

NEUROLOGICAL ANATOMY

In Relation to Clinical Medicine

THIRD EDITION

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Preface

THE SCOPE and aim of the third edition of this book are the same as those outlined in the preface to the second edition (see below), to which the reader is referred for a general orientation. It should be emphasized that the book is not intended to serve as a systematic textbook of neuroanatomy. In general, purely topographical relations have accordingly been little dealt with. For information on this subject the reader should consult some of the available atlases, for example DeArmond, Fusco, and Dewey's (1976) or Nieuwenhuys, Voogd, and van Huizen's (1978).

In the ten years that have passed since the publication of the second edition, our knowledge in all fields of the neurological sciences has increased with an ever-accelerating speed. This is the case not least in neuroanatomy, due first and foremost to the development of several new methods, to be considered in Chapter 1. The new data have given us a picture of the structure of the central nervous system which encompasses a complexity that we should not have imagined ten years ago. This is true also in the fields of neurophysiology, neurochemistry, neuropharmacology, and behavioral and communication research.

Only a fraction of the new anatomical information can as yet be satisfactorily correlated with observations in clinical neurology; consequently only a few of the findings can be of immediate value in practical medicine. However, there are other reasons why it is important for the clinical neurologist to be aware of essential results of recent research. An insight into present-day knowledge of the structure and function of the nervous system will aid in evaluating the frequent deviations—seen in the clinic—from the textbook descriptions of symptoms, signs, and syndromes. Second, insight of this kind may initiate thinking about problems and may foster ideas about how to explain certain symptoms and how to elaborate refined testing methods of neurological disorders in man.

Today it is virtually impossible for a single author to cover the entire field of neuroanatomy in a satisfactory way. I am very grateful, therefore, for the assistance offered by my son, Assistant Professor *Per Brodal*, M.D., and by my friends and colleagues, Assistant Professor *Kirsten Kjelsberg Osen*, M.D., and

Professor *Eric Rinvik*, M.D., all of the Anatomical Institute, University of Oslo. They have assisted me in the revision of Chapters 2, 3, 4, 8, and 9. Some chapters or parts of chapters have been entirely recast. Some 75 new figures have been added, while some of the old ones have been deleted.

The amount of new data from research in recent years is enormous. What should be included for thorough consideration in the third edition of a book like this, what might be treated more superficially, and what can be neglected? To some extent, decisions about these matters must be subjective. To give a balanced presentation of the entire field is virtually impossible. Much relevant information has certainly not been considered as fully as some readers might have wanted. Other readers, on the other hand, may find that too many details have been discussed. It is inevitable that the numbers of pages and references have increased considerably. It has not been possible to include references to all papers relevant to a particular item. The choice of authors to be quoted has of necessity often been arbitrary.

Several friends and colleagues have read through parts of or complete chapters and given valuable advice concerning special subjects about which they have firsthand knowledge. Professor Emeritus of Neurosurgery, K. Kristiansen, M.D., and Associate Professor of Neurology, B. Vandvik, M.D., University of Oslo, have given special consideration to the clinical questions treated in the book. I am greatly indebted to all these friends and colleagues for advice and constructive criticism. However, the responsibility for errors and omissions that are to be found in the text rests entirely with myself and my coauthors.

The expert technical assistance given by the artists of the Anatomical Institute, the late Mrs. Nanti Stang-Lund and Mrs. Kari Øztürk, and the photographer, Mr. E. Risnes, is gratefully acknowledged. Valuable assistance has further been given by the Institute's librarian, Miss Wenche Sandberg. I am deeply indebted to Miss Oddlaug Gorset for indefatigable and conscientious help during the preparation of the third edition in typing the manuscript and secretarial assistance of various kinds. It is hardly an exaggeration to say that the preparation of the third edition would not have been possible without the assistance of the collaborators mentioned above. My sincere thanks, therefore, go to the present head of the Anatomical Institute, my close collaborator for many years, Professor Fred Walberg, M.D., for putting the technical facilities of the institute at my disposal and for assistance of many kinds during the work.

The careful scrutiny of the English of the manuscript by Miss Ellen Johannessen is greatly appreciated. I would also like to thank the editors of journals and many colleagues in various countries who have given permission to reproduce illustrations from their publications.

It is a pleasure to extend my thanks to the staff of Oxford University Press for an agreeable collaboration and for their efforts to make this a better book.

Finally, I would like to thank my wife for a lifelong enduring patience and forbearance during my preoccupation with the present and other works, and for encouragement and valuable criticisms.

From the Preface to the Second Edition

Of all the natural phenomena to which science can turn its attention, none exceeds in its fascination the working of the human brain. Here, in a bare two-handful of living tissue, we find an ordered complexity sufficient to embody and preserve the record of a lifetime of the richest human experience. We find a regulator and co-ordinator of the hundreds of separate muscle systems of the human body that is capable of all the delicacy and precision shown by the concert pianist and the surgeon. Most mysterious of all, we find in this small sample of the material universe the organ (in some sense) of our own awareness, including our awareness of that universe, and so of the brain itself.

D. MACKAY (1967)

SOME TWENTY YEARS have passed since the first edition of this book appeared. During this time there has been a steadily increasing activity in all fields of neurological research, which has furnished us with a wealth of new information on the structure and function of the nervous system. As a consequence of our increased knowledge, many points of view have had to be modified. Some traditional concepts have had to be discarded; new ones have been created. For example, there is no longer any justification for retaining the traditional concept of the "extra-pyramidal motor system," as will be discussed in Chapter 4. On the other hand, the neurological literature has been enriched with concepts such as the "ascending reticular activating system," "the limbic system," and others. In order to proceed in research we obviously have to create concepts as tools in the formula-

tion of working hypotheses. However, we are often inclined to forget the limited validity of such concepts, particularly when a concept is verbalized in a simple and catching fashion. This tendency of the human mind has been aptly characterized and ridiculed by Goethe:

Denn eben wo Begriffe fehlen,
da stellt ein Wort zur rechten Zeit sich ein.
Mit Worten lässt sich trefflich streiten
mit Worten ein System bereiten.*

The neurological literature furnishes numerous examples of the truth of this dictum. Much confusion and unnecessary disputes have arisen because a sufficiently clear distinction has not been made between facts and hypotheses, between observations and interpretations. There is little doubt that many concepts which are at present accepted and in general use will in the future have to be considerably modified or even abandoned. The speed with which new information is forthcoming makes it more important than it was some decades ago to keep incessantly in mind the provisional tenability of current concepts. This, however, is not as easy as it may sound.

The author has felt this very strongly in the preparation of a second edition of this book. Largely due to the accumulation of new data our views are today on many points quite different from those accepted twenty years ago. It has therefore been necessary to rewrite entirely several chapters and sections of the first edition. For the same reason it has been difficult to decide what to include in the text, and to make clear what may be considered as established and what is still hypothetical. The main criterion in the selection of data to be presented has been to retain the original aim of the book: to bridge the gap between basic neurological sciences and clinical neurology, with particular reference to correlations between the structure of the nervous system and its functions as revealed in man under normal and pathological conditions.

Like the first edition, the present does not pretend to be a systematic textbook on neurological anatomy, nor is it a textbook of clinical neurology. Some subjects are discussed in considerable detail, others are treated only briefly, and still others are not dealt with at all. Attempts have been made to include anatomical data which may be of interest from a clinical point of view. However, certain subjects are selected for more comprehensive consideration, in order to convey an impression of contemporary problems in the field of neurological research, even if the subjects are not of immediate practical interest. Results of neurophysiological research have been incorporated insofar as they can be correlated with structural features and can be understood by a writer who is not a neurophysiologist. More specific neurophysiological problems are not considered. The extensive new data

*For just where fails the comprehension,
A word steps promptly in as deputy.
With words 't is excellent disputing:
Systems to words 't is easy suiting.

Goethe: *Faust*, First Part, Scene IV.
Translated by Bayard Taylor, Strahan & Co.,
Publishers, London, 1871.

in neurochemistry and neuropharmacology will be mentioned only to a limited extent. This is due to two circumstances. In the first place the author's knowledge of these subjects is too limited to permit a fuller treatment. Second, at the present state of research, data from these fields can only in few instances be definitely correlated with structural features. Likewise, most of the attempts made by workers in the field of neurocommunication to prepare models or theories of the brain or parts of it are not considered. Interesting as they may be, most of the models and theories are still of rather limited interest from the clinician's point of view.

With the enormous literature in the neurological sciences of today it is virtually impossible to give references to all relevant publications, nor would this be practical. In the selection of references to original publications, preference has in general been given to recent papers (in them interested readers will find references to previous publications). Furthermore, attempts have been made to give credit to authors who have been the first to report a new observation. Finally, where reviews or monographs are available, these are mentioned. However, the selection of references will of necessity be to some extent arbitrary, and it cannot be avoided that some papers which ought rightly to have been included are left out.

OSLO

May 1968

A. Brodal

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THIRD EDITION

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1

Introduction, Methods, Correlations

BEFORE DEALING with different parts of the nervous system certain generalizations with regard to its anatomy must be considered, since this will facilitate an understanding of the material dealt with in this book. It is necessary first of all to look briefly at the methods we have at our disposal for the investigation of the anatomy of the nervous system and especially its fiber connections.

Structure and function. Anatomy is one of the fundamental branches of medicine, but anatomy alone, without relation to function, is a somewhat barren study, for it is function which primarily interests us in medicine. Some knowledge of the structure of organs and organisms is a necessary prerequisite for the understanding of their function. In fact, a knowledge of structure will often yield information on functions which have not been elucidated by other data. It is now recognized almost as an axiom that where structural differences are found there are also functional differences and vice versa. To take a simple example from the nervous system, one can, as is well known, differentiate between the somatic and visceral efferent nuclei in the brainstem. On some occasions it is not clear that there are structural differences, but this may be due to the inability of our present methods to bring more subtle differences to light.

In neurology a knowledge of structural features is perhaps more important for an understanding of function under normal and pathological conditions than in any other branch of medicine. Symptoms produced by diseases of the nervous system can be multifarious and involve different functions and components of functions, according to which different structures are affected. By clinical examinations we attempt to analyze the functional conditions and to understand the extent to which normal functions have been altered. The better our knowledge of the anatomy of