

PREFACE

MY earliest scientific interests were aroused by an introductory collegiate course in psychology under Professor E. B. Delabarre. This course of instruction left me in an inquiring state of mind concerning what seemed to me to be the fundamental principles of psychology—the nature and interrelation of sensation, perception and thought. Eventually this attitude ripened into a decision to enter upon graduate study in psychology. But before an opportunity came for me to carry out this decision I became aware that the natural approach to the kind of psychological information I wanted lay through the physiology of the nervous system. Obviously, also, the physiology of the nervous system must be approached through its anatomy, about which I knew nothing.

As a matter of great good fortune, just at this juncture in my reasoning, I fell under the immediate instruction and inspiration of the late Professor Clarence Luther Herrick, who, with his characteristic personal devotion to the student, and with all the material resources at his command, encouraged me to begin studies on the comparative anatomy of the nervous system, and suggested *Amblystoma* as an appropriate form for my investigations. Work of this nature, the purpose of which was to analyse the peripheral nervous system upon the basis of functional units according to the conception of nerve components, brought me at once under the influence of my first great teacher's brother, Professor C. Judson Herrick. In the first of these two brothers I found the inspiration and opportunity to

enter the field of scientific inquiry; in the second, I have enjoyed these many years a constant influence of orientation and stimulation in neurological work. To these two men I cannot estimate how much I owe in the methods of study and interpretation of the questions presented in the lectures which constitute this book. Certainly my debt to them is very great.

In the progress of my studies I soon met the conventional neuroanatomy; but this was disappointing to me, as it apparently still is to those who are psychologically inclined, as a foundation for thinking along the lines of my chief interests. Certain fundamentals for physiology and pathology, of course, were there: the neurone, the conduction path, cortical localization of motor functions, sense organs, etc.; all leading up to the conception of the nervous system as a telephone or telegraph with its conductors carrying "messages," a conception that seemed to me utterly inadequate and misleading. Nevertheless, questions concerning the comparative anatomy of functional units of the nervous system held my interest as a possible approach to a more satisfactory interpretation of the nervous system until the rapidly developing literature upon animal behaviour, or comparative psychology, suggested to me the idea of making parallel studies of the development of behaviour and the development of the nervous system. It seemed to me basic to a scientific study of behaviour to know whether the behaviour pattern of an animal develops haphazard or in an orderly manner; and that, if it should be found that behaviour develops in an orderly manner, then there should be a corresponding order of development structurally and func-

tionally in the nervous system. Should such correlation be found to occur, it seemed to me that the development of behaviour would offer a new basis for the interpretation of nervous structure and function, and that the development of the nervous system would throw new light on problems of behaviour. Meanwhile I found myself engaged in neurological studies upon animals that were ideal for such a correlated anatomical and physiological inquiry, *Amblystoma* and its near relatives.

At about the time I began on the Pacific coast my studies upon the correlation of structure and function in the development of the nervous system of amphibians, Stewart Paton began similar studies upon amphibians and fishes on the Atlantic coast, each of us unaware of the other's work or interests. Paton began his work, as he states, with the intention of describing "some of the more important of the earliest reactions of the embryo to stimulation, and then noting in a parallel column the synchronous morphological changes in the nervous system." The aim of his first published report upon his studies (The reaction of the vertebrate embryo to stimulation and the associated changes in the nervous system. *Mittheilungen aus die zoologische Station zu Neapel*, Bd. 18, June, 1907) was "to describe some of the more striking phenomena that occur in the embryo at the time when the first cardiac beats and earliest responses to external stimulation begin, and then to determine in a general, but not in a specific, way how far these reactions are dependent upon the functional activity of the nervous system." "This problem," he says, "is essentially different from the far more difficult

task of trying to determine the links between the two sets of facts." His conclusions relate to the myogenic and neurogenic origin of movement and to the origin and physiological significance of neurofibrils. Paton's studies on the correlation of structure and function in the development of the nervous system are, therefore, along very different lines from mine. His correlations concern general processes and general structures; mine relate to specific relations in definite behaviour processes (see citation of literature, 12 *a, b, c*).

The leading results of my studies upon the correlation of structural development of the nervous system with the development of behaviour are presented in the first lecture. But the work is by no means complete. Although, from what has already been accomplished, it is clear how the nervous system maintains the integrity of the individual while the behaviour expands in scope and increases in complexity, it remains still to determine more precisely the structural basis for the individuation of partial patterns (reflexes) within the total pattern. Of course it is not anticipated that every response of adult animals can ever be exactly explained in detail by structural organization and development; but it is reasonable to hope that the general mechanistic and dynamic principles that are basic to the individuation and conditioning of behaviour can be determined, and that the anatomical foundation of these principles can be made of much more immediate use to psychology than the conventional anatomy that has long been in vogue as an introduction to elementary textbooks on the subject.

The topic treated in the second lecture thrust itself

into my problem in the early period of my studies, particularly in connection with the origin of the motor root fibres; and it was about this time that Professor C. M. Child began to publish his interpretation of the physiological gradient as a factor in the regulation and development of organisms. This interpretation appealed to me at once as possibly applicable to the problem of why conduction paths grow as they do in the central nervous system of *Amblystoma*, and soon after this Professor Child published his book, *The origin and development of the nervous system*, which makes specific application of the principle of physiological gradients to the development of the nervous system. Although, as pointed out in the text, there are minor differences in detail between Professor Child's interpretation and mine, I cannot make too generous acknowledgment to him for the use I have here made of his conception of gradients.

In the third lecture my original interest in psychology presents itself in an effort to interpret, in terms of behaviour, the results that are recorded in the first and second lectures. But I must state here definitely that I do not regard myself as a psychologist. My ambition to study psychology still lingers; but it can in all probability never be realized. If this attempt to apply new facts to the behaviour problem, or to psychology in its broadest sense, should prove to be wide of the mark, the facts themselves remain. It is hoped at least that their presentation in the present necessarily brief form may lead to wholesome discussion and eventually make for progress in biological interpretations of psychological problems.

I am indebted to Dr Engelbrekt A. Swenson for the motion pictures from which Figs. 3, 4 and 5 were traced; and to Dr R. C. Baker for permission to use Figs. 33 to 41 inclusive. The drawings are by Miss Dorothy Harris.

Especially would I gratefully acknowledge my indebtedness to the University of London for the privilege of speaking upon my work in University College, and to Professor G. Elliot Smith and his colleagues of the Institute of Anatomy for their gracious personal hospitality while I was a guest among them.

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PHILADELPHIA, PENNSYLVANIA, U.S.A.

15 June 1928