ment of an x-irradiated mouse. The markedly improved survival in vitro of these cells offers an experimental system for the study of the factors which may be responsible for expression of these potentials in vivo or their repression in vitro.

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Function of the Dorsal Motor Nucleus of the Vagus

Abstract. *The dorsal motor nucleus of the vagus was destroyed in cats. After periods of survival ranging from 9 to 44 days the response of heart, bronchi, esophagus, and duodenum to stimulation of the distal end of the cut cervical vagus was within the normal range or slightly depressed. It is concluded that the dorsal motor nucleus is not a major source of visceromotor fibers.*

It is generally accepted that the dorsal motor nucleus (DMN) of the vagus is the source of visceromotor fibers to the heart, bronchi, and gastrointestinal tract. This concept is based on the observations of Marinesco (*1*) that retrograde chromatolysis reaches its peak in this nucleus 6 days after cervical vagotomy and that the neurons in the DMN do not have the cytologic characteristics of those of the hypoglossal and ambiguus nuclei, which are known to innervate somatic musculature. The relatively rapid onset of chromatolysis was, in Marinesco's opinion, a strong argument in favor of the DMN neurons' being motor rather than sensory, as had been proposed by previous workers. Cajal (*2*), who had regarded them as sensory neurons up to that time, reinvestigated the problem with the use of the Golgi technique and was able to follow their axons into the emerging vagal rootlets. Accordingly, he revised his opinions and concurred with Marinesco's view that neurons in the DMN were motoneurons that innervated visceral smooth muscle. This concept has remained almost unchallenged, with the exception of Szentagothai's (*3*) report in which he notes that after electrolytic lesions in the dorsal motor nucleus he was unable to find a single degenerating fiber in the intra-axial vagal rootlets. His observation was in conflict, however, with that of Cajal and with the occurrence of retrograde degeneration after vagotomy as described by Marinesco (*1*), a finding that has been confirmed by subsequent investigators, who also described a rostrocaudal organization of this nucleus according to the level at which vagotomy was performed (*4*). The possibility that the retrograde chromatolytic changes might be on a transynaptic basis is remote, because of the brief time course to maximum change, as pointed out by Marinesco (*1*), and because no terminal degeneration appears in the DMN after vagal rhizotomy (*5*).

Electrophysiological studies of the DMN that employ techniques for recording single units have only recently been reported. Urabe and Tsubokawa (*6*) found that these cells could not be fired antidromically from the cervical vagus, a finding that we [Kerr and Higgs (*6*)] noted several years ago at a time when we were unaware of their report. Calaresu and Pearce (*7*) have also raised the question whether at least some of the cardioinhibitory vagal fibers may have an origin other than the DMN, and before that several other authors had suggested that these fibers arose from the nucleus ambiguus.

In the experiments reported here, 20 adult cats were used. In the first stage of the experiments the floor of the fourth ventricle was exposed under nembutal anesthesia and the DMN was destroyed unilaterally by means of an incandescent filament 6 mm long and 0.08 mm (0.003 inch) in diameter. After periods of 9 to 44 days, the 15 surviving animals were reanesthetized, and responses of the heart, bronchi, and gastrointestinal tract to electrical stimulation of the cervical vagus, both ipsilateral and contralateral to the lesion, were monitored by means of Statham strain gauges attached to catheters in the aorta, esophagus, and duodenum and to the trachea. Respiratory exchange was controlled by a Harvard pump respirator that operated at frequencies of 8 to 12 per minute and with stroke volumes of 75 to 100 ml; bilateral thoracotomies were done in all animals.

Histological controls were made in every instance; serial frozen sections (20 μ thick) were made of the medulla in the transverse plane and were stained by the Luxol fast blue and Nauta techniques. In two experiments the DMN was widely destroyed, in a third all but about 40 neurons were destroyed and these showed variable degrees of damage. In all four experiments the DMN was uninjured, and in the remainder only partial destruction was obtained.

Figure 1 shows the result of stimulating the distal end of the cut cervical vagus (6 volts; pulse duration, 1 msec; frequency, 10 per second) 44 days after extensive destruction of the DMN. The cardioinhibitory vagal effect (tracing No. 1) is within the normal range of activity, the esophageal response (tracing No. 2) is present both as an "on" and an "off" response, and a marked duodenal response (tracing No. 3) is seen. The bronchiolar constrictor response (tracing No. 4) is unsatisfactory in this record, although normal bronchiolar constrictor responses have been recorded from similar experiments. The two bottom lines indicate onset and end of stimulation. The time line at mid-left corresponds to 10 seconds. On the left, blood pressure is given in millimeters of Hg, and esophageal and duodenal pressures, in centimeters of

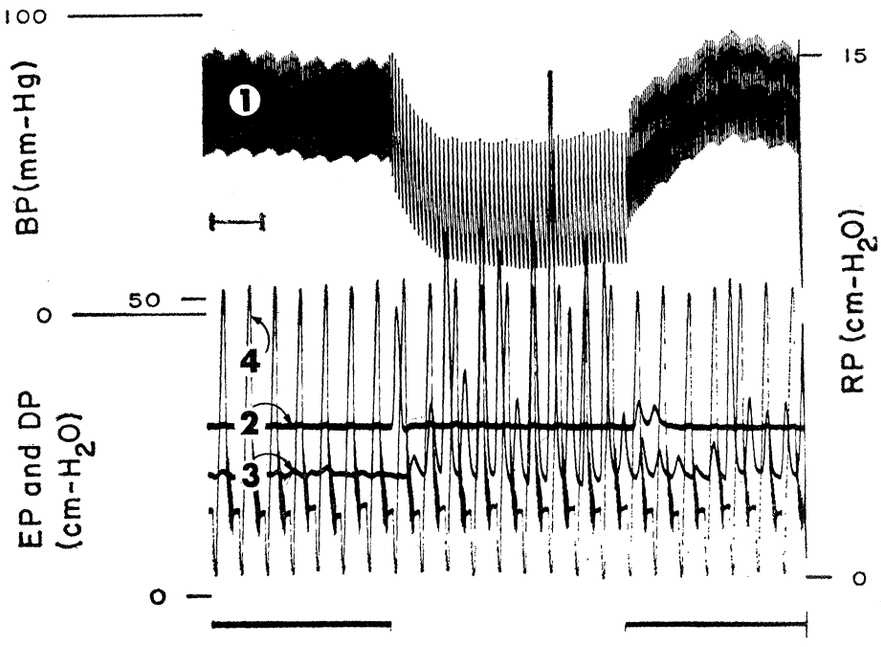

Fig. 1. Visceromotor responses to stimulation of the distal end of the transected cervical vagus 44 days after destruction of the ipsilateral dorsal motor nucleus. *BP*, blood pressure; *EP*, esophageal pressure; *DP*, duodenal pressure; and *RP*, respiratory pressure.

H_2O; on the right, respiratory pressure is given in centimeters of H_2O.

The response to stimulation of the cervical vagus on the unoperated side was similar to that shown in Fig. 1. It should be noted that in normal animals there are frequently moderate differences in intensity of visceromotor response to stimulation of right and left vagi, particularly with regard to the cardiodecelerator effects. When the nucleus was only partially damaged, no alterations in visceromotor responses were observed, as might be expected.

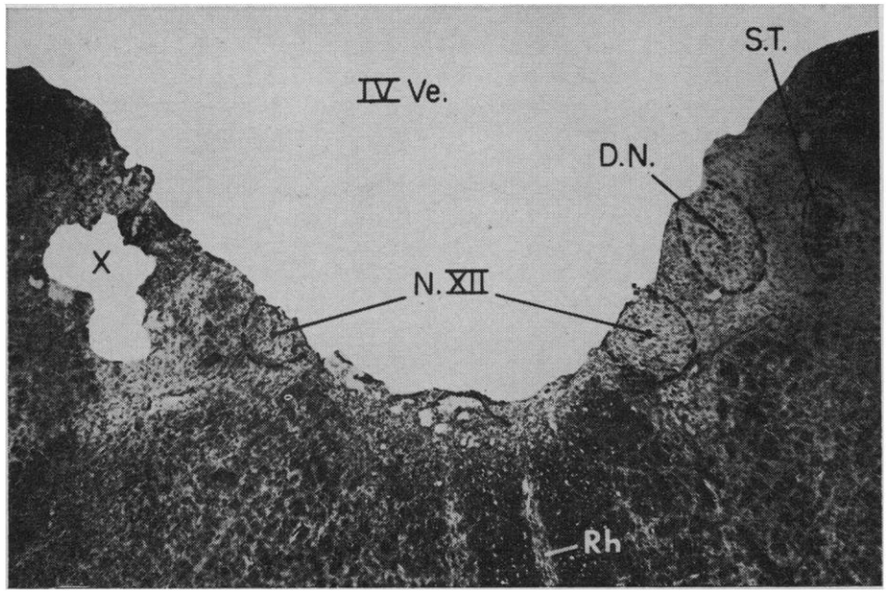

Fig. 2. Transverse section through the floor of the fourth ventricle (*IV Ve.*) from the experiment in which the tracing in Fig. 1 was obtained. *N.XII*, hypoglossal nucleus; *D.N.*, dorsal motor nucleus of the vagus; and *S.T.*, solitary tract. The area of the lesion is indicated by *X*. Some asymmetry between right and left sides of the medulla is secondary to residual edema resulting from the lesion.

Figure 2 shows the extent and location of the lesion in this experiment. Serial sections from a level below the obex to the rostral end of the DMN showed extensive destruction of this nucleus, as in this representative example in which examination at higher power revealed few surviving DMN neurons.

Presently available evidence concerning the relation of the DMN to the vagus nerve suggests that the axons from these neurons do in fact run in the nerve. Results presented here show that it is not the major visceromotor nucleus related to contraction of the wall of the viscera, and that the long-held assumption that the DMN controls visceromotor function should not have been as readily accepted as it was on the basis of cytology of the neurons and retrograde chromatolysis. It is concluded from these experiments that most, if not all, vagal fibers to smooth muscle in the viscera arise elsewhere than in the DMN. Since a viscerotopic localization has been found in this nucleus by authors employing the technique of retrograde chromatolysis following vagotomy at various levels (*4*), it is possible that the nucleus provides secretomotor fibers to the epithelial glandular structures throughout the viscera innervated by the vagus. This, however, can be regarded only as a working hypothesis until further data have been obtained.

From studies in this laboratory it appears that the neurons responsible for vagal visceromotor activity lie in the vicinity of the nucleus ambiguus over a rostrocaudal extent that corresponds to that of the DMN.

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