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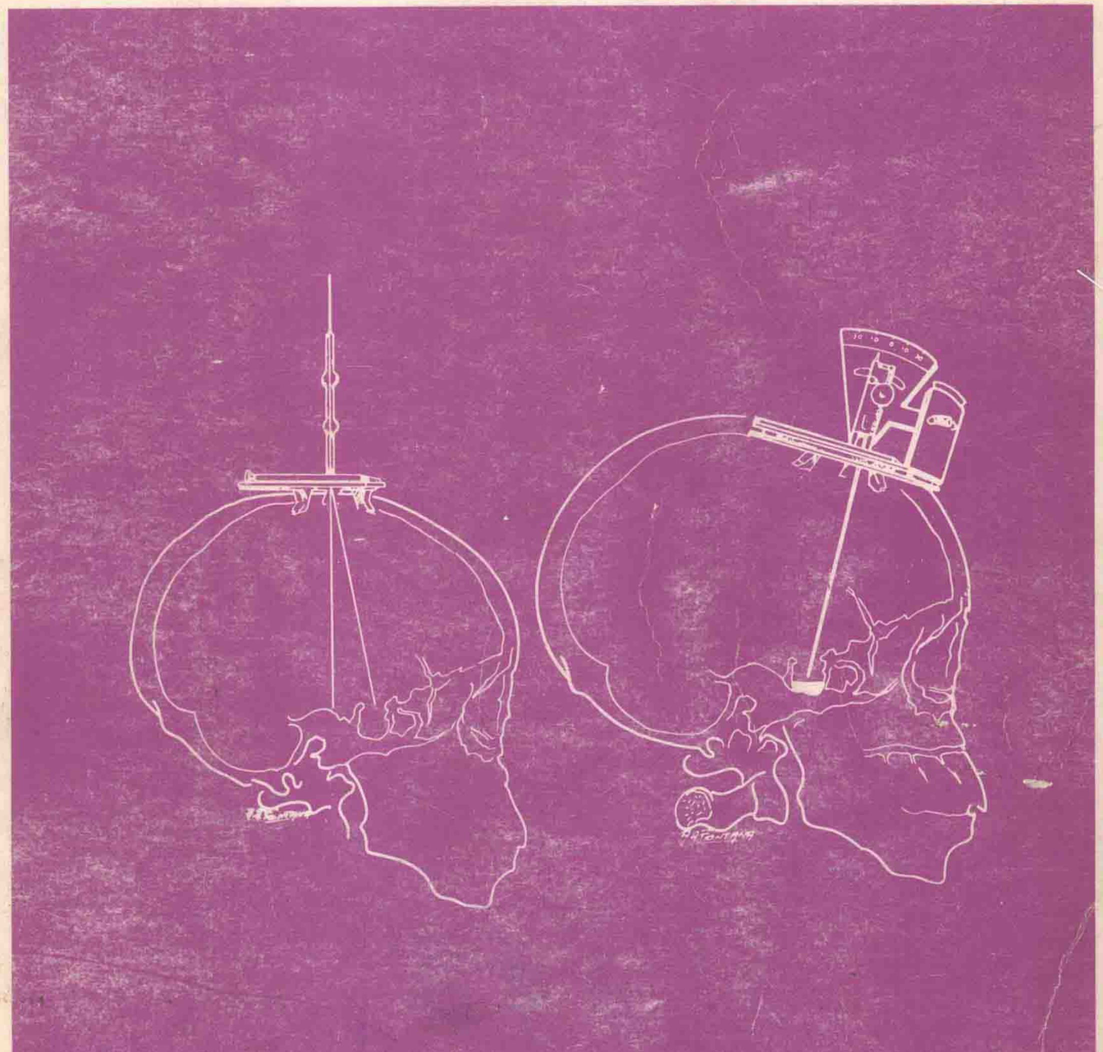
Advances in Stereoencephalotomy

Vol. 7 Sixth Symposium of the International Society for Research in Stereoencephalotomy, Tokyo 1973

Editors: H. Narabayashi and Philip L. Gildenberg



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Tokyo, October 12–13, 1973

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H. Narabayashi, Tokyo, and Philip L. Gildenberg, Tuscon, Ariz.

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Advances in Stereoencephalotomy

Vol. 7

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Commemoration of Dr. Henry T. Wycis

Ladies and gentlemen, Henry Wycis is no longer with us for he died on 30th June this year. This large, amiable man with his curious apologetic modesty would never allow you to understand that here was one of the two great pioneers of a startling new scientific method in surgery. As one of the younger men who met him many years ago, he was always encouraging, enthusiastic and defended his ideas to the last, and most of them have stood the test of time. This warm-hearted man took his modesty and care of people to those who lived near him on holiday. He and his family took a small cottage in a remote area of Nova Scotia and enjoyed taking the medical care of the community in which he stayed. Here he loved to fish when he could in the midst of his busy practice and on one occasion nearly lost his life. He was a philatelist, an entomologist and a splendid photographer and, of course, this played a great part in his excellent visual presentations at scientific meetings.

Very early his destiny as a doctor and scientist became clear. As a student he worked in the Institute of Dr. Spiegel in Philadelphia and acquired the basis of experimental investigation. Later he continued his education and worked at Temple University Medical School, but his mind and motivation had been captured by Dr. Spiegel. He made a great impression on his senior colleagues and ultimately he became Clinical Professor of Neurosurgery.

He was the Attending Neurosurgeon at the St. Christopher's Hospital for Children, at the Philadelphia General Hospital, at the Veterans Administration Hospital, at the Bloomsburg Hospital and at the Burdett-Tomlinson Memorial Hospital. In 1947 he became a Fellow of the American College of Surgeons. He was Honorary and Corresponding Member of the French, Scandinavian, German and other Neurosurgical Societies. He was President of the Philadelphia Neurological Society, Member of the Harvey Cushing Society, the American League against Epilepsy and the American EEG Society. But these activities were merely the furnishings and backcloth of this man's life. The light and activity in it began to shine with increasing brilliance with his association and work with Dr. SPIEGEL. They startled the medical world in 1948 by the application of CLARK and HORSLEY's animal stereotaxy to the great therapeutic benefit of man. But the full significance of what they had begun is only now being realised. Not only have we seen the great therapeutic benefit in a broad field of chronic neurological disorders but now the uncovering of the basic mechanisms of some of these diseases. Little did they realise, I am sure, of the full implication of those first operations for Huntington's chorea and psychiatric disorders. Previously open operative approaches to the solution of these problems had been too clumsy and associated with a high mortality and morbidity because of crossing the cerebral cortex and its immediate sub-cortical structures. The stereotactic technique allowed WYCIS, for the first time, to operate with an up to then unexpected precision and low morbidity.

For the first time it was possible to use electrophysiological studies in man for the improvement of localisation of target sites and gain important and additional knowledge of brain structure and function, both pathological and physiological, motor, sensory, visual, intellectual and emotional. Operations were more safely and satisfactorily carried out on the conscious patient and this itself with the patient's own co-operation has led to a vast increase in knowledge – now extending to the spinal cord in stereotactic spinal surgery. This would have been beyond VICTOR HORSLEY's wildest dreams as one of the earliest surgical neurologists working on the spinal cord. Now we have all the additional help of advanced radiological apparatus such as computerised transaxial tomography, depth microelectrode recording and audiomonitoring, stimulation and impedance techniques. New areas of work are being explored such as the possibility of aneurysm thrombosis using the proton beam and the work on pituitary ablation.

Perhaps of equal importance, Dr. SPIEGEL and HENRY WYCIS were responsible for the foundation of this Society. Their attitude from the first was that it should be international, and I well remember that first historic meeting and the underlying excitement of that moment of history as our secretary HENRY WYCIS carried on the business informally and easily, and the Society has prospered. His devotion to its prosperity and the underlying hard work is only too clearly evident now that he is no longer with us.

For his scientific work he was awarded outstanding honours and in 1965 he was awarded an honorary doctorate of science of his university.

F. JOHN GILLINGHAM

The International Society for Research in Stereoencephalotomy

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Fiber Connections within the Extrapyramidal System

Chairmen:
J. GILLINGHAM, Edinburgh, H. NARABAYASHI, Tokyo

Proc. 6th Symp. Int. Soc. Res. Stereoencephalotomy, Tokyo 1973, part I
Confin. neurol. *36:* 205–222 (1974)

Connections of the Basal Ganglia and of the Cerebellum

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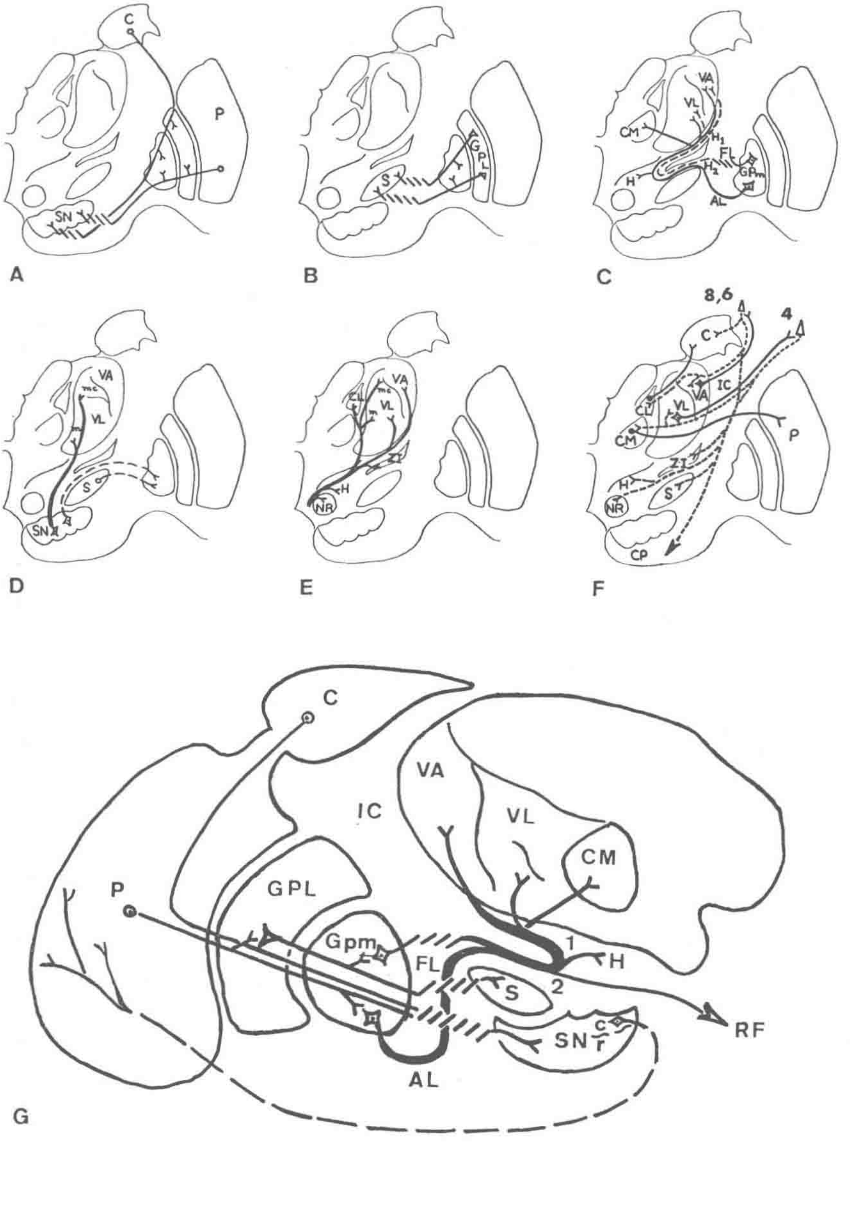
and Massachusetts Institute of Technology, Cambridge, Mass.

The results of modern experimental studies of the efferent fiber connections of the chief basal ganglion components and the history of their gradual discovery during the last century have been reviewed *in extenso* by the authors [NAUTA and MEHLER, 1966] and others [CARPENTER and STROMINGER, 1967; KUO and CARPENTER, 1973]. Several accounts of basal gangliar fiber systems based on observations on normal and diseased human brains have also appeared [SMITH, 1967; BECK and BIGNAMI, 1968]. The present report is intended, therefore, to serve chiefly as an updated review of recently demonstrated intra-thalamic relationships of efferent fiber projections of basal gangliar structures and the cerebellum [MEHLER, 1971].

'Basal ganglia' is a nebulous term. Generally, it is used to refer to some or all of the major subcortical gray masses at the base of the forebrain. These include the striatum (caudate nucleus and putamen), globus pallidus, claustrum, and amygdala. Not much is known about the claustrum and there is little evidence relating it to any of the diseases of the basal ganglia. The amygdala is also enigmatic, but studies have indicated that it is functionally associated with the hypothalamus; hence the amygdala is generally regarded as being part of the limbic system [VON BONIN, 1959; NAUTA and HAYMAKER, 1969]. Certain other nuclei, such as the subthalamic nucleus and the substantia nigra, are often also included among the basal ganglia. There is little anatomical justification for this because the subthalamic nucleus, unlike the telencephalic striatum, is a diencephalic derivative, and only the pars reticulata of the substantia nigra is embryologically related to the globus pallidus. However, in view of their prominent interconnections with the caudoputamen and globus pallidus, and their involvement in certain extrapyramidal dyskinesias, there is some justification in including these structures in the category of the 'basal ganglia'.



Connections of the Corpus striatum and the Substantia nigra

Certain other definitions also are necessary. For example, the term 'striatum' is here used to denote the caudate nucleus and putamen, both of which are composed of similar small-sized cells and some larger neurons that appear in a ratio of about 20:1 in Nissl preparations. Golgi studies and EM analysis of the caudate in the monkey [Fox *et al.*, 1971] and cat [KEMP and POWELL, 1971a, b] suggest several other cell types, some of which are apparently intrinsic to the striatum.

Afferent connections of the striatum originate from at least three sources: the cerebral cortex, certain thalamic intralaminar nuclei and the substantia nigra. The cortical projection upon the striatum is massive. Nearly all cortical regions participate in a cortico-striate projection which is organized in a strip-like spatial pattern [KEMP and POWELL, 1970]; putaminal connections originating from the pre- and postcentral gyri are significant [PETRAS, 1969, 1972]. In fiber degeneration preparation these cortico-striate connections seem to separate at right angles from fibers traversing the striatum in the internal capsule suggesting a collateral origin. KEMP and POWELL [1971c] also have Golgi method evidence indicating capsular fiber collateral origin of striatal afferent connections.

The thalamus was considered the chief subcortical source of striatal afferent connections until recently. For example, the intralaminar nuclei

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Fig. 1. A–F Transverse sections. *A* Striatonigral connections. *B* Connections of the lateral pallidum. *C* Connections of the medial pallidum. *D* Nigrothalamic and pallidal connections. *E* Brachium conjunctivum-diencephalic connections. *F* Thalamocortical, thalamostriatal, and corticodiencephalic connections. *G* Schematic sagittal summary of the striato-, pallido-, and nigro-fugal fiber projections and interconnections. After MEHLER [1969b].

AL	ansa lenticularis	IC	internal capsule
C	caudate nucleus	NR	red nucleus
CL	central lateral intralaminar nucleus	P	putamen
		RF	reticular formation
FL	fasciculus lenticularis	S	subthalamic nucleus
CM	nucleus centrum medianum	SN	substantia nigra; c, pars compacta; r, pars reticulata
CP	basis pedunculi		
GPL	globus pallidus, lateral segment	VA	ventral anterior nucleus (mc–magnocellar part)
GPM	globus pallidus, medial segment	VL	ventral lateral nucleus (m–medial part)
H, H_1, H_2	H-fields of Forel	ZI	zona incerta

centralis lateralis and parafascicularis have been found to project to the caudate, whereas the centrum medianum projects preferentially to the putamen [POWELL and COWAN, 1956; MEHLER, 1966a]. All three of these thalamic areas receive afferent connections from diverse subcortical and/or cortical regions (fig. 1E, F) [MEHLER, 1966b, 1971].

A third important system of striatal afferents has recently been established. It originates in the substantia nigra (SN), chiefly the pars compacta. The existence of this connection was suggested years ago by the appearance of cell atrophy in the substantia nigra following massive striatal lesions. Despite this evidence, the failure of anterograde techniques (both Marchi and Nauta-Gygax) to reveal more than sporadic fiber degeneration leading to the striatum from lesions in the substantia nigra raised doubt as to the actual existence of a nigro-striatal projection. This observation posed the question whether the nigral cell atrophy, instead of being retrograde in nature, might not represent a transneuronal phenomenon caused by the degeneration of the well-documented striato-nigral connection. Recent studies utilizing the Flack-Hillarp fluorescence-histochemical method and other techniques, however, have brought forth evidence of an ascending system of extremely fine, dopamine-laden fibers extending from cell bodies in SN to terminal plexuses dispersed throughout the caudoputamen that probably constitute the main vehicle of transport for striatal dopamine.

Experimental evidence indicates that this fine fibered reciprocal nigro-striatal dopaminergic pathway originates in the pars compacta, ascends in the lateral part of the medial forebrain bundle, filters through the internal capsule and distributes mainly to the caudoputamen [POIRIER and SOURKES, 1965; MOORE *et al.*, 1971; HEDREEN and CHALMERS, 1972; CARPENTER and PETER, 1972; MALER *et al.*, 1973].

Another ascending nigral connection, which is non-fluorescent and more easily demonstrated by light microscopy, is a *nigro-thalamic* projection originally described by a co-worker and the authors [COLE *et al.*, 1964] in the cat and confirmed to exist in the rat [FAULL and CARMAN, 1968], cat [AFIFI and KAELBER, 1965] and monkey [CARPENTER and PETER, 1972]. Its exact nigral origin has been obscure. A collateral fiber origin from the nigro-striatal projections, which originate from the dopamine rich cells of the pars compacta, has been suggested, but the idea of such an origin is incompatible with known histochemical differences in the two fiber systems.

Initial studies of clinicopathologic material to ascertain the origin of