A History of Neurophysiology in the 17th & 18th Centuries

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RAVEN PRESS

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From Concept to Experiment

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Raven Press ■ New York

Preface

In this volume, the first of two designed to cover three centuries, I have attempted to extract from the wealth of material about the 17th and 18th centuries that which is germane to our present understanding of the nervous system, and to highlight the development in that era from age-old concepts to the modern one of experimentation.

The goal of these volumes is to acquaint the modern worker in the neural sciences with the gradual growth of knowledge about the fuctioning of our nervous systems. Taken for granted today is the fact that the agent that operates our nerves and muscles is electricity, but when the 17th century opened not even the differentiation between magnetism and electricity had yet been made. Once identified, this mysterious invisible agent continued to puzzle the world of physics and of physiology (a word not yet coined). In the final decade of the 18th century that world was rocked by the findings of Galvani, and the science of electrophysiology was born. It had an uphill fight for recognition and understanding in the 18th century, in which only two forms of electricity had received recognition, namely, "atmospheric" and "natural." To these now had to be added "animal electricity."

In the account that follows I have attempted to describe for the reader those original experiments whose results would replace old ideas with experimental proof. Where possible, the worker's own sketch of his experiment is reproduced—for this was a time that preceded the age of photography. Where actual quotations are given, the source will be found in a footnote. Reading lists are appended that include the writings of those great men that are germane to neurophysiology, together with selected studies of their works, which can guide the student who wishes to read more deeply in this field.

Important for the recognition of the transition from traditional methods to the new experimentation without constraints is an awareness of the age in which the experimenter was living—the intellectual environment, the political flavor of thought, and the freedom to disagree with ancient dogma. This background forms part of the central core of this work, which presents the historical breakthrough in thought and experiment about the nervous system in the 17th and 18th centuries.

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Prologue

This historical account of the science of neurophysiology takes as its starting point the year 1600. Before that time, although there were great thinkers, there was little exact science of the nervous system. How the concepts of these thinkers came to influence the working scientists in the centuries to follow is traced, for the construction of this study is based on the scientist's recognized procedure: frame a working hypothesis and then design experiments to test it. Many of the discoveries in the field of neurophysiology are the outgrowths of ideas, the hypotheses of nonexperimentalists—philosophers, historians, and writers.

In contrast to medicine, a science demanding synthesis of observations, experimental physiology, with its reliance on analysis and laboratory findings, has little significant history before the 17th century. Leaders in medicine developed and practiced its therapies for many years before they felt the need to understand the nature and functions of the body's parts in any truly physiological sense and, when the urge for this knowledge first arose, it was to come as much from the philosophers as from the healers of the sick.

Neurophysiology (a term not to come into use until centuries later) had as a legacy from the ancients only their speculative inferences and their primitive neuroanatomy. Aristotle had confounded nerves with tendons and ligaments, and had thought the brain bloodless and the heart supreme—not only as a source of the nerves, but also as the seat of the soul. The function of the brain according to his views was to condense the hot vapors rising from the heart. Herophilos and Eresistratos had recognized the brain as the center of the nervous system and the nerves as concerned with both sensation and movement. However, preliminary to all disciplines was the development of the scientific method and in this Aristotle was a forerunner.[1] If Aristotle is to be evaluated as a scientist, it must be admitted that he was almost always wrong in every inference he made from his vast collections of natural history and numerous dissections; yet in spite of the stultifying effect of the immoderate worship given to him by generations to follow, he earns a position by his invention of a kind of formal logic. Although his system lacked what the modern scientist uses most, namely, hypotheses and induction, his was a first step toward the introduction of logic as a tool for the scientist. Unfortunately Aristotle did not use his logic for this purpose himself. As Francis Bacon, who was the outstanding opponent of Aristotelianism in the 17th century, wrote, Aristotle "did not consult experience in order to make right propositions and axioms, but when he had settled his system to his will, he twisted experience round, and made her bend to his system."

[1]The fragments of Aristotle's writings that exist (probably his lecture notes) were not collected until more than 200 years after his death. His *Opera* were among the early scientific works to be reproduced (in Latin, 1472) by the printing press invented in the West nearly 1800 years after his death. English translations *(The Works of Aristotle)* were published by the Clarendon Press, Oxford, in several volumes between 1909 and 1931, edited by J. A. Smith and W. A. Ross.

FIG. 1. In the 4th century A.D. and for several hundred years to follow, the faculties of the mind were thought to be housed in the ventricles of the brain. **Left:** a 15th century illustration designed to illustrate the 1494 edition of Aristotle's *de Anima*. Four regions of the brain are labeled: *sensus communis*, *virtus cogitativa*, *virtus imaginativa*, and *memoria*. (Courtesy of the Incunabula Collection at the National Library of Medicine, Bethesda.) **Right:** Leonardo's localization of the *sensus communis*. In the lower figure his own words state: "Where the line a–m is intersected by the line c–b there the meeting place of all the senses (senso commune) is made." (Courtesy of the Royal Library at Windsor Castle.)

In terms of anatomy, although for many centuries the heart had reigned over the brain, some site in the brain for mental processes was sought even in the dark ages when, in fact, our various functions were assigned to the ventricles rather than to the solid tissue. Numerous illustrations of this idea came down to us, all devoid of scientific meaning and, all but a few, crude in execution—many being merely copies of earlier ones. What is striking, however, is that all of these depict a *sensus communis* and place it anteriorly. Figure 1 from the 15th century, an exception for its artistic beauty, is an example of this placement of the *sensus communis* and we notice more posterior sites for "virtus cogitativa," "virtus imaginativa," and "memoria."

One great artist who, unlike the others, was also an experimentalist, gave us his exact stereotaxic coordinates for finding the *sensus communis*. Figure 1 depicts Leonardo's drawing of the skull; in his marginal notes in mirror writing he says (in translation) "Where the line a–m is intersected by the line c–b, there the meeting place of the senses *(senso commune)* is made." Elsewhere in his writings we find that he believed the *sensus communis* to be the site of the soul.

The aim of the following account is to trace the development of ideas as to how the nervous system works and the great progress that was made when dissatisfaction with traditional but unproven theories led to the testing of these concepts by experiment. In the 17th century for the first time the function of the nerves was scientifically explored and some very tentative attempts made to understand the brain. Their structure was better known than their function, for dissection has a much longer history than physiology; anatomy had flowered in the previous century with the great masters, da Vinci, Vesalius, and Estienne.

This study has been written around the major figures who made the first giant steps toward a rational science of what was then called natural philosophy, but, as they did not work in solitude, an effort has been made here to describe them within the historical settings of their times—political, artistic, literary, at peace or at war. These great men of the 17th century were not students only of the nervous system, although it is from this area of their work that material has been extracted here for description. Many actually achieved fame in other fields, but their contributions to neurophysiology are the milestones emphasized in the following chapters. As we read, we find speculation flowed freely, even if it was rarely in the form of a working hypothesis formulated for testing. But experiment won, marking this as a century of revolutionary knowledge about our nervous systems.

SUGGESTED READING

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