromosomes was applied. The slides were stained by conventional Giemsa and by our C-band technique (Yosida and Sagai 1975).

Results and discussion. 1) Morphology of a tetravalent in the prophase and the metaphase of the first meiotic division. In the diplotene, diakinesis and metaphase of the first meiotic division, 19 bivalents and one tetravalent were observed. The tetravalent was consisted of four chromosomes, no. 11, 11-Y translocation, dot-Y and X elements. In the diplotene and the diakinesis, the longitudinal association of the four members was clearly seen (Figs. 1–6). These four elements were associated by the following order; the dot-Y (Y-11 translocation), the normal no. 11, the 11-Y translocation and the X chromosome. The telomere of the dot-Y which was translocated from that of the short arm of the no. 11 was associated to the short arm of the normal no. 11, and the telomere of the long arm of the no. 11 was associated to the telomere of the no. 11 in the 11-Y translocation. A chiasma was often observed between the no. 11 and the 11-Y translocation (Fig. 3). The top of the X chromosome was associated to the telomere of the Y chromosome translocated to the no. 11. The top-to-end association of the X and Y chromosomes in the rat was already demonstrated by us in the normal spermatogenesis (Wada et al. 1984). The order of the association in the tetravalent was well demonstrated by the C-band staining. The top of the dot-Y was sometimes stained heavily, because it was consisted of the Y-heterochromatin (Figs. 2, 4, 6). The centromeric region of the no. 11 was also stained heavily. The Y chromosome translocated to the no. 11 was shown to be heavily stained. A scheme of the above association in the tetravalent was shown in the Fig. 7. A diagram of the tetravalent in the 11-Y translocation heterozygous male was also shown in that figure.

2) Frequency of the precocious dissociation of the dot-Y in the first maturation division. The dot-Y chromosome was often observed to be dissociated in the prophase and metaphase of the first meiotic division (Figs. 5, 6). In the two male rats with the heterozygous 11-Y translocation, the precocious dissociation of the dot-Y was analysed in 1,056 cells in total, which were distributed in the diplotene (79 cells), diakinesis (367 cells) and metaphase-I (610 cells) (Table I). The rate of the precocious dissociation of the dot-Y was not so
different between these two rats; it was rare (1.3%) in the diplotene stage, but in the diakinesis it increased to 16.9% in average of two rats. The precocious dissociation was markedly increased in the metaphase stage to 41.5% in the average. The high occurrence of the precocious dissociation in the X and Y chromosomes in the primary spermatocytes was observed in the F₁ hybrids between the Japanese
wild mice and the inbred laboratory mice (Imai et al. 1981). In the precocious dissociation of the X and Y chromosomes in the meiosis-I, they suggested to be controlled genetically. In the case of the 11-Y translocation, the dot-Y would be precociously dissociated by the physical or mechanical factor such as the difficulty of formation of the tetravalent or of the simultaneous separation from the multivalent.

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Table I. Frequency of the precocious dissociation of the dot-Y element in the tetravalent formed in the first meiotic division of the 11-Y translocation heterozygous male

<table>
<thead>
<tr>
<th>Stages and types</th>
<th>Diplotene</th>
<th>Diakinesis</th>
<th>Metaphase-I</th>
<th>Total no. of cells observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>46</td>
<td>1 (2.1%)</td>
<td>175</td>
<td>33 (15.8)</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>0</td>
<td>130</td>
<td>29 (18.2)</td>
</tr>
<tr>
<td>Total no. of cells</td>
<td>78 (1.3)</td>
<td>305</td>
<td>62 (16.9)</td>
<td>357 (41.5)</td>
</tr>
</tbody>
</table>

References