

Historical note: CME Neurology

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Thomas Willis (1621-1675)

Cerebri anatome

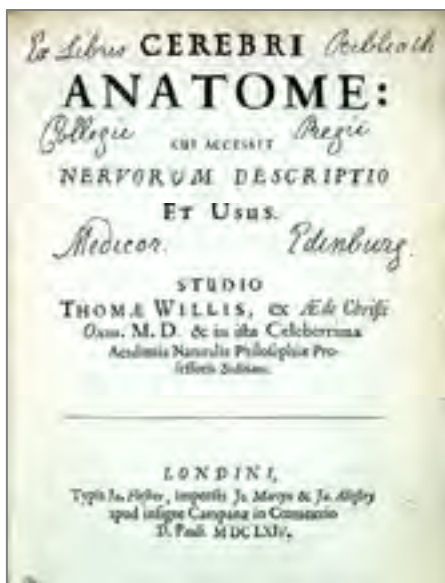
London : James Fleisher for John Martyn & James Allestry 1664

René Descartes (1596-1650)

De homine figuris et Latinitate donatus a Florentio Schuyt 1662

Leyden: P. Leffen & F. Moyardum

Studying the structure and function of the nervous system posed enormous problems from ancient times until well after the Renaissance. The central nervous system's anatomy was difficult to fathom because, without fixatives, it rapidly becomes semi-fluid after death. Its function was even more obscure, partly because of the lack of any appropriate investigative method other than observing effects of gross lesions on function but also, even after the anatomy began to be unraveled in the seventeenth century, the prevailing Galenic humoral theories made no predictions that were open to experimental test. But the new experimental philosophers of the seventeenth century rose to the challenge.



The year 1664 saw the publication of two books which greatly influenced thinking about the nervous system, the *Cerebri anatome* of Thomas Willis and the 'original' French version of the *Traité de l'homme* of René Descartes. For neural anatomy Willis is enormously the superior, but as a theorist of neural function Descartes is much the more interesting.



Though Willis is now best known as the first to describe accurately the details of the circular arterial anastomosis at the base of the brain that bears his name, *Cerebri anatome* was also a much more accurate description of the anatomy of the brain and cranial nerves than had previously been given. Following Galenic tradition Willis speculated on the functions of parts of the nervous system on the basis of their structure though he was also influenced by the emerging experimental science – such as Harvey's discovery of the circulation of the blood. He was part of the circle of

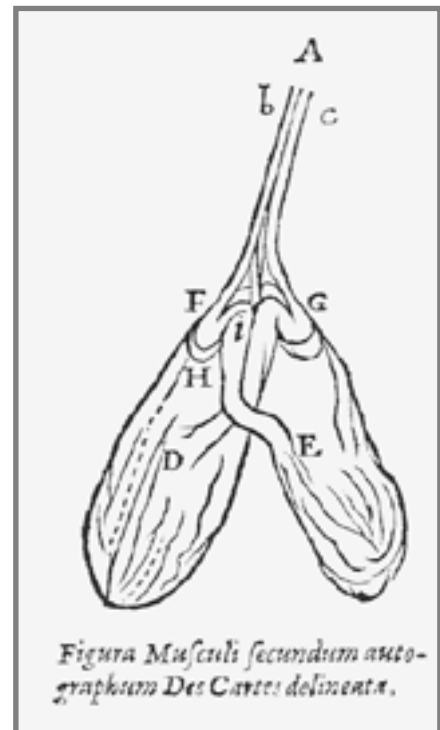
Christopher Wren's drawing of the arteries at the base of the brain for Willis's *Cerebri anatome*.

[Click the figure to enlarge it](#)

experimental philosophers in Oxford and was assisted in some observations by another of the group, Christopher Wren, recently (1661) appointed Savilian Professor of Astronomy, who drew some of the illustrations for *Cerebri anatome*. Wren's architectural genius was not yet manifest. Willis's main preoccupation was probably an attempt to understand the soul on the basis of anatomical observation.

Descartes did not publish his *Traité* himself because he was alarmed by what had happened to Galileo at the hands of the Inquisition but, some time after his death, his manuscript, which had circulated among his friends and correspondents, was edited and published, first in a Latin translation (*De homine*) by Schuyl in 1662, then as the now better-known 'original' French version edited by Clerselier in 1664. In the 17th century the 1662 Latin version was probably much the more widely read. Like Willis, René Descartes was interested in trying to understand the relationship of the soul and the body and he also believed this to be mediated by the brain and nervous system. However, his approach was different to that of Willis. He was greatly influenced by the engineering developments of the 17th century, particularly by the hydraulic automata that had been installed at Versailles. Descartes did not invent the idea of hydraulic inflation of muscle but he greatly elaborated it and developed an hydro-mechanical theory of how the soul controlled the contraction of muscle through the intermediary of the pineal and the cerebral ventricles, and how it received, through the nerves from the periphery, signals that gave rise to sensation.

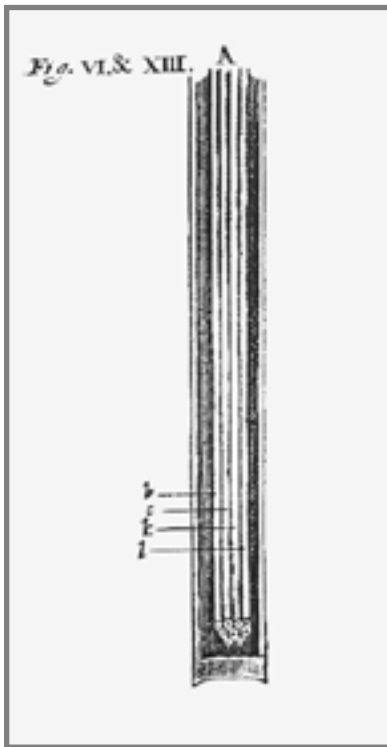
According to the motor part of this theory the shortening of muscle was brought about by the transfer into it of fluid ('animal spirits') the bulk of which derived from the collapse of the antagonist muscle as it lengthened but was primed by the injection of a small quantity of 'spirits' from the cerebral ventricle; the 'priming' fluid was switched into the correct pathway by the pineal. The resulting inflation caused the muscle to expand in width and shorten in length. This arrangement presupposed what Sherrington was later to call 'double reciprocal innervation'; Descartes was the first to point out specifically that, to bring about movement, the shortening of the agonist must be accompanied by lengthening of the antagonist muscle. He illustrated this by considering several muscle groups as shown in the diagrams in the *Traité* and *De homine*. Though these illustrations (at least those in the French edition) are fairly well-known, it is often not realised that, with two exceptions, the images were constructed by his editors solely on the basis of their understanding of Descartes's text. But one image that we know is Descartes's own, copied from a sketch in his manuscript, indeed shows the double reciprocal interrelation of the lateral and medial extraocular muscles. To control the mutual flow of spirits between these, Descartes invented non-return valves and nervous cross-connections between the muscles. The non-return valves were flipped by the priming injection of spirits from the ventricle under the soul's direction. Though Leeuwenhoek's microscopic observations appeared to confirm the hollow tubular nature of peripheral nerve - and the presence of longitudinal fibres within the tube - the motor part of the theory was disproved a little later by Swammerdam in Holland and Goddard in London who demonstrated that muscle volume did not increase during contraction as the inflation theory required. This did not in the least prevent widespread belief in the theory and, indeed, it was the subject of a number of talks at the new Royal Society in the 1660s. The inflation theory was considerably elaborated by Croone in his



The supposed interconnections of the lateral and medial rectus muscles and their associated valves. Copied by Schuyl (1662) from Descartes's own sketch.

[Click the figure to enlarge it](#)

De ratione motus musculorum (also published in 1664) in which he added the notion that part of the ‘inflation’ was caused by an interaction - a sort of fermentation - between something carried into the muscles by the nerves and ‘particles’ brought in by the arterial circulation.

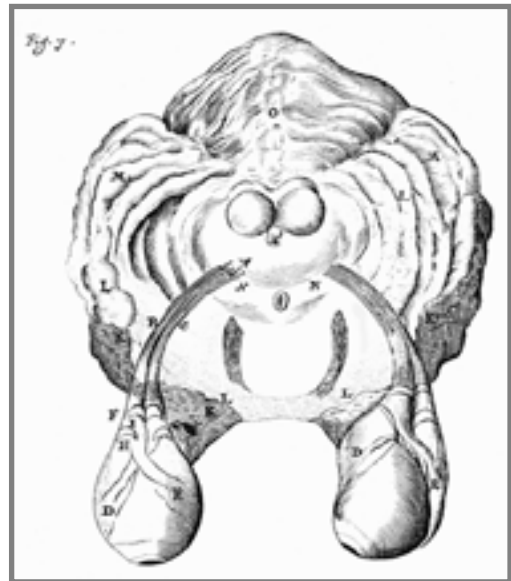


Schuyt's interpretation (1662) of Descartes's text on the structure of nerves.

[Click the figure to enlarge it](#)

The sensory and sensory-motor parts of Descartes's theory depended on the existence of thin fibrils within the hollow tubes of the peripheral nerves (b, c, k, l in the figure on the left). “ See here for example the nerve A whose external membrane is like a large tube which contains other little tubes b, c, k, l etc. that are made of an inner much more delicate membrane, and these two membranes [i.e. that surrounding the whole nerve and those of the tubules] are continuous with the two membranes K, L which envelop the brain M, N, o. [Schuyt shows the continuity of the tubes and tubules with the dura and pia mater in his following figure, below right]. “ See also that within each of the little tubes there is something like a marrow made up of several extremely fine filaments which come from the true substance of the brain N and whose extremities finish at one end in its interior concave surface

[i.e. the wall of the ventricle] and at the other on the skin and flesh against which the tube containing them [the tubules within the nerve] ends. ”



Schuyt's interpretation (1662) of Descartes's text on the structure of nerves and how they connect to the brain.

[Click the figure to enlarge it](#)

(The translations are from Descartes 1662 pp. 19-20, and 1664 p. 15).

Descartes then explains that these fibrils transmitted ‘signals’ from the periphery; in Descartes's own analogy in the way in which pulling on a rope causes a bell to ring. There did seem to be such fibrils in the nerves in Leeuwenhoek's drawings. The appearance of the nerves as hollow tubes containing fibrils can now be explained as resulting from the preparation of the specimens – the fresh (frog) nerve was soaked in plain water before cutting and squashing sections for microscopical examination.

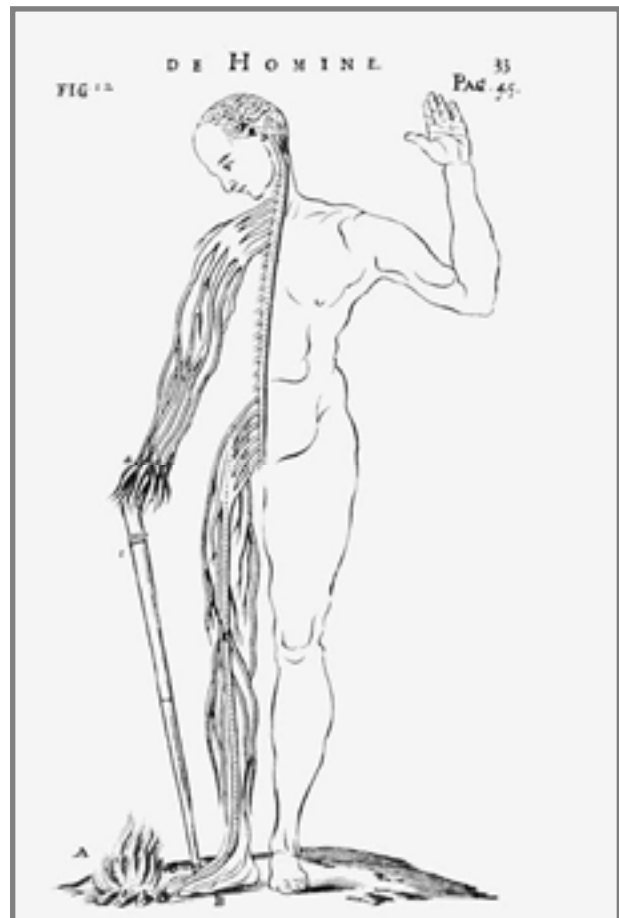
In the figure below, devised by Schuyl from Descartes's text, the fire causes irritation of the toe which results in a tug on the filament (dotted line) extending within the nerves from the foot via the spinal cord to the cerebral ventricle. This alerts the soul and gives rise both to the sensation of pain and to a (motor) command to move the foot.

“If the fire is close to the foot, the little particles of the fire which, as you know move very rapidly, are able to move with them the skin of the foot that they touch and thus, pulling the little thread c,c [the dotted line in the figure] that you see attached to it, they immediately open the pores d,e at the end of the thread just as by pulling one end of a rope one instantly rings the bell hanging at the other end.” The text continues by explaining how the animal spirits are directed from the cerebral ventricle *“partly into those muscles that serve to pull the foot away from the fire, partly to those that turn the head and eyes to look at the fire and partly to those that extend the hands and turn the body to protect itself.”*

Here Descartes comes very close indeed to describing a set of reflex actions with their afferent limb (the thread), efferent limb (the hydraulic system to inflate the muscles) and their central mechanism (the pores in the cerebral ventricle and the actions of the pineal to direct the fluid to the correct muscle nerves). He then diverts to consider the senses before *“I explain to you more precisely how the spirits follow their paths through the pores in the brain and how these pores are arranged.”* (Translations from Descartes 1662 p. 32 and 1664 pp. 27-28). The next chapters fulfil these promises.

Later in his book Descartes provides explanations for the mechanisms of visual perception - including dealing with the central interpretation of the inverted retinal image, and of visuo-motor coordination using as a specific example the process of pointing to a visual object. He also attempts to explain how the distances to visual objects are perceived. All of these explanations are based on treating the human body as though it were a machine operating according to his hydro-mechanical hypotheses, though he was very clear that the analogous machine which is Man contained a directing soul.

It was quite some time before better alternative explanations of the physiology of the nervous system became available.



Schuyl's interpretation (1662) of Descartes's text on sensory-motor action following a noxious stimulus.

[Click the figure to enlarge it](#)