THE CHROMOSOMES OF THE CHICK SOMA.

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The accumulated evidence in favor of the chromosomes being in some way concerned with the determination and control of the somatic characters has become so impressive as to be almost unassailable despite the possible objection of a few that the last link in the chain (a demonstration of the actual activity of these nuclear bodies as hereditary character bearers), due to the deficiencies in our knowledge of cell chemistry, has yet to be forged. This latter point is one about which geneticists and cytologists are, at present, not greatly concerned and conclusive data upon the physiological behavior of the chromosomes does not seem at all imminent. While information is gradually accumulating in preparation for this final analysis much may still be accomplished by purely morphological studies with tentative interpretations of physiological activity based on these observations. A recent study of the chromosomes associated with sex in the chick (5) involved extensive observations on the chromosomes of dividing somatic cells, the results of which are recorded below.

OBSERVATIONS.

The technique of preparation (3), of counting and measuring the chromosomes, the amount and source of the material (5) have all been recorded and need not be repeated here. The chromosomes of over 150 cells have been drawn and studied. As the nervous system is the most actively growing of all the regions of the body the majority of the cells studied have naturally been found in some part of it. Cells with clear polar views of metaphase chromosomes have been found in the brain, neural tube,

[1] The observations recorded in this paper were made principally at the University of Pennsylvania during the writer's tenure of a National Research Council Fellowship.

optic cup, auditory vesicle, connective tissue, heart muscle, blood, amnion, gonads and in tissue cultures of muscles.

The Chromosome Number.—The difficulties involved in determining the exact number of chromosomes in the chick have been described in detail (5). Briefly, the trouble encountered may be said to be due, first to the extreme smallness of the shortest chromosomes of the complex making observation at times uncertain and second, to the apparent failure of the component granules of the smaller chromosomes to unite or at least to clearly indicate their proper relations to each other until late metaphase if indeed it really and always happens then.

The average number of chromosomes in the soma of the chick, based on 78 counts, is 33. I think that this is perhaps lower than the actual number which the most satisfactory counts indicate to be about 35 or 36. This variation in the chick is apparently due to a failure of the chromomeres or parts of the smaller chromosomes to unite rather than to fragmentation as in the case of the pig (1). This opinion is based upon the observations in the chick of larger numbers of distinct chromatin bodies (with occasional visible connecting threads between them) in the prophase than could be found in cells in later stages of mitosis whereas in the pig a reduction in the chromosome number as the metaphase was neared did not occur. The smaller chromosomes of the chick are the only ones concerned while in the pig the long ones are the ones that become broken up.

The Chromosome Form.—All of the longer chromosomes (about 12 in number) of the somatic cells are in the form of J's while the shorter ones are rods. Their structure and size relations (5) are alike in all the tissues studied including tissue cultures (4). The largest chromosome (chromosome pair in the male) of the complex has been shown to be the one associated with sex and is found in all somatic cells as clearly as in the cells of the gonads (5), Figs. 1 to 9. The female embryonic cells are heterozygous for this chromosome while the male cells are homozygous. No differences in the chromosomes or their behavior have been noted between any of the body tissues or in comparison with those of the embryonic germ cells.

Discussion.

The morphological data on the behavior of the chromosomes in the developing embryo, although admittedly scant, has so far given no clue to the manner in which the chromosomes may contribute their potentialities to the growing organism. Before a study of somatic chromosomes had been made it seemed reasonable to expect to find the various highly differentiated cells of the body with chromosome numbers, morphology or behavior at variance both with those found in other tissues and with the specific number and general characteristics found in the gonads. This has been found not to be the case in at least three forms, the pig (1), the evening primrose (2) and the chick (5). There was some fragmentation of the somatic chromosomes in the first two forms but it was shown that none of the chromatin was lost. Furthermore this fragmentation was neither specific for any particular tissue nor constant in amount. In general the chromosome situation in the soma seems to be entirely similar to that found in the unreduced gonad cells. This is a matter difficult to understand in the present state of our information. Of all the characteristics that must be controlled or borne by or at least associated with the chromosomes (as shown by the studies on *Drosophila*) few have any chance for expression in the majority of the somatic cells and tissues and must therefore be inhibited in one way or another. The cells of the lower forms of animal life largely retain the germ-like power of reproducing the portion lost or even an entire organism following injury. This power is perhaps even more marked in plants. As differentiation becomes more extreme in the animal kingdom the ability to regenerate a part or a whole animal from cells already specialized becomes less and less until in the highest types of animals somatic cells are usually able to produce only somatic cells like themselves. Yet the chromosomes in these highly specialized cells have, in the examples studied, been found to be entirely similar to those in the germ cells containing the possibilities for a complex animal or plant. This may suggest that the chromosomes are functionless in the differentiated Soma. Or it may be that having contributed their share in the production of the specialized tissue are thereafter inactive as far as are concerned the general somatic

attributes or determiners with which originally they must have been equipped. If the latter interpretation is correct the perpetuation of the complete mitotic mechanism in the soma as it exists in the reproductive organs may seem, as far as any need for an exact division of the genes is concerned, somewhat unnecessary, to be classed possibly with vestigial organs and having no more significance. In view of the great delicacy of the mechanism that exists in all cells for accurately dividing the chromatin the last suggestion does not seem impressive. But as far as our morphological data on the behavior of somatic chromosomes go, together with the behavior of the soma in growth and regeneration, the above suggestion is at least a possibility to be considered in our attempt to get at the physiology of development and genetics.

Summary.

1. The chromosome number in the somatic cells of the chick is about 35 or 36.

2. No characteristic differences between the number, the sizes, the morphology or the behavior of the chromosomes in comparison either with each other or with the cells of the gonads have been noted.

3. In view of the entire similarity of the somatic and germinal mitotic behavior and in consideration of the complete inability of highly specialized cells to regenerate other than cells similar to themselves it is tentatively suggested as a basis for future discussion that the somatic chromosomes, as far at least as their genetic function is concerned, have either become functionless or their cytoplasmic environment is incapable of reacting to the possibilities presumably carried by them.

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DESCRIPTION OF PLATE I.

All figures were drawn at table level with a Zeiss 1.5 mm. apochromat and a 15 × Orthoscopic ocular. They are reproduced at the size originally drawn. All are polar views of metaphase plates in chick embryonic cells with the exception of Fig. 5.

FIG. 1. From optic cup. 35 chromosomes.

FIG. 2. From amnion. 30 chromosomes.

FIG. 3. From a male gonad. 39 chromosomes.

FIG. 4. From neural tube. 32 chromosomes.

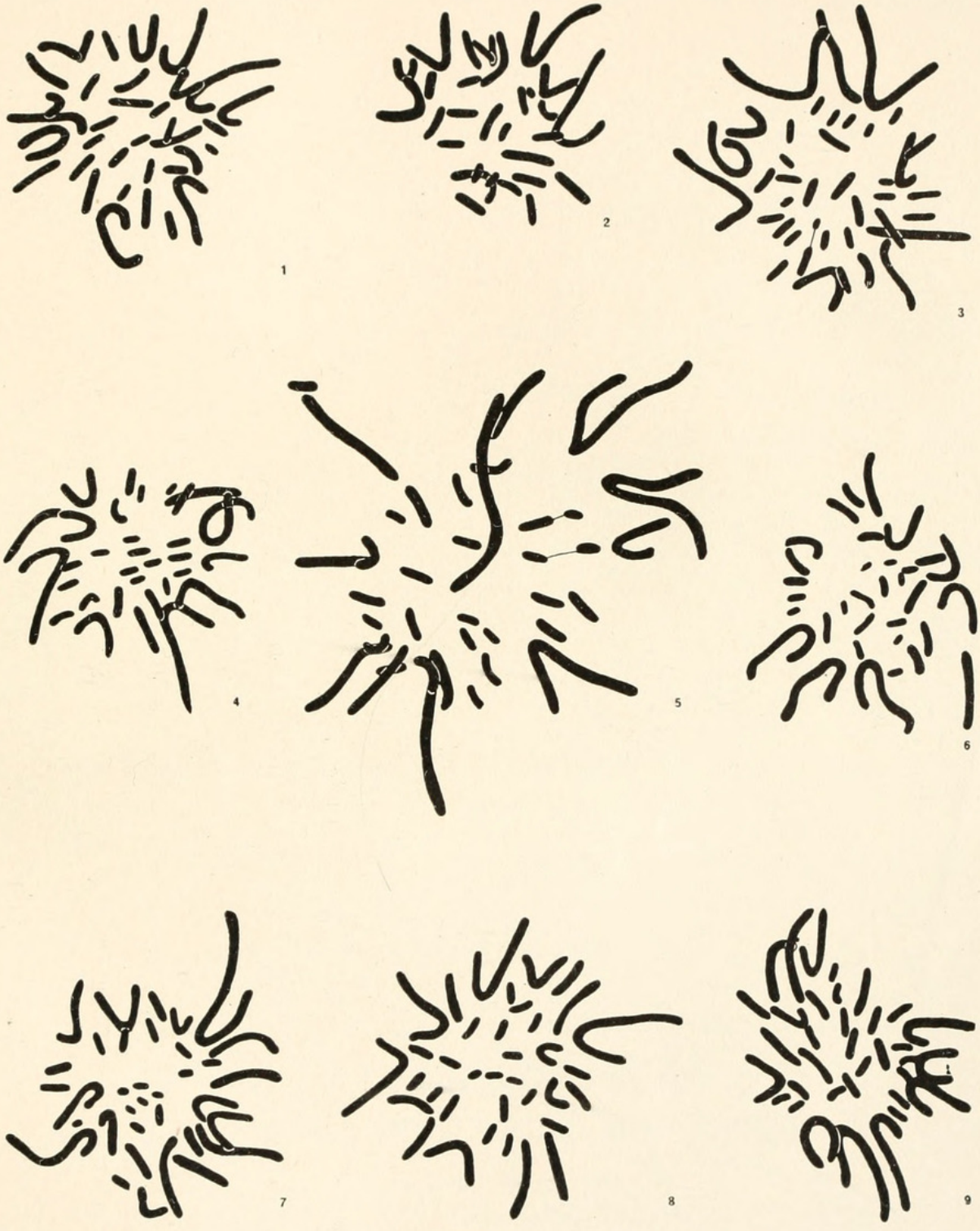
FIG. 5. Late prophase in connective tissue cell grown in a tissue culture. 38 chromosomes.

FIG. 6. From heart muscle. 33 chromosomes.

FIG. 7. From brain. 35 chromosomes.

FIG. 8. From female gonad. 36 chromosomes.

FIG. 9. From neural tube. 35 chromosomes.



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