NOTES AND COMMENTS

SEX CHROMOSOME INVERSION IN A MOSAIC GIRL*

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1. Introduction

The human X chromosome is very uniform both in size and structure (Chicago Conference, 1966). But a number of morphological anomalies have been described such as isochromosomes, duplications, rings, minutes, fragments, giant chromosomes and, especially, deletions involving one arm which may or may not be associated with mosaicism (see reviews by Turpin and Lejeune, 1965; Bartalos and Baramki, 1967).

In the work reported here we investigated an unusual female mosaic composed of two kinds of cells, one with a normal chromosome set (46, XX), the other with a structurally aberrant X chromosome.

2. Case report

The chromosome anomaly was observed in a malformed white girl born on 30th July 1957, weighing 3200 gr. at birth. The mother did not mention any previous spontaneous miscarriages and her pregnancy and delivery were normal. At the time she was 31 years old and her husband was 40. Both were in good health and had a 16-year-old daughter whose growth and development were normal. There was no family history of consanguinity or malformations.

Multiple congenital anomalies were noted at birth, including low-set ears, micrognatia with unusual small facial appearance, pterigium colli and pulmonic stenosis of a mild degree without heart failure. Other recent X-ray examinations revealed neither uterus nor adnexa and a spina bifida occulta of the first sacral vertebra. At present (11 years) she is short (108·5 cm.) and has a mental age of eight years.

The dermatoglyphic study showed that the axial triradius on the palms is in the *t'* position. The atd angles are 67° and 70° for the right and left hand respectively. Triradius *b* tends toward the ulnar side of the hand and the distance between *a* and *b* is increased in both hands.

3. Cytological observations and statistical analysis

Sex chromatin of normal size was seen in 34 per cent. of the cells in buccal smears. Blood cultures were carried out following a simplified version (Lejeune, 1965) of the micromethod of Edwards (1962). Karotype analysis followed international Conventions (Denver, London, Chicago) but the

* Dedicated to Prof. F. A. Saez on the occasion of his 70th birthday.

chromosomes of group C 6-12 and X were distinguished according to the data presented by Lejeune (1965). For accurate identification of all six chromosomes of pairs 6, 7, and X, the centromere index ($Ic = \frac{y}{w}$, y being the short arm and w the total chromosome length) and the chromosome length expressed in arbitrary units were determined from very well-spread metaphases

TABLE 1

Arctangent in radians of arm ratio

	Both X Chromosomes	Both Sixths	Both Sevenths
Normal cells			
Average	0·558	0·533	0·573
Mean error	0·007	0·008	0·010
Standard Dev.	0·048	0·059	0·070

	Affected X Chromosome*	Normal Homologue*	Both Sixths	Both Sevenths
Affected cells				
Average	0·465	0·561	0·525	0·563
Mean error	0·006	0·006	0·010	0·013
Standard Dev.	0·022	0·020	0·047	0·062

Logarithm of percentage of relative length

	Both X Chromosomes	Both Sixths	Both Sevenths
Normal cells			
Average	1·2469	1·2228	1·1899
Mean error	0·0039	0·0032	0·0028
Standard Dev.	0·0274	0·0229	0·0196

	Affected X Chromosome*	Normal Homologue*	Both Sixths	Both Sevenths
Affected cells				
Average	1·2623	1·2561	1·2123	1·1884
Mean Error	0·0057	0·0082	0·0035	0·0042
Standard Dev.	0·0197	0·0284	0·0173	0·0207

* These values are presented separately in order to show the differences observed in measurements.

with relatively uncondensed chromosomes (Sharat Chandra and Hungerford, 1967). These two estimates were obtained simply by using a proportional divider following a procedure of Professor Lejeune. The individual relative lengths were expressed as percentages of the total length of the six measured chromosomes.

All these parameters were used according to Moore and Gregory (1963). A similar morphological estimation for other chromosomes has been presented by Philip *et al.* (1965). The arm ratio $\frac{y}{x}$ (y = short arm and x = long arm) was calculated directly from the formula $Ar = \frac{Ic}{1-Ic}$ in order to test the significance of our cytological observations.

The aberration ($Ic = 0{\cdot}33 \pm 0{\cdot}0127$) appeared in approximately one third of the total number of studied cells (Plate I).

In order to test our hypothesis of chromosome abnormality, X chromosomes with centromere indices below 0·35, and the cells bearing them, were arbitrarily considered as " affected ". The other cells carrying X chromosomes within normal centromere index values were considered as " normal ".

Table 1 shows a comparison of arm ratios (arctangent $\frac{y}{x}$ expressed in

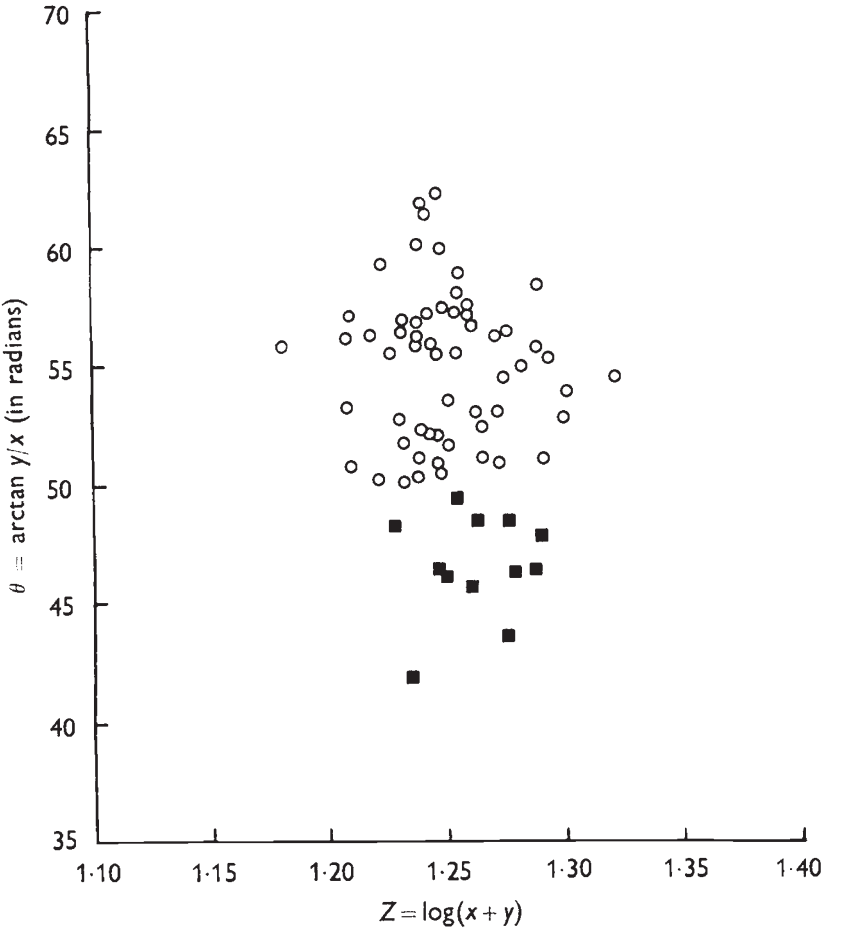


FIG. 1.—Plot of θ versus Z for 70 X chromosomes.
○, normal X chromosomes; ■, affected X chromosomes.

radians) and of relative length (expressed as the logarithm of percentages of relative length) for chromosomes, 6, 7 and X in normal and affected cells. Θ versus Z plots are presented in fig. 1.

The results of t tests between chromosomes from affected and normal cells is shown in table 2. A significant difference in arm ratio is found between the affected X and (*a*) its homologue in affected cells (t value = 11·20; $P < 0·001$) and (*b*) the X chromosomes from normal cells (t value = 6·59; $P < 0·001$). But no significant differences were noticed in regard to relative length in these cases (t value = 0·62; $P < 0·6$ and 1·84; $P < 0·1$ respectively).

Table 2 also presents various comparisons between affected X chromosomes, normal X's and members of pairs 6 and 7. These were planned in the design (Steel and Torrie, 1960) of the study in order to check our criteria of chromosome identification. The *t* test confirms that the identification followed for these chromosomes is correct and agrees closely with the expected differences and similarities in centromere indices or in chromosome lengths.

TABLE 2

Results of statistical comparisons between chromosomes from affected and normal cells

	X−X*h*	X−X*n*	X−6*n*	X−7*n*	X*h*−X*n*	X*n*−6*n*	X*n*−7*n*	6*n*−7*n*	6−6*n*	7−7*n*
Arm *t* value	11·20	6·59	3·90	5·27	0·21	2·33	1·26	3·09	0·58	0·60
Ratio	P<0·001	P<0·001	P<0·001	P<0·001	P<0·9	P<0·05	P<0·3	P<0·01	P<0·6	P<0·6
	Sig.	Sig.	Sig.	Sig.	No Sig.	No Sig.	No Sig.	No Sig.	No. Sig.	No Sig.
Length										
t value	0·62	1·84	5·49	11·48	1·04	4·76	11·97	7·75	1·97	0·30
	P<0·6	P<0·1	P<0·001	P<0·001	P<0·4	P<0·001	P<0·001	P<0·001	P<0·1	P<0·8

X and X*h* denote affected X and its normal homologue respectively.
6, 7 and X*n*, 6*n*, 7*n* denote chromosomes from affected and normal cells respectively.

4. Discussion

This analysis reveals heterozygosity and mosaicism in respect of the structure but not the length of an X chromosome.

The origin of the aberration is a matter of speculation, but the data are consistent with the view that it arose during an early embryonic stage by a pericentric inversion. Autosomal polymorphism involving such inversion has been described in spleen cells of the deer mouse, *Peromyscus maniculatus* (Ohno *et al.*, 1966).

It is more difficult to establish whether there is a causal relationship between the phenotypic findings and the chromosome aberration. It is possible, however, that minute chromosomal anomalies similar to the one described here could have been overlooked in malformed patients of the kind considered.

Complete cytogenetical, autoradiographic and clinical observations on the case, as well as other statistical chromosome analysis will be reported later.

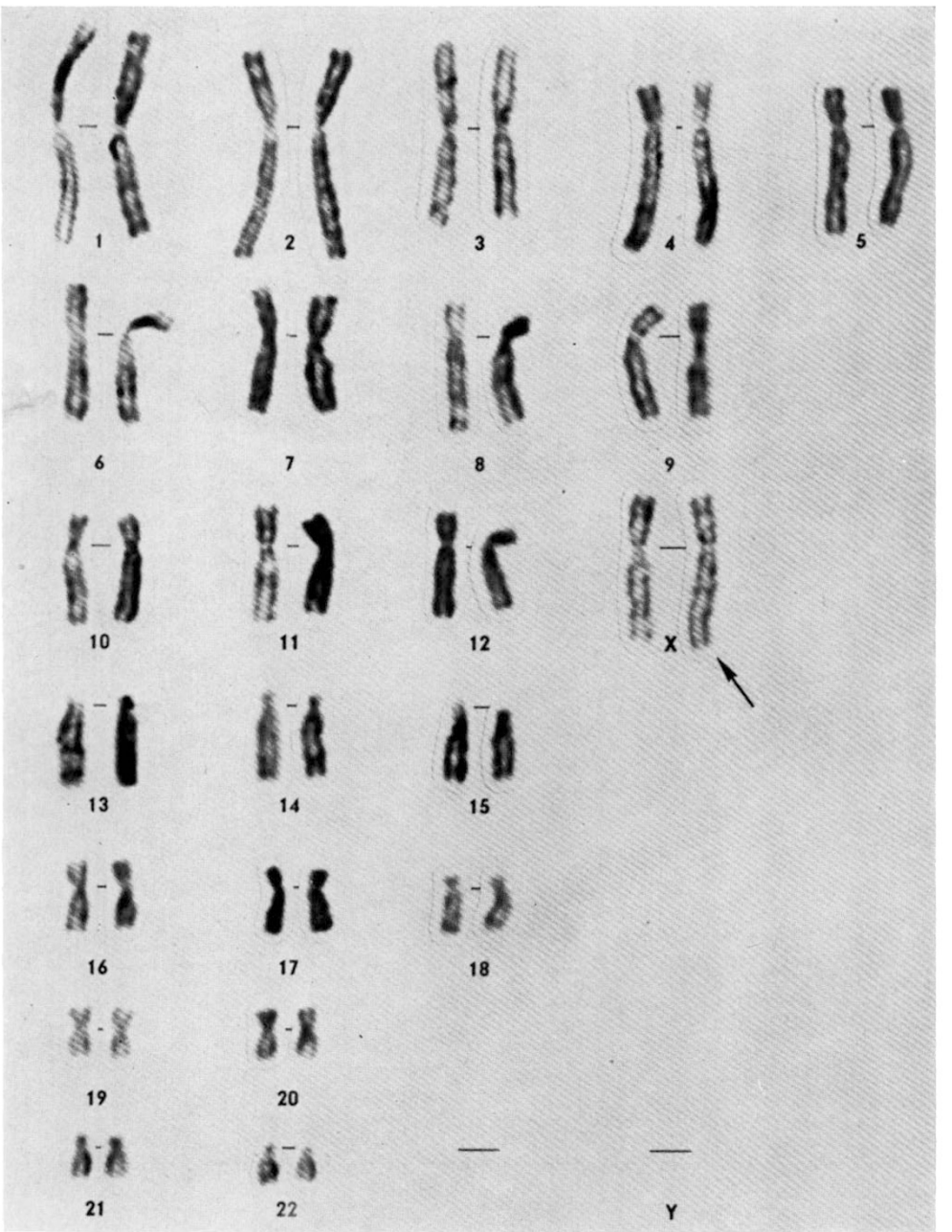
5. Summary

1. The karyotypes obtained from leucocytes of a retarded and malformed girl revealed that she has both normal cells and cells with an aberrant X chromosome.

2. Comparisons between the aberrant X chromosome and normal X chromosomes from normal or abnormal cells revealed significant differences in centromere index but not in relative length.

3. This analysis supports our view that the girl studied is a mosaic due to a pericentric inversion of one X chromosome, the chromosome formula being: 46, XX/46, X inv(X*p*−*q*+).

Plate I



Typical karyotype showing the X aberration.

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A SPONTANEOUS CHLOROPHYLL MUTANT IN HEXAPLOID WHEAT

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1. Introduction

Only a limited number of chlorophyll mutants have been obtained in hexaploid wheat, *Triticum aestivum* L emend Thell. This is a consequence of the duplicated genetic material which buffers deletion of genes effecting chlorophyll production.

Those mutants that have been isolated and studied involve intragenic changes or deletion or two duplicate loci (Sears and Sears, 1963), Neatby's virescent, a spontaneous mutant, and *chlorina-1,* an E.M.S.-induced mutant, are examples of the former and Hermsen's virescent, a spontaneous mutant, an example of the latter (Sears and Sears, *loc. cit.*). This paper reports on a further chlorophyll mutant, of spontaneous origin, which involves an intragenic change.

Biochemical analysis of this type of mutant is of interest as it is clear that the mutant gene is an active gene rather than a deletion. It could not be a deletion as all 21 nullisomics of hexaploid wheat are normal green. Such analyses which are lacking in organisms with duplicated genetic material, may eventually elucidate the genetic control of chlorophyll production and the mechanisms of genetic diversification in polyploids.