[29] Miss Hoffleit, *H. B.* (in press).

[30] Mrs. Payne-Gaposchkin, these PROCEEDINGS, **22**, 332 (1936); Zwicky, *Ibid.*, **22**, 557 (1936).

[31] Jeffreys, *M. N.*, **89**, 731 (1929).

[32] Eddington, *The Internal Constitution of the Stars*, p. 143 (1926).

[33] Milne, *M. N.*, **91**, 4 (1930).

[34] Baade and Zwicky, these PROCEEDINGS, **20**, 259 (1934).

OBSERVATIONS ON CHROMOSOME ELIMINATION IN THE GERM CELLS OF SCIARA OCELLARIS[1]

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Communicated February 15, 1939

One of the interesting problems that have arisen in the course of the work with Sciara concerns the time and manner of chromosome elimination from the germ line of this organism. Since the sperm regularly transmits an extra sex chromosome to the fertilized egg (Metz, Moses and Hoppe, 1926),[2] it necessarily follows that a subsequent elimination process must occur in order to maintain a constant chromosome number in the germ line (for general review see Metz, 1938).[3] The sperm contributes five chromosomes, one more than the haploid number, while the egg has the normal haploid number of four. Thus in the fertilized egg there are nine chromosomes. However, observations on the gonads of the early larval stage show that there are only eight chromosomes present. Therefore, one chromosome must have been eliminated at some early stage of development. It is the purpose of this paper to give some of the details of the process of elimination as it occurs in the germ cells.

DuBois (1932, 1933)[4] observed chromosome elimination from the somatic cells of *Sciara coprophila* during the early cleavage stages. In this species the "limited" chromosomes were eliminated at the fifth cleavage, and one ordinary chromosome in the female and two ordinary chromosomes in the male were eliminated at the seventh or eighth cleavage of the cells of the somatic line. In each case the eliminated chromosomes failed to complete the mitotic process and remained at the equatorial plate, thereby being excluded from the daughter nuclei. DuBois also found that the germ cells had migrated into the poleplasm previous to the time of chromosome elimination in the somatic cells, but her observations did not reveal any elimination from the cells of the germ line at that time.

In the present study observations on the chromosomes of the germ cells of *Sciara ocellaris* Comst., have been made from the time of their differentia-

tion to the formation of the gonads. These observations indicate that there is no chromosome elimination during the cleavage stages of the germ cells that is comparable to the process which occurs in the somatic cells, but that there is an elimination of one chromosome from the germ cells of both the male and female embryos after these cells have migrated to their future gonadal site. This elimination occurs from a resting cell and is apparently effected by the moving of the chromosome from its position within the nucleus directly through the nuclear membrane into the cytoplasm. The elimination occurs at a definite stage in embryonic development and approximately at the same time in all the germ cells of a single individual.

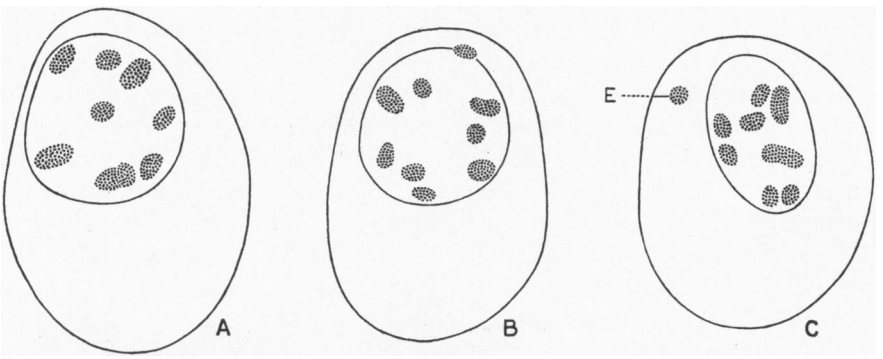

FIGURE 1

Camera lucida drawings from aceto-carmine preparations of cells in the germ line. × 1800.

A. A germ cell before migration, showing nine chromosomes.

B. A germ cell in which the one chromosome is being eliminated from the nucleus.

C. A germ cell after elimination has occurred. There are eight chromosomes in the nucleus and one in the cytoplasm (E).

The eliminated chromosome remains in the cytoplasm for several days and then gradually degenerates.

Within about seven hours after the eggs are laid, the germ cells complete their division stages at the pole and subsequently go into a resting stage (Fig. 1,A). This resting stage is maintained throughout the period of germ cell migration and for some time thereafter. The absence of mitotic activity in this period is shown not only by the observed absence of mitotic figures but also by the fact that the number of germ cells formed at the pole before migration occurs is equal on the average to the number found in the very young gonads. The chromosomes in the resting cells are in the form of diffuse but definite bodies ("prochromosomes"). There are nine of these in the nucleus of the early germ cells, but at a period in development when the caudal end of the embryo has completely surrounded the germ cell, one chromosome passes out into the cytoplasm of each germ cell. There-

after one chromosome is found in the cytoplasm and eight in the nucleus (Fig. 1,C). The body in the cytoplasm can be identified as a chromosome not only by its morphological features but also by the fact that it stains with the usual nuclear stains and gives a positive Feulgen reaction. This elimination is a regular process that occurs in the germ cells of all the developing embryos.

The exact mechanism involved in the process of elimination is not known. Observations just previous to the time of elimination do not reveal any characteristics to distinguish the chromosome which is to be eliminated from any of the others. This chromosome apparently does not undergo a change, nor does the nucleus as a whole appear changed in any way to facilitate the exit of the chromosome. There is no budding and the nuclear membrane appears to be present at all times. Numerous observations on stages just previous to and during elimination indicate that the chromosome that is to be eliminated at first comes into close contact with the nuclear membrane and then migrates through it into the cytoplasm (Fig. 1,B). Its movement through the nuclear membrane seems to be autonomous, but the activity is probably affected by some coördinating influence, since the process of chromosome elimination occurs in all the germ cells of a single individual at approximately the same time and in all individuals at a particular period in their development.

The eliminated chromosome cannot be distinguished morphologically from the other six rod-like chromosomes of the group, but genetic evidence shows that it is one of the two sister sex chromosomes contributed by the sperm (Metz, 1938).[3]

So far as the writer is aware this is the only instance known in which a chromosome is eliminated from the germ line, except during maturation, and is the only instance of the occurrence of a chromosome elimination from a resting cell. The bearing of the phenomena on the problem of chromosome movement and on sex determination will receive consideration elsewhere.

[1] The author is indebted to Dr. C. W. Metz, Department of Embryology, Carnegie Institution of Washington, for helpful criticism during the course of this work. The author is now at the Agricultural Experiment Station, A. and M. College of Texas.

[2] Metz, Moses and Hoppe, *Z. Abstammgslehre*, **42**, 237–270 (1926).

[3] Metz, C. W., *Amer. Naturalist*, **72**, 485–520 (1938).

[4] DuBois, A. M., these PROCEEDINGS, **18**, 352–356 (1932); DuBois, *Zeitschr. Zellforsch. Mikr. Anat.*, **19**, 555–614 (1933).