

Dependence of the Sex Ratio at Birth on the Age of the Father

RECENTLY I have attempted to develop a general theory of ageing applicable to mammals¹. This theory assumes that, during the life-time of the animal, whole chromosomes, which are contained in the somatic cells, suffer a total loss of function in a single random event. It further assumes that the probability of such an event remains constant throughout life-time and that it is the same for all individuals of a given species.

From the American life-tables I have derived, on the basis of the theory, the frequency with which such random events occur in man and found that on the average one chromosome, of the haploid chromosomal set of the somatic cell, suffers such a 'hit' in about twelve years. If we assume that this holds also for the spermatogonia in man, we should then expect that the ratio of boys and girls, at birth, decreases appreciably with the age of the father. This conclusion is based on the following notions :

We may assume that any cell of the male becomes non-functional if the *X* chromosome for which the cell is hemizygous suffers an ageing hit, that is, the absence of the *X* chromosomes is lethal for the somatic cell in the male. The absence of the *Y* chromosome is not lethal for the somatic cell and, as a matter of fact, it need not be lethal even for the zygotes ; there exist individuals whose cells contain one *X* chromosome and no *Y* chromosome and these exhibit Turner's syndrome.

Accordingly, if the *X* chromosome in a spermatogonium suffers an ageing hit, then the cell is eliminated; if the *Y* chromosome in a spermatogonium suffers an ageing hit, then the cell remains fully functional and will give rise to spermatozoa, but only to spermatozoa which contain an *X* chromosome.

The length of the *Y* chromosomes amounts to about 2 per cent of the total length of the haploid set of the autosomes² and on this basis we may perhaps assume that an average of 2 per cent of the *Y* chromosomes of the spermatogonia suffer an ageing hit in a 12-year period.

We may assume that some spermatogonia are lost due to causes other than ageing and are replaced by other spermatogonia undergoing divisions. Then if

Table 1

15-19 yr. (~ 46,000): 106.7;	20-24 yr. (~ 410,000): 105.7;
25-29 yr. (~ 590,000): 105.0;	30-34 yr. (~ 440,000): 105.0;
35-39 yr. (~ 250,000): 105.0;	40-44 yr. (~ 120,000): 104.1;
45-49 yr. (~ 45,000): 103.6	

spermatogonia which lack a functioning *Y* chromosome divide at the same rate as spermatogonia which carry a functioning *Y* chromosome, the ratio, at birth, of boys and girls would decrease by 2 per cent for a 12-years increase in the age of the father, and by 4 per cent for a 24-years increase. However, if the spermatogonia which lack a functioning *Y* chromosome undergo divisions at a somewhat lower rate, then the ratio of boys and girls would, initially, decrease with the father's age at the rate quoted above, but the ratio would approach a fixed value with increasing age of the father.

One may compute on the basis of birth data³ for the United States, 1955, the dependence of the ratio of boys and girls on the age of the father. For the age-group of the father indicated and for the sample sizes—for boys alone or girls alone—given in brackets, the ratios are as given in Table 1.

These data do not take into account the age of the mother, and there is, of course, a strong correlation between the age of the father and the age of the mother. What one would want to know is the dependence of the sex ratio at birth on the age of the father, for a fixed age of the mother. However, if one tabulates the available data on this basis the sample sizes become too small.

From the data given in Table 1 it would appear that the ratio of boys and girls does fall with increasing age of the father. It will not be possible, however, to draw conclusions which are relevant from the point of view of the theory until the data based on larger samples become available.

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¹ Szilard, Leo, *Proc. U.S. Nat. Acad. Sci.*, **45**, 32 (1959).

² Tijo, J. H., and Puck, T. T., *Proc. U.S. Nat. Acad. Sci.*, **44**, 1929 (1959).

³ "Vital Statistics of the U.S.", **1**, 213 (1955).