

always takes place *perpendicular to the conductor*. Bok has called attention to the fact that in the living organism the nerve fibers grow out from the spinal cord *perpendicular to the long fiber paths* growing down from the brain stem. Kappers has tried to explain this as a galvanotropic phenomenon. To this observation, an interesting analogy is thus found in tissue cultures.

The hypothesis of Kappers, as the main result of this author's work on "neurobiotaxis," that electrical forces are determining factors in the outgrowth and distribution of the different constituents of the nervous system, has been proved to be a fact in pieces of the central nervous system of the chick cultured in vitro.

As several authors (Hyde, Mathews, Pfeffer) have pointed out, electrical currents flow in developing organisms. The currents successfully employed in our experiments correspond in range in electromotive force with those found in various embryos. From this it may be concluded that electrical forces play a rôle in the formative processes in morphogenesis.

106 (1566)

### Experiments on the lens in amblystoma.

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The embryo of *Amblystoma punctatum* has been reported as one of those in which the ectoderm normally giving rise to the lens is dependent upon the continued influence of the optic vesicle to effect its differentiation.<sup>1</sup> It was surprising, therefore, to find that in certain experiments, directed toward the study of the gills, lenses developed from the proper ectoderm when transplanted to regions far from the eye.

There are obviously two ways of testing the independence of lens differentiation: one is to take away the eye rudiment as has been done in previous experiments (Spemann, Lewis, Le Cron); the other is to transplant the lens-forming ectoderm to another

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<sup>1</sup> Wilbur L. Le Cron, "Experiments on the Origin and Differentiation of the Lens in *Amblystoma*," *Am. Journ. Anat.*, 1906-7, VI.

region of the embryo. The present experiments upon *Amblystoma* show that the results may be different in the two cases.

Excision of the eye rudiment in the medullary plate stage is followed by suppression of the lens. Likewise, if the optic vesicle is removed immediately or shortly after closure of the medullary folds, the lens fails to develop, as shown by Le Cron.

If, however, this same lens ectoderm is transplanted to other regions of the head, a well differentiated lens will develop, provided the ectoderm is taken from the eye region after closure of the medullary folds. Contact between optic vesicle and ectoderm has at this time been established, though the two are not adherent and may be readily separated without cells from one layer sticking to the other. If the lens ectoderm is taken in earlier stages, small and not fully differentiated lenses are sometimes but not always formed.

Barring one or two questionable cases, there is no evidence that, in *Amblystoma*, ectoderm from other parts of the head or from the trunk can give rise to a normal lens. When such ectoderm is transplanted to the eye region, even before closure of the medullary folds, abnormalities in the optic cup, due to irregular infolding, frequently arise and no lens develops. When a circular piece of ectoderm, having the diameter of the optic vesicle, is removed from the eye region, the surrounding ectoderm, which pushes in and covers the wound, usually gives rise to a lens, as Spemann found to be the case in *Triton*. When larger pieces of ectoderm are removed, the lens usually does not develop.

These experiments show that *Amblystoma* must be added to those forms in which the lens ectoderm is capable of self-differentiation. Why this power is manifested only when it is removed from its normal position and not when it is left in place after removal of the optic vesicle is problematical. The difference in behavior can scarcely be referred to differences in the degree of injury to the cells, but it is apparent that at times secondary circumstances of some unknown character may dominate more fundamental ones and thus lead to mistaken conclusions.