FUNDAMENTALS OF

Neurology

GARDNER

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Neurology

Third Edition, Illustrated

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To LaVearl Gardner

Preface to the Third Edition

IN THE present revision, special attention has been paid to sensory endings, particularly those in muscle, to vision, and to basal ganglia. It also seemed worth while to provide a brief account of neurochemistry, an important field of increasing importance. In bringing material up to date, new illustrations have been added, and some replaced.

Certain arrangements are unchanged. The references cited are intended to provide the interested student with a starting point for further reading. The short biographical sketches are of those men whose names are mentioned in the text, or who were outstanding in neurology.

I am indebted to Evelyn J. Erickson of the Department of Medical Illustration, and to Mrs. Geraldine Fockler of the same department, for their preparation of the illustrations. I am also indebted to Mr. Charles Pickard and Mr. Robert Wright of the Department of Medical Photography for aid in preparation of illustrations.

I wish to thank Dr. Ferdinando Morin, Department of Anatomy, Wayne State University, Dr. Otto Neuhaus, Department of Physiological Chemistry, Wayne State University, and Dr. Frederick Crescitelli, Department of Zoology, University of California at Los Angeles. All contributed valuable criticisms and suggestions during the preparation of the revision, particularly in connection with the chapter on neurochemistry.

Special thanks are due my wife, LaVearl Gardner, Mrs. Barbara Stopke, and Miss Gwen Gerada, for typing the manuscript.

Finally, I am indebted to the W. B. Saunders Company for the help and many courtesies they extended me.

ERNEST GARDNER

Detroit, Michigan
February, 1958

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CHAPTER 1

Descriptive and Analytical Methods

THE MATERIAL in this volume is based upon dissection and microscopic study of the nervous system, analysis by experimental methods, and the study of neurological disorders. Because this knowledge has accumulated over many centuries, a confusing terminology has arisen. Names were often given to portions of the body before the functions of these parts were known. For instance, an area of the brain which in general configuration somewhat resembles a sea horse was named the *hippocampus.* Often the name of the investigator who first described a structure became associated with that structure, as, for example, the *vein of Galen* (p. 5).

Various national and international anatomical groups have attempted to clarify and simplify anatomical terminology. The most recent revision is that by the International Anatomical Nomenclature Committee, and the list of Nomina Anatomica submitted by that committee to the Sixth International Congress of Anatomists in Paris, 1955, was approved by that Congress. Anatomical terms in this book for the most part are those of the Nomina Anatomica, translated into English where appropriate.

Orientation

Information as to the position of any object, such as a house in a city, is expressed in terms of direction, such as east and west, or right and left. When the human body is in the *anatomical position,* that is to say, when it is upright, with the upper extremities

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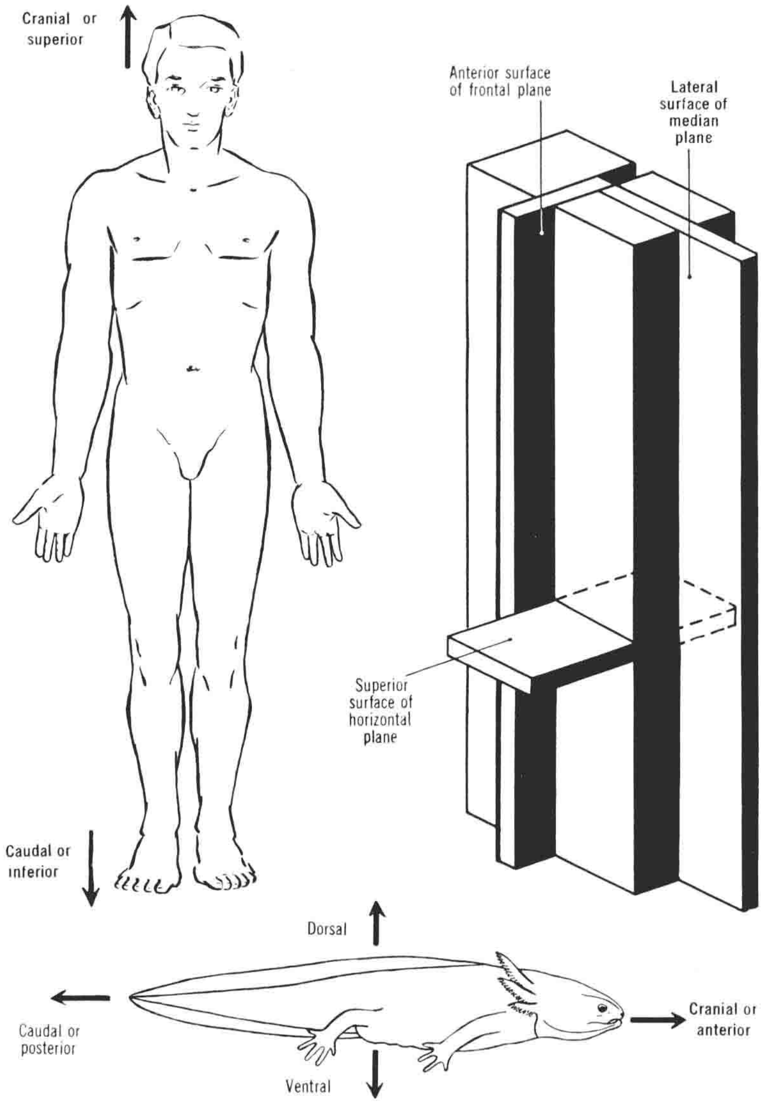

Figure 1. The anatomical position and synonymous terms of direction; a block diagram showing the primary planes and surfaces; and an amphibian, illustrating comparative anatomical nomenclature.

at the sides and the palms facing forward, three primary planes may be defined (Fig. 1). These are the *sagittal, frontal,* and *horizontal* planes. A sagittal plane in the middle of the body (*median* plane) divides the body into right and left halves. A frontal plane is a vertical plane at right angles to the sagittal that divides the body into front and back parts. A horizontal plane is any plane at right angles to the preceding ones that divides the body into upper and lower parts.

Structures toward the front of the body are *anterior;* toward the back, *posterior. Cranial* (or *superior*) refers to upper, and *caudal* (or *inferior*) to lower structures. The fact that man stands upright has led to a difference from the terminology used in comparative anatomy. In lower forms, structures which in man are toward the front of the body are *ventral,* those toward the back, *dorsal.* Cranial and anterior become synonymous, as do caudal and posterior (Fig. 1). In connection with the nervous system, the comparative anatomical nomenclature is often followed, particularly as regards "dorsal" and "ventral." For instance, the roots of the spinal cord usually are termed "dorsal" and "ventral" rather than "posterior" and "anterior" (pp. 24 and 35). "Ventral" is sometimes used to indicate structures at the base of the human brain; the comparable surface in animals that walk on all fours is ventral.

Other important terms are *medial,* nearer the median or midsagittal plane, and *lateral,* farther from that plane. *Proximal,* in referring to a limb, indicates a position nearer the trunk or central axis of the body; *distal,* a more peripheral position. For other terms of position and directions one should consult the textbooks of anatomy cited at the end of this chapter.

Techniques for Gross and Microscopic Study

Many important characteristics of the nervous system, such as size, shape, position and surface markings, may be noted by ordinary inspection. Details may be revealed by dissection of the nervous system, that is, by separating it from other tissues or organs, or by cutting it in various ways so as to obtain access to structures not apparent on the surface. The minute anatomy can be studied by examining portions of the nervous system under the microscope. Tissues examined by this means must be thin and transparent so that light can pass through them into the microscope and eventually to the eye. Although it is desirable to study tissues in the living state, thin sections are difficult to obtain and structures in the tissues may not be readily distinguishable. Therefore, special techniques are used to kill tissues and obtain thin slices to which dyes are applied so as to color structures differentially.

In order to preserve a structure in a state resembling the living as closely as possible, small pieces of fresh tissue are *fixed* in a chemical solution which simultaneously kills them and preserves them from alteration during subsequent treatment. Solutions of formalin or alcohol are the fixatives most commonly used for nerve tissue. After fixation, water in the tissues is slowly removed by transferring them through increasing concentrations of alcohol. Water-free tissues are then infiltrated with some substance which can be hardened later. Melted paraffin or a solution of nitrocellulose (celloidin) is used for such purposes. The hardened blocks can be cut into thin slices (as thin as 1 or 2 *microns* or less) without marked damage or distortion. This is done with a sharp knife and a special machine, the *microtome*. The thin slices or sections are then stained. Because all parts of tissues are not of the same chemical composition, some stains will color one structure, some another. Numerous dyes are available, and their choice depends upon the structures being studied. The stained sections are then made transparent by immersing them in a substance such as xylol. To prevent the drying and destruction which occur on exposure to air, they are placed on glass slides, covered with a solution of a transparent resin, and sealed with a thin piece of glass. As the resin dries, it remains clear and forms a hard, protective coat for the sections which will last for many years.

In hospitals, where a rapid method is often necessary, fresh pieces of tissue are quickly frozen into hard blocks by contact with solid carbon dioxide, "dry ice." Sections may be cut immediately, stained and mounted.

Experimental Methods of Study

There are many methods of studying the living nervous system. Most of them are carried out in animals other than man. The function of a particular portion or structure in the nervous system may be adduced by stimulating it with an electric current and observing the results directly. A part of the nervous system may be removed surgically and any effect or loss of function noted. Habit formation, behavior, reactions to stimuli, and the like, may be observed before and after surgical procedures in animals and in man. Drugs may be given which affect or stimulate certain elements of the nervous system and thereby alter their functions. The inception of function may be observed by correlating physiological and morphological development during embryonic, fetal and infant life. Finally, there are methods involving special techniques. Some of these will be discussed in subsequent chapters. For instance, living tissue, especially that of the nervous system, undergoes electrical changes during an alteration in activity. These changes can be studied and recorded, usually by means of special electronic equipment, and the methods allow one to examine a variety of phenomena. Some of these are nerve conduction, the localization of active nerve centers and the tracing of pathways in the central nervous system. The effect of various drugs, such as anesthetics, on electrical activity can also be included.

Clinical Methods of Study

A disease or injury of the nervous system usually causes a loss of function or may give rise to an abnormal condition. If a patient with a neurological disorder dies, the signs and symptoms which that patient presented during life may be correlated with pathological changes found after death. Over many years the study of great numbers of such cases has yielded considerable information. Data may also be obtained when operations are necessary. These clinical methods are the only comprehensive ones available for neurological studies in man, if one excludes special tests used by psychologists and psychiatrists.

Names in Neurology

Galen, of Pergamum (about A.D. 130–200)

Galen was a Greek physician who, after many years of study, settled in Rome. Here, as the founder of experimental physiology, he did an incredible amount of work. He knew of the effects of cutting the spinal cord, with its resulting sensory losses and motor disturbances. Galen studied the heart and knew that the arteries contained blood. He saw and described the cerebral aqueduct. His knowledge of anatomy was comprehensive and accurate. He set so high a standard that for thirteen centuries his works were the only authoritative sources. Since he rarely, if ever, dissected human cadavers, the errors he made in attributing animal structures to man were perpetuated. In spite of the fact that during medieval times it became heresy even to question these errors, there is no doubt that Galen was one of the great scientific figures of all time.

References

The following textbooks are general anatomical ones, of which the following three are standard volumes. The first two are widely used in medical schools of Great Britain and Ireland, and the third in the United States.

Brash, J. C., ed.: Cunningham's Textbook of Anatomy. 9th ed. London, Geoffrey Cumberledge, Oxford University Press, 1951.

Johnston, T. B., and Whillis, J., ed.: Gray's Anatomy. 31st ed. London, Longmans Green and Co., 1954.

Schaeffer, J. P., ed.: Morris' Human Anatomy. 11th ed. Philadelphia, Blakiston Company, 1953.

The following textbook is one of the best on comparative anatomy in the English language. The chapters on sense organs and the nervous system are of particular interest here.

Romer, A. S.: The Vertebrate Body. 2nd ed. Philadelphia, W. B. Saunders Company, 1955.

The following two volumes are suitable both for the beginning and the advanced student. The textbook (the first listed) is simply and clearly written, the body being discussed according to regions, in contrast to the three listed above, which discuss the body according to systems (muscles, vessels, etc.).

Grant, J. C. B.: A Method of Anatomy. 5th ed. Baltimore, Williams and Wilkins Company, 1952.

Grant, J. C. B.: Atlas of Anatomy. 4th ed. Baltimore, Williams and Wilkins Company, 1956.

The following two textbooks for the beginning student present elementary facts about the structure and function of the human body.

Marshall, C., and Lazier, E. L.: Introduction to Human Anatomy. 4th ed. Philadelphia, W. B. Saunders Company, 1955.

Millard, N. D., King, B. G., and Showers, M. J.: Human Anatomy and Physiology. 4th ed. Philadelphia, W. B. Saunders Company, 1956.

CHAPTER 2

The Central Nervous System

DURING THE course of development in the embryo, the nervous system becomes a tubular structure, and this tubular arrangement is found in the adult in a considerably modified form (Chap. 5). That part of the tube in the head region develops into the *brain* and its various subdivisions. The rest of the tube becomes the spinal cord. The brain and spinal cord constitute the *central nervous system.*

Nerve cells in the brain and spinal cord have processes of various lengths. Many of these processes connect parts of the brain and spinal cord, while others collect in bundles, leave the brain and spinal cord as cranial and spinal nerves, and are distributed to muscles and glands. Other nerve cells are found adjacent to the brain and spinal cord, and their processes convey sensory impulses from non-nervous structures to the brain and spinal cord. The *cranial* and *spinal nerves,* their peripheral combinations, and the peripheral portions of the *autonomic nervous system,* constitute the *peripheral nervous system.*

In order to pave the way for more detailed anatomical and physiological discussions, this and the next two chapters will be devoted to a general presentation of the gross or macroscopic anatomy of the nervous system.

Location and Coverings of the Central Nervous System

The brain and spinal cord are protected by the *skull,* the *vertebrae,* and their ligamentous connections. The brain occupies the cranial cavity in the interior of the skull. This cavity is commonly

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