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# EFFECT OF REPEATED TRAUMATIZATION OF THE CENTRAL STUMP OF THE HYPOGLOSSAL NERVE ON DEGENERATION AND REGENERATION OF ITS FIBERS AND CELLS

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FOUR FIGURES

The purpose of this study was to determine the effect of repeated traumatization of the central stump of a nerve on its fibers and cells and on the extent of their regeneration in cats.

## PROCEDURE

This was the same for all nerves and for all experiments. It consisted of sectioning the nerve and cauterizing or pinching the central stump every two weeks for six to nine times. The maxillary nerve was selected for the first tests, because it was expected that it could be easily reached in the orbit after a preliminary enucleation of the eye, but after two or three traumatizations the stump of the nerve became surrounded by so much scar tissue that it could be located only after considerable dissection. The lingual nerve presented similar obstacles. The hypoglossal, however, proved especially adapted for this purpose. It is easily located laterally and superficially in the tongue musculature directly behind the mandible. Its cells are large and the Nissl substance coarse—making them ideal for the study of degeneration and regeneration.

Upon completion of an experiment, the animal was killed by bleeding or injecting air into the veins. Central pieces of the nerve some distance above the lesion and corresponding pieces of nerve from the uninjured side were removed, treated after the method of Marchi, and sectioned. The medulla was fixed in a mixture of alcohol, formalin, and acetic acid, sectioned, and stained with toluidin blue. If a neuroma had been formed at the central stump, it was excised, stained after the method of Ramón y Cajal, and sectioned.

### EXPERIMENT 1

An attempt was made in cat 230 to determine the extent of degeneration of nerve fibers and cells which would result from eight traumatizations of the central stump of the left hypoglossal nerve, the animal being killed two weeks after the last traumatization.

Marchi sections proximal to the point of injury demonstrate complete retrograde degeneration of the nerve fibers, identical in every way to the degeneration in cat 228, in which the nerve was cauterized but once at the time of sectioning.

Cells from the hypoglossal nucleus of the injured side (fig. 1) show an advanced degree of chromatolysis differing in no way from the chromatolytic cells of the hypoglossal nucleus of the lesion side of cat 228, where the nerve was traumatized only at the time of sectioning. These cells (fig. 1) reveal an absence of Nissl granules, some reduction in the size of the cells, a considerable decrease in the size of the nuclei, and frequently a peripheral arrangement of the nuclei.

Cat 240 was treated after the same manner as 230, except that the left hypoglossal nerve had fewer traumatizations (six). A comparison of the Marchi sections of the injured nerves and Nissl-stained sections through the hypoglossal nuclei of the injured nerves discloses the same type of degeneration in the two animals.

### EXPERIMENT 2

Experiment 2 differed from experiment 1 in that sufficient time was allowed after the last traumatization for regeneration to take place if this were possible.

In cat 232 the central stump of the left hypoglossal was cauterized or pinched every two weeks for nine times. Four months after the last traumatization, the animal was killed, and pieces of the injured and uninjured nerves, the medulla, and the neuroma formed about the traumatized trunk were prepared as described in the paragraphs on procedure.

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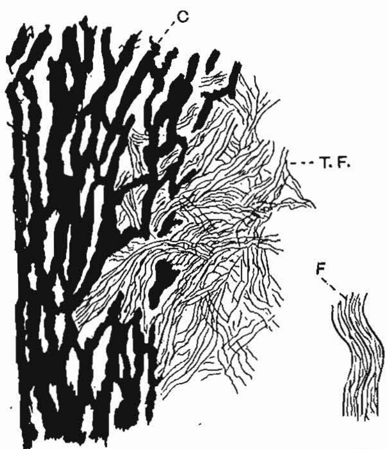


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Fig. 1 Camera drawing of a Nissl section through the hypoglossal nucleus from cat 230, showing chromatolysis produced from repeated traumatization of the central stump of the left hypoglossal nerve.

Fig. 2 Portion of a Ramón y Cajal section through a neuroma formed on the central stump of the left hypoglossal nerve. This animal was killed four months after a long series of traumatizations. Outlines made with a camera lucida.

It is clear from a study of the neuroma (fig. 2) that the thick connective capsule (*C*) is penetrated only a short distance by the great masses of terminal regenerated fibers (*T.F.*). The main nerve fibers in these sections (*F*) and in Marchi sections of the injured nerve appear perfectly normal in both transverse and longitudinal sections. The cells of the hypoglossal nucleus on the lesion side (fig. 3) become of especial interest when compared to those of the normal side (fig. 4) and to the chromatolytic cells of figure 1. These cells appear to have progressed some distance toward complete regeneration. Both the cells and their nuclei have regained their normal size and the latter are centrally located. The chief difference between these cells and the normal cells is in the much finer texture of the Nissl substance, as is readily shown by comparing figure 3 with figure 4.

Every section through the hypoglossal nucleus of the injured side of cat 232 reveals one or more chromatolytic cells and one or more chromatolytic cells undergoing disintegration, some of which are mere 'ghosts.' In the section from

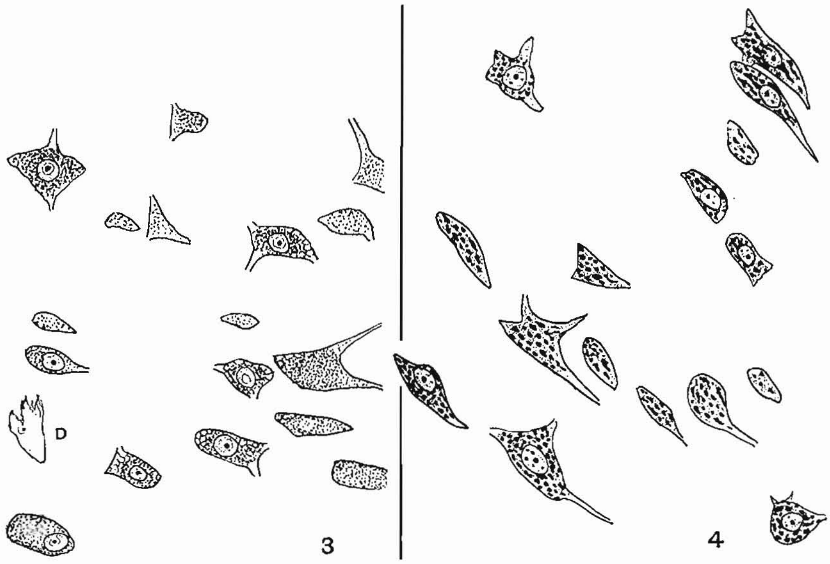


Fig. 3 Nissl section through the hypoglossal nucleus of the lesion side from the same cat as figure 2. Outlines made with the aid of a camera lucida.

Fig. 4 Same as figure 3, but made through the opposite hypoglossal nucleus, viz., the uninjured side.

which figure 3 was drawn there are some sixty-two cells in the hypoglossal nucleus of the injured side, two of which appear to be chromatolytic and one (*D*) is undergoing disintegration, while the remainder are of the type described above. In the caudal end of the nucleus the disintegrating and chromatolytic cells appear to be slightly more numerous. One section having some fifty-three cells shows six or seven disintegrating cells and about the same number of chromatolytic cells. An average number in any one section would be two or three disintegrating cells and the same number of chromatolytic; the total number of cells appearing in the section would lie between fifty and sixty. There are a few cells possessing the coarse Nissl substance of normal cells scattered through the hypoglossal nucleus of the injured side. They may be cells of fibers which left the nerve central to the lesion. By far the great bulk of the cells are of the fine-granular type.

Cat 233 was treated the same as 232, excepting that the central stump of the left hypoglossal was traumatized six times, instead of nine, and the animal was killed two weeks earlier (106 days after the last traumatization). Histologically, the hypoglossal cells, fibers, and the neuroma formed at the stump are identical with the same structures described for cat 232.

### EXPERIMENT 3

Cat 243 served as a control for experiments 2 and 1. The central stump of the left hypoglossal showed no trace of a neuroma in this animal, which was killed four months after one traumatization at the time of sectioning. The peripheral end of the nerve had regenerated anatomically and physiologically (shown by faradization). Marchi sections through the nerve central to the original point of severance and Nissl sections through the medulla disclosed perfectly normal hypoglossal fibers and cells on the injured side.

## COMMENT

It was not determined in experiment 2 whether there was any physiological significance in the remarkable resemblance of the Nissl substance of the hypoglossal cells on the injured side to the Nissl substance of the sensory ganglion cells. The appearance of a fine-granuled sensory type of Nissl substance in these motor cells may represent only a stage in regeneration in which these cells had stopped, or it may have further significance. It is unlikely that these motor cells could transmit motor impulses to the tongue muscles, even though they themselves received central stimulation. Since it appears to be well established experimentally that peripheral impulses can travel short distances centrally in a motor nerve, it is possible that the terminal nerve fibers of the neuroma in experiment 2 were stimulated from irritations and from other sources and that the hypoglossal nerve conducted these impulses to the neurons of the medulla, if not to higher centers.

The fine-granuled sensory type of hypoglossal cells which were prevented from stimulating the tongue musculature by a neuroma are also of interest if these central changes are compared to the peripheral changes which Boeke describes from joining the central stump of a motor nerve with the peripheral stump of a sensory nerve, and vice versa. As a result of suturing the central end of the lingual with the peripheral stump of the hypoglossal, the regenerated lingual developed motor endings on the muscle fibers of the tongue, and the hypoglossal fibers grew into the peripheral part of the lingual and formed sensory endings in the mucosa.

Boeke ('22) reviewed completely the general literature on degeneration and regeneration.

## SUMMARY AND CONCLUSIONS

In so far as could be determined, repeated traumatization of the central stump of the hypoglossal nerve in cats caused no more degeneration of the nerve fibers and cells than one traumatization at the time of sectioning the nerve.

Complete anatomical and physiological regeneration of the fibers and cells occurred in four months after one traumatization of the central stump of the hypoglossal nerve.

Histological sections of the central stump and of the nucleus of the hypoglossal, made three and one-half and four months after the nerve had been repeatedly traumatized, reveal: 1) a neuroma of the central stump; 2) normal nerve fibers; 3) normal cells for the most part, possessing a very fine sensory type of Nissl substance. There are a few chromatolytic and disintegrating cells scattered through the nucleus.

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