

Herophilos, the great anatomist of antiquity*

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Abstract

Herophilos (ca. 330 to ca. 260 B.C.) was a Greek physician and precursor in learning and teaching of human anatomy through systematic anatomical dissections who made extraordinary anatomical discoveries. He developed the theory of using the pulse as a form of diagnosis and introduced the use of experimental method to medicine.

Keywords: dissection; Herophilos, human anatomy

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Introduction

The city of Alexandria, Egypt, was the world center of learning and scholarship in the 3rd century B.C. It was founded by Alexander the Great in 332 B.C. and established by the mighty Ptolemaio Pharaohs. This city was home to many prominent philosophers and medical practitioners of that time.^[1]

Although there are very few historical documents, it may fairly be stated that the Alexandrian physicians were the first in the medical tradition to perform systematic dissections of human cadavers.

The knowledge of human anatomy (from the Greek word *ανατομία* (anatomē), which means dissection) constitutes an essential pillar in the broad and complex field of medicine. Among the main contributions in the field of learning and teaching of human anatomical dissections, those made by Herophilos of the school of anatomy in Alexandria stand out.^[2] The cultural, social, intellectual and political conditions of Alexandria in the third century B.C. provided Herophilos with opportunities to dissect human cadavers. He was thus able to make an unprecedented number of anatomical discoveries and accompany them with precise descriptions (Figure 1).^[3]

The objective of this paper is to make a review of Herophilos' contribution to of human anatomy. Little is

known about Herophilos' life. From secondary sources, such as the physician Galen, the writer Celsus and the theologian Tertullian in the 2nd century A.D., Herophilos and his works are known. About 250 years after the death of Herophilos, Celsus and later Tertullian blamed him to have performed vivisection on condemned criminals awarded to Herophilos by the rulers of Alexandria, but such accusations remain speculative.^[2,4,5]

Background

Aristotle dissected animals in the 4th century B.C., and there were also dissections by other Greek physicians in previous centuries and later on by Galen in the 2nd century, but Herophilos' work drew widespread praise.

It is believed that Herophilos was born in Chalcedon, currently Kadikoy, a settlement on Bosphorus, Turkey, about the year 335 B.C.^[6,7] His name comes from the ancient Greek word *ρόφιλος*, later sometimes Latinized as Herophilus.

We have no knowledge of his childhood. He was trained as a physician with Praxagoras and Crisipus of Cnido, physicians and anatomists who taught in the medical school of Greek island of Cos. After his medical training, Herophilos went to live in Alexandria, where he

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learned and practiced human anatomy dissection and medicine.^[8]

Systematic dissections of human cadavers started in Alexandria in the third century B.C. and for about 30 years of Herophilus' life, the prohibition on human dissections was removed, initiating this medical practice. He and some of his colleagues and disciples had the exclusive opportunity to perform human dissections, a procedure that was not tolerable anywhere else at the time.^[9] After this period, human dissection was banned and not permitted again for about 1,800 years until it began to be practiced again during the 14th century A.D. Herophilus was among the first physicians to perform anatomical dissections in public, dissected more than 600 human cadavers and being among the first to compare human and animal morphology. His dissections provided unprecedented knowledge of how the human body and its organs worked.^[2,7] He created terms to systematically describe the objects of study, as opposed to the use of "natural names", named them for the first time and established anatomical nomenclature so that there was some uniformity for study and description.

His anatomical discoveries of the nervous system

Herophilus made outstanding anatomical discoveries in human cadavers: for example, he distinguished the brain from the cerebellum, and described the brain as the seat of intelligence,^[10] contrary to the beliefs of his contemporaries.

He recognized and studied the internal surface of the skull and the cranial sutures. Herophilus described the lower brainstem and spinal cord as one structure he referred to as "spinal marrow", and also identified and described several brain structures, some of which still have his name, such as the concavity on the internal surface of the occipital bone, in which lodges the posterior confluent of the cranial venous sinuses, known as the Herophilus' press (*torcular Herophili*).^[11] The three membranes of the brain were also recognized by Herophilus and designated as "chorioid" because they resembled the chorionic envelope surrounding the fetus. On the vision system, Herophilus explored the optic nerve and described the sclerotic ring, the retina, and the choroid coat.^[2,7] He studied the encephalon by dissecting human cadavers and carrying out investigations with animals, describing the choroid plexus, the meninges, and the fourth ventricle. He discovered that nerves originated in the brain, was the first to distinguish nerves from tendons and observed the difference between the motor and sensory nerves.^[11,11] Herophilus also described at least six cranial nerves and named them the optic, oculomotor, trigeminal, facial, auditory and hypoglossal nerves, and pointed out that

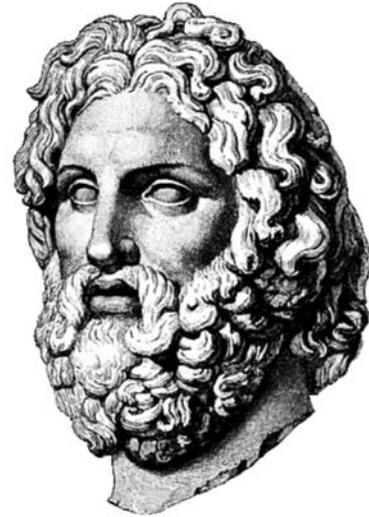


Figure 1. Herophilus (ca. 330 to ca. 260 B.C.) from *How human experimentation works?*^[13]

damage to motor nerves produced paralysis.^[12] Herophilus named the styloid process of the skull.^[13]

His anatomical discoveries on the digestive system

Herophilus studied the liver extensively and described and named the duodenum, the ileum and colon, performed the first research of the pancreas.^[14] He described the submandibular glands and the parotid gland and he also described and gave his name to the hyoid bone.^[15,16] Herophilus knew the vessels of the mesentery, and showed that they did not go to vena portae. Herophilus also noted the existence of the lymphatic system but did not rule out its function.

His anatomical discoveries on the cardiovascular system

Herophilus established the distinction between arteries and veins and confirmed that the arteries had thicker walls than the veins^[6,12] and maintained the idea that arteries carried blood rather than air.^[16,17] He described the pulmonary artery which he denominated arterious vein and also described the pulmonary vein.^[18] His mentor Praxagoras' misconception that the pulse was not associated with the heart beat was refuted by Herophilus,^[19] who pointed out the importance of the pulse, establishing the synchronicity of pulse and heart beats. He sustained that the pulse was not a natural faculty of the arteries, but was derived from the heart, and differentiated the pulse as not simply quantitative but also qualitative of palpitations, tremors and spasms which are muscular in origin.^[9,17,18] He was the first

to point out that the pulse could be used as an indicator of disease, believing that artery pulsations were involuntary, as a result of the dilatation and contraction of arteries due to impulses sent by the heart. He observed the pulse of the arteries and developed measuring standards, using a water clock and made important contributions to medicine by developing the theory of diagnosing through the pulse.^[19] Herophilos is considered for his researches as one of the precursors of cardiology. He described the anatomy of the heart valves.^[20] He also described the respiratory movements.

His anatomical discoveries on the reproductive system

On the male reproductive system, Herophilos described the epididymis, the prostate gland, and identified the various parts of the spermatic duct.^[6] He recognized that the testicles produced spermatozoa. On the female reproductive system, Herophilos described the ovaries, the uterine tubes, and the uterus,^[21] showing that the latter was attached by the broad ligament and thus not mobile in the body as had been previously thought. He described the phases and duration of pregnancy as well as causes for difficult childbirth. Herophilos also described and explained the causes of *uterus prolapsus* and rightly held that only the cervix, and not the entire uterus, can protrude. He was also interested in the relationship between menstruation and general health.

Herophilos' medical practice

In the field of medical treatments, Herophilos was a sponsor of Plato's dogmatic doctrine, which gave preference to reason above experience, classifying all diseases based on the theory of the accumulation of humors and maintained the ancient doctrine of the four humors as the basis for treatment.^[7,8] Herophilos revised the humor theory of Hippocrates. In his own theory, he argued against the notion that the veins were filled with a blend of blood, water and air; rather he showed, through his dissections that it was pure blood in the veins. Thus, he used blood-letting and purging to evacuate the unwanted humors.^[8] To Herophilos, an imbalance of the four humors triggered all diseases.

The cardiocentric thesis enjoyed great success well beyond Aristotle and Praxagoras, and among others Greek physicians and philosophers,^[10] but Herophilos rejected cardiocentric thesis and returned to Hippocraticencephalocentrism supported in his anatomical research on the configuration and function of the brain.^[21] He was also one of the first doctors who recommended the habits of proper diet and exercise.^[7,17] For

Herophilos, prognosis was derived from the symptoms, and for this reason, symptoms should be clearly recognized. Herophilos acquired great prestige, both as a practitioner and as a teacher of human anatomy. He considered there were limits to medical activity, arguing that an accomplished physician can differentiate what is possible from what is not possible. It is attributed to Herophilos to have said "*When health is absent, wisdom cannot reveal itself, art cannot manifest, strength cannot fight, wealth becomes useless, and intelligence cannot be applied*".^[2,7,8] Herophilos is thought to be one of the founders of the scientific method. He had introduced the experimental method to medicine, for he considered it essential to found knowledge on empirical bases. For that, he was criticized by Galen for whom the experimental method contradicted rationality.

Discussion

Herophilos was a precursor in the learning and teaching of human anatomy through systematic dissections of human cadavers that is why he is considered the 'Father of Human Anatomy'.^[6,21,22] It appears that he wrote three treatises devoted to anatomy, one to midwifery, two each to the study of the pulse and to therapeutics, one to ophthalmology and one to dietetics.^[1,7] None of his works have been preserved, they disappeared with the destruction of the library of Alexandria.^[15,23]

His teachings and research were complemented and enhanced by his disciple Erasistratus,^[12,24,25] but after Herophilos' death, about the year 280 B.C, his followers got caught up for centuries in unfriendly and needless polemics, with the following decline in the medical application of his teachings and research in the field of human anatomy studies.^[7,17,26]

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