MODERN TRENDS
IN
NEUROLOGY

(SECOND SERIES)

Edited by

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The contents of this present volume is quite independent of that in the first series, and the two books should be regarded as companion volumes

CONTENTS OF FIRST SERIES

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PREFACE

THE MODERN TRENDS series presents the Editor with an accepted title which must be honoured in the contents, and it has therefore been my prime aim in inviting contributors and selecting material to follow the title literally. I think that the two dozen essays all have contemporary interest, and each essayist was invited because he had something to say; some are senior, some junior but each has written about a subject that really interests him. Any could have been invited to contribute in his own right, but each was chosen because of his known interest. His instructions were to assume a high level of knowledge in his readers, to review current work critically and concisely, and to follow the trend of his work as far into the future as scientific propriety will allow. If the essays and their bibliographies are short that is to the contributors' credit, the editor's blame, and the readers' benefit.

Of course many subjects are missing either by design or default. There has been little attempt to dovetail into, or continue from the First Series edited by Dr. Anthony Feiling, since each volume should reflect its epoch, and not even the immediate past. There is little overlap of subjects or of subject matter, and each essay is as complete in itself as rapidly advancing knowledge will allow.

There is a bias towards the basic sciences upon which neurological medicine and surgery stand, and clinical description is minimal. Thus ten chapters are directly concerned with anatomy, physiology and pathology, and all the contributions are built upon these subjects. But it is to be noticed that workers are increasingly concerned with experiment and application, so that the boundaries between each subject are indistinguishable and no research worker, however specialized, can be just a specialist. That this paradox is a reality today is strikingly exemplified in Professor Lumsden's two chapters in which many sciences meet in their application to neurology. Notice too that Neurology is a generic term, including all the basic scientific study of the nervous system, in health and disease, by chemistry or dissecting, by physician or surgeon. As many of the essays are surgical and pathological as are written by physicians. It should not matter greatly that more are written by British authors than by authors overseas, for travel and exchange of knowledge is today so rapid that personal or national bias is as easily avoided as detected.

It remains to thank the contributors for their willing help and forbearance and the publishers for their efficiency, and to assure the reader that as this volume has appeared so few months after the invitation to undertake its direction, the trends it describes are indeed modern.

DENIS WILLIAMS

January, 1957

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CHAPTER 1

RECENT ADVANCES IN THE ANATOMY OF THE NERVOUS SYSTEM

P. W. NATHAN

INTRODUCTION

IT MIGHT be thought that men have studied anatomy for so long that little remains to be discovered. Advances, however, continue to be made in two ways: by re-exploring already charted territory, and by exploring new land. Within the realm of re-exploration and re-interpretation, the subjects that have received particular attention in recent years are the mode of ending of nerve fibres in the skin, and the origin and course of the fronto-pontine tract. Within the realm of opening up new territory, investigations have been made of the connexions of the thalamus and of the hypothalamus, and of the location in the spinal cord of the pathways subserving micturition and defaecation.

All statements in this chapter refer to man; no work concerning other species will be discussed.

NERVE ENDINGS IN THE SKIN

The classical conception of the modalities of sensation is that there are four basic kinds of sensation—touch, warmth, cold and pain—and that each of these is subserved by specific nerve fibres ending in specific end organs; free nerve endings are thought to subserve only pain sensibility.

Weddell and his collaborators in Oxford have established that all four modalities of sensation are present in skin having none of the specific nerve endings usually supposed to subserve them. The skin of the human auricle does not contain any of the classical organized nerve endings; and yet touch, warmth, cold and pain can be felt on this skin. Again, all four modalities of sensation can be felt on the red part of the lip and on the adjacent hairy skin; various kinds of encapsulated nerve endings are present on the red part; they are all absent from the hairy part. It has been known for many years that the only kind of end organ in the centre of the cornea consists of free nerve endings; Weddell has shown that in this region touch, thermal sensations and pain can all be felt.

According to Weddell and his collaborators, cutaneous nerves end in three different ways: (1) As a series of widely-disseminated filaments ending freely between cells; (2) as a series of filaments in relation to hair follicles; (3) in circumscribed, usually encapsulated, aggregations of filaments. Whatever the significance of these end organs, each kind of nerve ending is not devoted to a different sensory modality. The fine, naked nerve filaments, ending between cells, are found in the epidermis, in the dermis, and in relation to blood vessels and sweat glands. The fibres running to the hair follicles are myelinated, but before each of these large fibres ends, it breaks into a profusion of fine naked filaments which form a basket-like network around the shaft. Some filaments encircle the hair-shaft and end freely in the middle layer of the dermal coat; others run parallel to the hair-shaft to end freely among the cells of the outer root sheath. Encapsulated nerve endings occur in glabrous skin and in mucous membranes; in these capsules the stem axon branches, breaking up into short, fine, naked nerve filaments, which, branching repeatedly, terminate among the cells of the capsule. Thus in the skin all nerves ultimately terminate as fine, naked nerve filaments, and these filaments always terminate between, and never within, the cells of the tissue supplied. It will be realized also that the histological examination of any nerve filament cannot show from what type of parent fibre it was derived.

Modalities of sensation without specific end organs

Time and space

Those who conceive the difference in cutaneous sensory modalities as being an effect of different types of end organs connected to different sizes of nerve fibres will ask how the various modalities of sensation can be subserved without specific end organs. In our present state of knowledge it seems that the peripheral apparatus of sensory conduction depends on only two variables, that is time and space. The variable of time covers the rate of conduction of impulses and the number of impulses conducted per unit time. The variable of space covers the number and distribution of nerve fibrils stimulated. Regarding the rate of conduction, the difference between nerve fibres is so wide that the fastest conducting nerve conducts a hundred times faster than the slowest conducting nerve. Regarding the spatial arrangement of the nerve fibrils, any point on the skin is supplied by nerve fibrils from two directions, from beneath the point and from around the point. A stimulus will set up impulses in a certain number of fibre filaments, which supply the spot stimulated from these two directions. It is thought that the various forms of stimulation, such as light touch, heavy pressure, radiant heat, set up certain temporo-spatial patterns of impulses in the axons, and that this gives rise to a similar pattern of activity among certain neurones in the central nervous system, and that the interpretation of this pattern of activity is learnt during the early years of life.

In the classical view of cutaneous sensibility, much was made of the fact that points can be found in the skin where certain sensations are most easily obtained, and that spaces can be found between the points where certain sensations are not easily obtained. The fact that cutaneous sensibility can be examined in such a way as to bring these features into prominence supports the conception of specific nerve endings no more than the conception of a temporo-spatial pattern of stimulation of naked nerve fibrils. The network of receptors, whatever their nature, is not so dense that there are no spaces in the skin lying relatively far from any receptors. With fine (and unnatural) forms of stimulation, such spaces can be found; similarly spots can be found where certain artificial forms of stimulation will initiate that temporo-spatial pattern of impulses that is interpreted as a certain sensation at a certain point. To those who established the classical view, our present conception did not occur. The fact that temperature points or touch points could be found indicated to them only one thing; that there must be a specific apparatus subserving these points. As, in our present conception, we imagine that learning to interpret a pattern of impulses arriving in the central nervous system plays an important part in our discrimination of sensations, we see no reason for recognizing four basic modalities; there is an infinite number of sensations. The only limitation to discussing them is the difficulty of finding adequate terms in which to do them justice.

FRONTO-PONTINE TRACT

The operation of leucotomy has given an opportunity to re-investigate the fronto-pontine tract (Arnold's bundle or pre-fronto-pontine tract). Beck (1950) has shown that the tract arises from the lateral and dorsal convexities of the frontal lobe. The areas giving origin to the tract are 6/FB, 8/FC, 9/FD, 45/FD gamma, and 46/FD delta.*

The fibres converge to form a tract at the level of the anterior tip of the globus pallidus. In the peduncle, the tract occupies the medial sixth, being adjacent to, and perhaps intermingled with, the fibres of the cortico-bulbar tract. It terminates within the medial fascicles of the pons.

CONNEXIONS OF THE THALAMUS

The thalamus may be seen as the great centre concerned with the reciprocal reactions between the individual and the external environment. In spite of its importance it is only within the last thirty years that the connexions between the thalamus and the cortex above it and between the thalamus and the hypothalamus and other structures below it have been studied in detail. Here, as so often occurs, anatomical investigation has followed the demands and opportunities made by clinical medicine; in this instance the various forms of leucotomy have been the main spur to anatomical investigation. To the neurologist the investigation of this territory is particularly interesting, for it opens up vistas of an eventual science of psychology based, as such a science eventually must be, on the anatomy and the physiology of the nervous system.

Pattern of thalamo-cortical projection

The fundamental pattern of thalamo-cortical projection is simple. If one were to place a small ovoid inside a larger one and to join every point on the inside ovoid to the nearest point on the outside ovoid by the shortest line, then one would have the fundamental pattern of the thalamic projections to the cortex. The cells of the medial part of the thalamus project to the medial part of the cortex, the cells of the dorsal part to the dorsal convexity of the cortex, the cells of the lateral part to the lateral convexity of the cortex, the cells of the posterior part to the posterior parts of the cortex, and the cells of the rostral part of the thalamus to the rostral parts of the cortex.

* Wherever possible, cortical areas are given with Brodmann's numerical classification and von Economo's and Koskinas' literal classification.

Division of thalamus and subthalamus

Various ways of dividing the thalamus and subthalamus have been proposed; here the division made by Kuhlenbeck (1954) on morphological grounds will be used. The nuclei will be considered as follows: (1) anterior group; (2) medial group; (3) nuclei of the midline; (4) intralaminar group; (5) ventro-lateral group; (6) posterior group; (7) pretectal group; (8) reticular nucleus; (9) zona incerta; and (10) ventral parts of lateral and medial geniculate bodies. Groups (8), (9), and (10) form part of the subthalamus; the function of these structures is not yet known.

The connexions of these nuclei will be given in the following order: first the infrathalamic connexions, covering all fibres coming to the thalamus from structures other than the cerebral cortex; secondly the suprathalamic connexions, covering the fibres going from the thalamus to the cortex; thirdly corticofugal fibres to the thalamus; and fourthly a recapitulation of the main connexions, presented as circuits relaying in the thalamus.

Infrathalamic connexions

Anterior group

The anterior group receives the mammillo-thalamic tract from the mammillary bodies of the hypothalamus.

Medial group

The largest nucleus of the medial group is the nucleus medialis (also called the nucleus medialis dorsalis or dorso-medial nucleus); some workers divide this nucleus into a pars magnocellularis and a pars parvocellularis. The nucleus medialis may be thought of as an intermediate station between the hypothalamus and the frontal cortex. The main inflow to the nucleus is from the hypothalamus, and it runs in the periventricular system. This nucleus receives also many fibres from other parts of the thalamus, particularly from the nuclei of the midline and the ventro-lateral group. These short intrathalamic fibres also run in the periventricular system. According to Hassler (1950), the nucleus medialis receives fibres from the oral third of the globus pallidus and from other parts of the basal ganglia.

The medial group of nuclei contains also the centro-median nucleus (or centrum medianum) and the nucleus parafascicularis. According to Hassler (1950), the centro-median nucleus receives fibres from the superior cerebellar peduncle originating in the nucleus emboliformis of the cerebellum. The nucleus parafascicularis lies ventral and medial to the postero-medial part of the nucleus medialis and medial to the centro-median nucleus.

Nuclei of the midline

The midline nuclei receive fibres from the hypothalamus *via* the periventricular system.

Intralaminar group

The intralaminar group receives fibres from other parts of the thalamus. According to Hassler, the nuclei of the lamella medialis receive fibres from the medial lemniscus.

Ventrolateral group

Some authors call this group of nuclei the external or the lateral ventral thalamic segment. It is divided by Kuhlenbeck into the following nuclei: (a) nucleus ventralis anterior; (b) nucleus ventralis lateralis; (c) nucleus ventralis postero-lateralis; (d) nucleus ventralis postero-medialis; (e) nucleus subparafascicularis; (f) nucleus submedius; (g) nucleus medialis ventralis; (h) nucleus lateralis dorsalis; and (i) nucleus lateralis posterior.

This nuclear mass may be looked on as the great sensory nucleus of the thalamus. This however does not imply that fibres subserving sensation go only to this nucleus, nor that this nucleus is not an essential station on motor pathways. Fibres subserving sensation from every part of the body (except the special senses, although fibres subserving taste probably run here) run to this group; the spino-thalamic tract, the medial lemniscus, and the trigeminal lemniscus end here. There are connexions between these nuclei and the lateral and medial geniculate bodies, which subserve the special senses of seeing and hearing. It is likely that there are also fibres derived from the vestibular system ending in this nucleus. Hassler (1949) considers that there is a direct vestibulo-thalamic tract, running in Forel's tegmental fasciculus, and also a tract running from the nucleus interstitialis that he considers to be vestibular, and also fibres from the opposite vestibular nuclei running in the median longitudinal bundle. The ventro-lateral group are also connected *via* the periventricular system of fibres with the hypothalamus and with subthalamic nuclei; the nuclei receive fibres also from the tectum, and many fibres from other parts of the thalamus.

The nucleus ventralis anterior is intimately connected with the basal ganglia. The nucleus ventralis lateralis receives impulses from the cerebellum and from the globus pallidus. The cerebellar fibres come from the dentate nucleus, mostly contralaterally; they come to the thalamus in the superior cerebellar peduncle; most of them run directly to the thalamus, but some form a synapse in the parvo-cellular part of the red nucleus. The globus pallidus sends two bundles of fibres, each taking origin in a different part of this structure; the one forms part of the fascicularis or ansa lenticularis (H1 of Forel), while the other forms a large part of the fasciculus thalamicus (H2 of Forel).

Posterior group

Kuhlenbeck considers this group as consisting of: (a) pulvinar; (b) corpus geniculatum laterale, pars dorsalis; (c) corpus geniculatum mediale, pars dorsalis; and (d) nucleus suprageniculatus.

Fibres subserving seeing and hearing run to this group; primitively the dorsal parts of the two geniculate bodies formed a part of the main sensory ventro-lateral nucleus, and they remain connected to this nucleus. The pulvinar, which is an outgrowth of the nucleus ventralis postero-lateralis, also remains connected to this nucleus, and to the dorsal and posterior lateral nuclei. It does not receive any direct sensory fibres, although its functions are undoubtedly sensory. It is probable that it is concerned with the integration of somatic sensory, auditory and visual functions.

Pretectal group

Not all the pretectal nuclei form a part of the thalamus. The pretectal nuclei receive fibres from the medial lemniscus and thus receive sensory fibres from the