

AXIAL DUPLICATION PRODUCED IN LOWER VERTEBRATES BY EARLY EXPOSURE TO ULTRAVIOLET RADIATION

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By means of early exposures of developing embryos of the chick and the salt-water minnow, *Fundulus heteroclitus*, it has been possible to induce the formation of axial duplications.

In the chick, it has been possible to produce only partial duplication, as for example, duplication in the region of the developing heart, or in the posterior somite region. Since the egg of the hen is already fertilized and the axis determined before laying, it has not been possible to induce the formation of double-headed forms by the means employed. The egg of the hen was removed from the incubator at various periods during development, and a window cut in the shell and shell membrane. The developing embryo was then exposed directly to the radiation from a quartz mercury-vapor arc, for short periods of time. The egg was again sealed, and replaced in the incubator and allowed to develop to the 72-hour stage, at which time it was compared to normal control eggs. Controls in each experiment were kept as follows: unirradiated, unoperated controls; unirradiated, operated controls; and controls radiated through the intact shell. Of the total number of malformations produced in this way, about 3 per cent of the embryos showed axial duplication of parts, most of them in the neural tube region.

A higher percentage of twin production was possible in *Fundulus heteroclitus*. The eggs of this fish were exposed at various intervals following fertilization. Since the eggs were obtained from the female fish by "stripping" and then fertilized in a dry dish and then washed free of excess sperm, it was possible to obtain embryos in which the axes had not yet been determined. By exposure to ultraviolet radiation just before the two-celled stage was reached, from 0.2 per cent to 12.5 per cent twinning was obtained in various experiments. Of exposures made at 12 to 96 minutes after fertilization, 12 out of 20 experiments showed twinned

embryos. There were varying degrees of twinning in the anterior region. Two completely formed heads, with a common body, appeared in some cases. In other experiments, typical autosite-parasite twins were formed. In these, one axis appeared to grow at the expense of the other, and the result was that there was formed one normal head, and a partly developed head appearing either laterally or ventrally to the normal head. In a few cases, the embryos were small, and both were abnormal. Such fish did not hatch. Double-headed fish, as described above, may possess either one or two hearts. In the latter case, the heart rhythms vary.

Twinning in the posterior region of the embryo was produced when exposures were made at a later stage of development, namely, when the germ ring is descending over the egg, at about twenty-five to twenty-eight hours after fertilization. A bifid tail is formed by exposures made during this period, but sometimes embryos which give promise of cauda bifida, later produce but a single, much-distorted tail, indicating a fusion of the temporarily separate growing regions.

For a review of the literature on twinning, the reader is referred to studies by H. H. Newman and by C. R. Stockard, to which references may be found in my paper on "*Fundulus Heteroclitus and Ultraviolet Radiation*," appearing in Jour. Morph. and Physiol., Vol. 41, No. 1, 1925.