ABSTRACT. Interest in anatomy dates from the earliest times. Such knowledge was acquired through dissections of animals and human corpses by many researchers. The macroscopic anatomy of the varied structures of the brain were identified over the centuries, and the predominating solid substance was seen as amorphous, and devoid of any specific function, until the Renaissance. René Descartes, a personage with a brilliant and creative mind, conceived the brain, its structure and function, in a distinct manner to what was known at his time. He valued the solid matter and gave it, for the first time, a theoretical minute structure, related to a presumptive function based on the presence of the pineal gland and the animal spirits, underlying cognitive, sensory and motor activities. Such structural view was endorsed, in a given sense, by the microscopic findings of Marcello Malpighi, which began to change the understanding of the nervous system.

Keywords: Descartes, brain, pineal gland, animal spirits, microscopy.

INTRODUCTION

Interest in anatomy dates from the most ancient times. Such knowledge was acquired through dissections of animals and human corpses by many researchers. Among those that must be cited are the pioneer studies of Aristotle (4th century BC) on animals, and Herophilus and Erasistratus (4th–3rd centuries BC) on human corpses. They were followed, much later, by two of the most relevant personalities in the history of anatomy, Claudius Galenus (2nd–3rd century AD), who established solid anatomic knowledge based on animal dissections, which lasted for more than a millennium, and Andreas Vesalius (16th century), with his milestone work on human anatomy.1-3 The anatomical findings were frequently accompanied by functional conjectures, and after a cardio-centric vs encephalocentric quest, where the latter prevailed, the ventricular system was chosen to house the faculties of the soul, as clearly postulated by Nemesius of Emesa (4th century AD), with his “ventricular...
doctrine”. Such view lasted for the entire Middle Ages and also during the Renaissance, and it was maintained even when the first human dissections reappeared, with Mondinus de Liuzzi (15th century).4

Those were the anatomical resources and functional propositions, when René Descartes (1596–1650), French mathematician, physicist, and philosopher, made his scientific appearance (Figure 1).5,6 Descartes intended to give a physical theory of the universe to explain all the phenomena of nature, and with that purpose, he produced a text, between 1629 and 1633, planned to be published as a book (Le Monde), where one part should be about man (L’Homme).7,8

The manuscript was almost finished, but in view of the condemnation of Galileo Galilei for religious reasons due to his “heretical” writings (1633), and afraid of similar consequences, he gave up the plan of publishing this text.7,8 A time later, he ceded to his scientific nature and resumed the work with the help of Gerard van Gutschoven as prosector and personal assistant. He performed a detailed study on the anatomy of the brain, initially of animals (especially sheep), and later also of humans, after which he made a revision of the

THE STRUCTURE OF THE CARTESIAN BRAIN

The published anatomical works at the time, it must be stressed, did not offer a characterization, except for the macroscopic features, of the structure of the substance of the brain, which remained an amorphous (unshaped) matter. A distinct view was presented by Descartes. Although he was not an anatomist, he committed a good time to consult anatomical studies (by Vesalius and others), watching butchers work, and personally dissecting various kinds of animals, and also human material, according to letters to his friend Marin Mersenne (1632, 1939).4,6,7,9

Descartes writes about an imaginary man, a conceptual model, stating that: “These men will be composed, as we are, of a soul and a body... I will show you how these two natures must be joined and united so as to compose men who resemble us...”. And then: “...I suppose that the body is nothing more than a statue or a machine made of earth..., and compared it to other similar machines such as clocks, fountains, mills. Regarding the soul, he wrote: “…when the rational soul will be united to such machine, it will receive a key place inside the brain...”.16

He describes the brain, in a hypothetical manner, as constituted by a substance forming broad walls, the solid part of the brain [medulla of the brain, according to La Forge], defined as “a tissue composed in a certain particular way” [nervous tissue], surrounding the cavities [concauites du cerveau] [ventricles] (EE) [conceived as a single continuous cavity, according to La Forge]. The internal part of the solid matter (AA),
in direct contact with the ventricles, is formed by filaments (“small tubules”) (petits tuyaux) that constitute a thick and compact net. Many very delicate filaments of unequal lengths originate from this net, where some occupy an external space (BB), interweaved in various ways, leaving between them intervals or “pores”; others course to the peripheral space (surface) (CC), each ending in the extremity of small vessels that are there, and the longest converge from each side to form a stalk-like structure (D) (Figures 2A and 2B). The middle of the brain is occupied by the gland H (pineal gland). The whole structure is enveloped by a double membrane [pia and dura mater, according to La Forge]. The stalk, enclosed by an extension of the double membrane is followed by a longer projection [spinal cord], from which emerge nerves destined for the trunk and the limbs.

The cerebral circulation is provided by large arteries that branch to supply the external surface, the bottom of the cavities, and the pineal gland, carrying blood formed by “its most lively, strongest, and finest part”, destined to nourish the brain matter, and to produce the “animal spirits” (esprits aninaux). Those are “like a very subtle wind, or rather a very pure and vivid flame”. The blood that reaches the pineal gland is filtered through its numerous very small holes that allow the passage of only the finest particles into the cavities, maintaining them filled, and flowing continuously to the tubules of the internal net and to the pores between the filaments of the external space, and beyond. The middle of the brain is occupied by the gland H (pineal gland). The whole structure is enveloped by a double membrane [pia and dura mater, according to La Forge]. The stalk, enclosed by an extension of the double membrane is followed by a longer projection [spinal cord], from which emerge nerves destined for the trunk and the limbs. The cerebral circulation is provided by large arteries that branch to supply the external surface, the bottom of the cavities, and the pineal gland, carrying blood formed by “its most lively, strongest, and finest part”, destined to nourish the brain matter, and to produce the “animal spirits” (esprits aninaux). Those are “like a very subtle wind, or rather a very pure and vivid flame”. The blood that reaches the pineal gland is filtered through its numerous very small holes that allow the passage of only the finest particles into the cavities, maintaining them filled, and flowing continuously to the tubules of the internal net and to the pores between the filaments of the external space, and beyond. The middle of the brain is occupied by the gland H (pineal gland). The whole structure is enveloped by a double membrane [pia and dura mater, according to La Forge]. The stalk, enclosed by an extension of the double membrane is followed by a longer projection [spinal cord], from which emerge nerves destined for the trunk and the limbs.

The function of the senses is elicited by stimuli that originate from a given source (object), such as light, sound, smell, touch, heat, and other qualities, which come in contact with the [terminal] small filaments lodged in the sense organs, which in turn results in the opening of adequate small tubules in the interior surface of the brain, outlining there a figure (image), and affecting also the pineal gland. The gland releases more spirits that open further the already selected tubules, and the figure [image] related to the real object is charted in the interior surface of the brain, and on the surface of the gland [perception]. The function of the sense organs, underlying perception, may further be involved in memory mechanisms, leaving tubules partially open [traces], easing memory formation; retaining images [memory], dependent of the strength, duration, and repetition of
Descartes' project of a fantasized brain

COMMENTARIES

Descartes was a personage with a brilliant and creative mind, a fact that nobody can deny. He regarded the solid matter or the brain differently from the authoritative researchers known at his time, who saw it as an amorphous matter devoid of any specific function. In a different manner, Descartes proposed, for the first time, a minute structure for this solid matter, although hypothetical, and based on it, a presumptive function. More than three decades after Descartes' description, and fifteen years after his death, the microscopic structure of the brain was revealed by Marcello Malpighi, first in letters (1665), and then in his *Viscerum Structura* (1666), with its deep structures, and an external layer, the cerebral cortex, constituted by packed small elements (neurons).20-23

Interest in the minute structure of natural objects appears to have especially developed towards the end of the 16th and during the beginning of the 17th century. In this period, a number of scientists projected or constructed instruments to see the amplified structure of plants and animals. Among those may be cited Zacharias Jansen (1590), Galileo Galilei (1623), René Descartes (1637), Robert Hooke (1665), and Antoni van Leeuwenhoek (1673), among others.24 Descartes demonstrated his interest in the minute (microscopic) world, considering that among his projects of instruments to improve the vision (lunettes of varied lengths) in his *La Dioptrique* (1637), he presented a schema of an instrument intended to amplify small objects [microscope] (Figure 3).
It is unlikely that he actually used such instrument to analyze tissues, as he never mentioned such fact. However, he was aware of the potential of the ability to see the minute structure of the tissues, as he wrote (La Dioptrique [10th Discourse]): “…And so the difficulty that you can find in the construction of the mentioned lunettes should not repulse you... I however find them much more useful because we will be able to see by their means the various mixtures and arrangements of the small parts of which are composed animals and plants... and from there get much advantage to come to the knowledge of their nature…” (1637).

Descartes, thus, provided, although in a hypothetical manner, the first structural and functional theories of the nervous system, the understanding of cognitive processes and of sensory and motor activities.

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