to be devoid of any genes or factors necessary for normal male development, this raises questions as to why it exists in its present form, and whether it may have some other functions. The existence of the fluorescing portion of the Y long arm may be explained as the result of evolutionary change involving the accumulation of non-functional genes on sheltered chromosomes, which Nei (1970) has demonstrated can occur in a reasonable period of evolutionary time. This process may explain the observed polymorphism in Y length, for unlike the X chromosome, in which deletions or duplications could present problems during meiosis, the Y chromosome has no similar restrictions. Furthermore, since survival is possible without the Y but not without an X chromosome, and since both the X and Y are believed to have evolved from a homologous pair of autosomal chromosomes, there must have been preferential inactivation of the genes of the Y chromosome. This inactivation would promote differentiation between the sex chromosomes and reduce the possibility of crossing-over. Lack of differentiation between the gonosomes could put a species at a selective disadvantage by making for a high incidence of intersex. That such inactivation occurred is suggested by the fact that there is virtually no recombination between the X and Y in organisms with well-differentiated sex chromosomes (Nei, 1970).

Despite the lack of structural genes, it is possible that the fluorescing Y long arm does have a function in orienting this chromosome in the sex bivalent during meiosis, when, as has been shown by Pearson and Bobrow (1970), the short arm of the Y enters into a terminal association with the X chromosome. The fact that fertility was not impaired in the present family may indicate that the Y aberration is indeed an isochromosome of the short arm, in which case it would not matter which end associated with the X. On the other hand, diminished fertility was noted by Muldal and Ockey (1962) in a family in which nearly one half of the Y long arm was deleted; and dicentric Ys are associated with infertility, with the X and Y appearing as univalents in the majority of cells at diakinesis (McIlree et al, 1966).

Summary

Normal male somatic development was found in a mentally-retarded man with an extreme deletion of the Y, which had the appearance of a small metacentric chromosome. Since the normal, fertile brother of the patient was shown to have the same Y anomaly, it appears certain that the fluorescing long arm portion of the Y is not necessary for total male differentiation, including fertility. Although it was not possible to establish whether the Y anomaly represents a long arm deletion or a short arm isochromosome, this study demonstrates that most or all of the Y long arm is genetically inert.

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REFERENCES


A Ring-20 Chromosome

Except in neoplastic cells, some haematopoietic abnormalities, and in cells known to be damaged by irradiation or chemicals or viruses, chromosomal abnormalities involving the F group (19–20) are rare. This report describes a ring-20 chromosome in a mentally retarded boy with a behaviour problem, seizures, and microcephaly.

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Case Report

The propositus, a 7-year-old illegitimate child, was admitted to the Massachusetts General Hospital because of seizures. There was a long history of bizarre behaviour and mental retardation. Grand mal seizures were first noted 4-5 months before admission. These involved tonic clonic movements of the limbs with urination and a post ictal state. The seizures increased in frequency, and at the time of admission there were 4-6 episodes daily despite sodium diphenylhydantoin and primidone therapy. Since the age of 1 year he had been a behaviour problem. He set fires and threw puppies from windows, and while in the hospital he threw bedpans at the nurses. Mental retardation and abnormal behaviour were said to be present in members of his father's family. There were 4 older, normal half-sibs. The mother remarried when the propositus was about 1 month old, and she has had 2 children by this marriage. One of these children is normal, and the other, aged 5, is said to be 'brain-damaged'. The propositus was the product of a full term uncomplicated pregnancy. There was no known exposure to irradiation.

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Palmar and sole ridge configurations were within normal limits.

FIG. 1. Karyotype of the patient showing replacement of a member of the F group (19–20) by a ring chromosome.
On physical examination the height was 118 cm (25th centile), the weight 19.9 kg (25th centile), and the head circumference 48.2 cm (less than 3rd centile). Mental development was at the level of a 3 or 4 year-old. The remainder of the physical examination was negative.

Urinalysis was negative. The urinary amino-acid excretion was normal, as were the white-cell count and the hematocrit. X-ray films of the skull and chest were negative. Electroencephalograms were abnormal due to continuous sharp and multiple spikes and slow wave complexes in both hemispheres.

The dermatoglyphic analysis by Dr Peter V. Tishler is shown in Table I.

While in the hospital the patient's seizures decreased in frequency with anticonvulsant therapy, but his behaviour could not be controlled with any behaviour modifiers. Therapeutic dosages of the following were used in different combinations: phenobarbital, sodium diphenylhydantoin, acetazolamide, primidone, paraldehyde, pyridoxine, ACTH, ethosuximide, trimethadione, dextro-amphetamine sulphate, methylphenidate hydrochloride, and chlorpromazine. The clinical impression was temporal lobe epilepsy with mental retardation and microcephaly. He was referred to a state institution for care.

**Cytogenetic Studies**

Routine chromosome studies were done on peripheral blood leucocytes. Forty-seven of 50 cells examined had 46 chromosomes with a ring chromosome replacing a member of the F group (19–20). The remaining 3 cells each had 45 chromosomes with the ring chromosome missing. The remainder of the karyotype was normal (Fig. 1). Another leucocyte culture of a sample obtained 1 week later showed the ring chromosome to be present in 32 consecutive metaphases examined. The ring did not show much variation in size, and it was about the same size as the normal members of the F group. The parents and sibs were not available for study.

Metaphases from cultured peripheral blood

![Fig. 2. Quinacrine mustard fluorescence staining of pairs 19 and 20 from 5 different cells showing 2 No. 19s and a ring chromosome replacing one of the No. 20s. Routine stain of the same chromosomes shown on the right.](http://jmg.bmj.com/)
leucocytes were stained with quinacrine mustard and prepared as described by Caspersson, Lomakka, and Zech (1971). The cells were examined under a Zeiss fluorescence microscope with an HBO 200-Watt mercury lamp, a BG 12 excitor filter, and a 50 barrier filter. After these cells were photographed, the slides were stained with Giemsa stain, and the cells were rephotographed. Examination of the F group showed 2 normal No. 19 chromosomes and 1 normal No. 20 with the ring chromosome replacing a No. 20 (Fig. 2). No. 19 has a very faint overall fluorescence with 2 fluorescing bands close to the centromere, whereas No. 20 fluoresces brightly with a brightly fluorescent distal region in the short arm (Caspersson et al, 1971).

A buccal smear for sex chromatin was negative.

Discussion

Ring chromosomes represent a type of deletion in which there is a terminal loss from both chromosome arms with rejoining of the broken ends carrying the centromere to form a ring. Cases with partial deletion of an F group chromosome have been described by Genest, Bouchard, and Poty (1971) and Ahmed (1972). The patient reported by Genest et al was a 22-year-old male with mental retardation, behavioural problems, microcephaly, muscular hypotonia, diffuse adiposity, ankylosis of both knees, bilateral cataracts with posterior luxation of the lens of the right eye, and atrophy of the iris in both eyes. The patient of Ahmed was a mentally retarded 69-year-old man with microcephaly, flat occiput, slanting eyes with epicanthal folds, and small genitalia.

The abnormal chromosome in the present case probably originated in a parental gonad or in an early division of the zygote following breakage on both sides of the centromere with subsequent ring formation and deletion of some chromosomal material. The clinical findings are presumably the result of this loss. The possibility exists that the chromosomal breakage in the No. 20 of this patient was caused by drug therapy. However, if such were the case it would seem more likely that random chromosome breakage and rearrangements would have occurred rather than the observed consistent abnormality involving one chromosome (Kihlman, 1966).

Summary

A 7-year-old boy with mental retardation, seizures, microcephaly, and a behaviour problem associated with a ring-20 chromosome is described.

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