The brain and nous in Greek antiquity

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᾽Επεγκρανίς ᾽Ερασίστρατος ὀνομάζει[1]

Introduction

Recent advances in neuroimaging could contribute further to our understanding of the function of the brain. In a recent communication published in *Nature* the authors present their *Next Brain*, a probabilistic histological atlas of the whole human brain. They argue that their *Next Brain* holds promise to increase the specificity of findings and accelerate the quest to understand better the human brain in health and disease [1].

The brain is a dominant organ among vertebrates. Some rudimentary elements of the nervous system have also been located in invertebrates, representing more than 90% of all living animal species on earth. The medicinal leech *Hirudo medicinalis*, was the first invertebrate in which a neuron cell was identified [2]. In the popular press, this hermaphrodite leech is reported to have 33 brains! [3].

But what did the ancients understand of the structure and function of the brain? In a period of the human history when the importance of the brain was underestimated, the mummification process practiced by the ancient Egyptians is revealing. Whereas the heart, believed to be endowed with all knowledge and feeling - *deemed essential for judgment in the afterlife*- was carefully preserved, the brain was totally discarded. The Greek historian and traveller Herodotus of Halicarnassus (c.484 – c.425 BC) explains: -πρῶτα μὲν σκολιῷ σιδήρῳ διὰ τῶν μυξωτήρων ἐξάγουσι τὸν ἐγκέφαλον, τὰ μὲν αὐτοῦ οὕτω ἐξάγοντες, τὰ δὲ ἐγχέοντες φάρμακα. (First, they remove the brain through the nostrils with an iron hook, that is, part of it, and then the rest by pouring drugs inside.) [4]. Perhaps the unremitting beating of the heart from the uterus to the grave, pounding during emotions and in combat, fascinated the ancient mind more than the apparent inertia of the enclaved brain. "*Be still my heart and let me rest a while*" says Lord Capulet, in Shakespeare's Romeo and Juliet.

References to the brain inscribed on stone, or papyrus, from the ancient Mesopotamian cultures and Egypt are variably interpreted by modern scholars as evidence that ailments of the brain, especially epilepsy, were known to these cultures. Many agree that such descriptions are not necessarily clinical observations but rather beliefs and interpretations largely by priests, of divine, often punishing interventions [5, 6].

Consider now the opening sentence of the "Sacred Disease" in the *Hippocratic Corpus*:" Περὶ μὲν τῆς ἱερῆς νούσου καλεομένης ὧδ' ἔχει· οὐδέν τί μοι δοκέει τῶν ἄλλων θειοτέρη εἶναι νούσων οὐδὲ ἱερωτέρη, ἀλλὰ φύσιν μὲν ἔχει ἣν καὶ τὰ λοιπὰ νουσήματα, ὅθεν γίνεται". (It is thus with regard to the disease called Sacred: it appears to me to be nowise more divine nor more sacred than other diseases, but has a natural cause for the originates like other affections) [7, 8].

[1]Galen reports that for the cerebellum Erasistratus uses the name *᾽Επεγκρανίς*. This should not be confused with the term *᾽Επικρανίς* used for the meninge (Greek English Lexicon – Liddell & Scot 1968, Oxford at the Clarendon Press – pages 613 & 640)

The Brain and the Greeks

References to the brain /ἐγκέφαλος are found in Homer's Iliad ὣδέ σφ' ἐγκέφαλος χαμάδις ῥέοι ὣς ὅδε οἶνος (brains be thus poured forth upon the ground even as this wine), [Hom. Il. 3.300] [9] and in Odyssey τῶ κέ οἱ ἐγκέφαλός γε (in Cyclops) [Hom Od. 9.458-460] but not as the organ of intellect rather, the target of injury in combative episodes.

It is perhaps not a coincidence that Athena, the goddess of wisdom and protector of the city of Athens is born, emerging from the head of Zeus. The philosopher Plato (428–347 BC) in his dialogue *Cratylus* devoted to language and onomatopoeia,

explains (through Socrates) the derivation of her name and attributes to this virgin Goddess "divine intelligence" "τὸν ποιητήν φασι τὴν Ἀθηνᾶν αὐτὸν νοῦν τε καὶ διάνοιαν πεποιηκέναι / ἀλλ᾽ὡς τὰ θεῖα νοούσης αὐτῆς διαφερόντως τῶν ἄλλων, Θεονόην ἐκάλεσεν. (θεοῦ νόησις, τὰ θεῖα νοοῦσα, she who has the mind of God, *a theonóa* - (the maker of her name seems to have had a similar conception of her, but he gives her the title of "mind of God" ἡ θεοῦ νόησις, seeming to say that she is Θεονόα) [10].

Alcmaeon of Croton (Ἀλκμαίων ὁ Κροτωνιάτης), the son of Peirithous, born c. 510 BC, the physician and philosopher from Magna Grecia, is considered the first in the ancient world to recognise the importance of the brain as the organ of intellect [10, 11]. His work has been cited by several ancient authors among them, predominately, Aristotle, Galen, Plutarch and others. Although not explicitly named, scholars have argued that Plato also refers to Alcmaeon's work in his *Phaedo* [11] when discussing the view that the brain is the seat of intelligence. It is believed that Alcmaeon practiced animal dissections and he was aware of the Eustachian Tubes [*vide infra*].

But it is the century after Alcmaeon's birth that medicine is decidedly and inextricably divorced from theosophy and superstition and emerges convincingly as a clinical discipline, studying among other organs, the brain in health and disease, its injuries from trauma and appropriate surgical interventions.

In the Hippocratic Corpus there are at least sixty references to ἐγκέφαλος / brain in ten treatises, predominantly, as expected, in the dissertation already mentioned, (ON THE SACRED DISEASE). In this same treatise we read: - Εἰδέναι δὲ χρὴ τοὺς ἀνθρώπους, ότι ἐξ οὐδενὸς ἡμῖν αἱ ἡδοναὶ γίνονται καὶ αἱ εὐφροσύναι καὶ γέλωτες καὶ παιδιαὶ ἢ ἐντεῦθεν, καὶ λῦπαι καὶ ἀνίαι καὶ δυσφροσύναι καὶ κλαυθμοί. (Men ought to know that from nothing else (but from the brain) come joys, delights, laughter and sports and sorrows, griefs, despondency and lamentations) [12].

Also, in this treatise we read, "Κατὰ ταῦτα νομίζω τὸν ἐγκέφαλον δύναμιν πλείστην ἔχειν ἐν τῷ ἀνθρώπῳ· οὗτος γὰρ ἡμῖν ἐστι τῶν ἀπὸ τοῦ ἠέρος γινομένων ἑρμηνεὺς, ἢν ὑγιαίνων τυγχάνῃ" (In these ways I am of the opinion that the brain exercises the greatest power in man. This is the interpreter to us of those things which emanate from the air, when the brain happens to be in a sound state) [12].

In the treatise on Airs Waters and Places (Περί Αέρων Υδάτων και Τόπων) there are references to the influence of weather conditions on headaches [13].

In the treatise on Traumata to the Head (Περί των εν Κεφαλή Τρωμάτων) the author discusses the anatomy of the skull and cautions the operator who treats head trauma, performing incisions on the temporal regions [13].

We read: - Σπασμὸς γὰρ ἐπιλαμβάνει τὸν τμηθέντα -καὶ ἢν μὲν ἐπ᾽ἀριστερὰ τμηθῇ κροτάφου, τὰ ἐπὶ δεξιὰ ὁ σπασμὸς ἐπιλαμβάνει τὸν τμηθέντα - ήν δὲ ἐπὶ τὰ δεξιὰ τμηθῇ κροτάφου, τὰ ἐπ' ἀριστερὰ ὁ σπασμὸς ἐπιλαμβάνει. (Because spasm seizes the one who is cut, and if the incision affects the left temple, spasm develops on the right side of the person and if on the right, spasm develops on the left) [13].

In the treatise Περί Αδένων (On Glands) it is argued that the brain has the consistency of a gland and we encounter the symptomatology of apoplexy (ἀποπληξίη τῷ πάθει τοὔνομα) [13].

In the chapter on Aphorisms there are seven references to the brain. Among others, we read ᾽Οκόσοισιν ἄν ὁ ἐγκέφαλος σεισθῇ ὑπό τινος προφάσιος, ἀνάγκη ἀφώνους γίνεσθαι παραχρῆμα. (Brain concussed from whatever reason, instantly results in aphasia) [13].

Herophilos (᾽Ηρόφιλος 335-280 BC) and Erasistratus (Ἐρασίστρατος c. 304 – c.250 BC) founders of the school of anatomy in Alexandria [14] are considered the first to have performed anatomical dissections on the nervous system and their work is largely preserved in the writings, among others, of Rufus of Ephesus and Galen. Although plausible, speculation, initiated by early theologians, that vivisections on convicted criminals were conducted in the anatomy school of Alexandria, have not been indisputably substantiated.

Rufus of Ephesus (Ῥοῦφος ὁ Ἐφέσιος, 1st c. early 2nd centuries CE), in the treatise Περί Ονομασίας των του Σώματος Μορίων (On the Names of parts of the Body) discussing the brain and cranial nerves, cites Herophilus and writes: -Ἡρόφιλος δὲ καὶ μήνιγγα χοριοειδῆ καλεῖ. Τὰ δὲ ἀπὸ τοῦ ἐγκεφάλου βλαστήματα, νεῦρα αἰσθητικὰ, καὶ προαιρετικὰ διὰ ὧν αἴσθησις καὶ προαιρετικὴ κίνησις, καὶ πᾶσα σώματος πρᾶξις συντελεῖται. (Herophilus names and a meninx choroid. And brain's offshoots, sensory nerves and motor nerves with which sensation and voluntary motion, and all actions of the body are performed) [15].

Physician, philosopher and experimentalist, a prolific writer, but also verbose and often critical of others, Galen of Pergamum (129 - c. 216 CE) is a devotee of Hippocrates [16], never missing the opportunity to express his admiration for the works of the Coan Physician, whilst he castigates Aristotle for misplacing the seat of the soul in the heart, rather than the brain. In Kuhn's edition of Galen's surviving works published in Leipzig between 1821 -1833, there are well over 300 references to the brain (cerebrum), including the cerebellum and meninges, listed in the 20th volume of this collection. Galen described the Great Cerebral Vein δευτέρας δὲ *(φλεβὸς)* πολύ μείζονος δύεται δ᾽ἡ φλὲψ αὐτή κατάντις εἰς τὸ βάθος ἔνθεν καὶ σχίζεται πολυειδώς; now often referred to as the *Galen Vein*, which passes backwards and upwards round the splenium of the corpus callosum [17, 18].

Galen in the treatise Περί Φιλοσόφου Ιστορίας, asks the question Τί πρῶτον τελειοῦται τοῦ βρέφους; (Which part of the foetus is completed first?). He quotes Alcmaeon as saying, Τὴν κεφαλὴν ἐν ᾗ ἐστι τὸ ἡγεμονικόν. (The head in which psyche resides) [19]. This is reiterated in another treatise ON SMELL (Περὶ ὀσφρήσεως) in which Galen cites him in the following sentence "Ἀλκμαίων, ἐν τῷ ἐγκεφάλῳ φησὶν εἶναι τὸ ἡγεμονικόν· τούτου οὖν ὀσφραίνεσθαι ἕλκοντος διὰ τῶν ἀναπνοῶν τὰς ὀσμάς." (Alcmaeon, in the brain is the hegemonic faculty; therefore, it is this that is inhaled, drawing in the odours through the breaths).

On hearing he writes: Ἀλκμαίων ἀκούειν ἡμᾶς φησι τῷ κενῷ ἐντὸς τοῦ ὠτὸς· τοῦτο γὰρ εἶναι τὸ περιηχοῦν κατὰ τὴν τοῦ πνεύματος εἰσβολήν· πάντα γὰρ τὰ κενὰ ἠχεῖ. (Alcmaeon says that we hear because inside the ear is empty. For this is what resounds with the force of the spirit, for all things empty, resound) [19].

Craniotomy a common neurosurgical procedure derives its name from cranium; Galen explains the derivation of the name of the osseus structure sheltering the brain: Τὸ περικείμενον ἔξωθεν ὀστοῦν ὁ δὴ καὶ κρανίον ὀνομάζουσι, καθά περ τι κράνος ἐπίκειται. (The surrounding bone outside, they name it *cranium,* because it resembles an overlying helmet).

As for Erasistratus and Aristotle, Galen writes in the book (Περί των καθ'Ιπποκράτην και Πλάτωνα Δογμάτων Βιβλίον Η΄). Ἐρασίστρατος μὲν οὖν, εἰ καὶ μὴ πρόσθεν, ἀλλ' ἐπὶ γήρως γε τήν ἀληθῆ τῶν νεύρων ἀρχήν κατενόησεν. Ἀριστοτέλης δε, μέχρι παντός ἀγνοήσας, εἰκότως ἀπορεῖ χρείαν εἰπεῖν ἐγγεφάλου. (Erasistratus then, though not before, but certainly in his old age understood the true origin of the nerves. Yet Aristotle, perpetually ignorant, rightly does not know how to explain the use of the brain) [20].

Among the many treatises of Galen, lost to us, one addresses "The practice of medicine in Homer" quoted by Alexander of Tralles (ca. 525 – ca. 605 CE) and referenced by Edward Theodore Withington in his book Medical History, available online.

The intellectual paralysis that gripped Europe with the coming of the new order, soon after Galen's death, stagnated further progress in the understanding of the nervous system and its properties [21].

The works of Oribasius, Aetius and Paul of Aeginae that followed produced little innovation and are essentially citations of earlier achievements of their illustrious predecessors. Europe had to wait for another thousand years before Vesalius' anatomical refinements.

Oribasius (Ὀρειβάσιος 320-400 CE) personal Physician to Emperor Julian (331- 363CE) and famous for his visit to the Delphic oracle in decline during its final days, provides among others a detailed description of the skull and of the cranial nerves, their origin from the brain, their course and exit through the various foramina, based largely on Galen's writings [22].

It is uncertain whether Aetius of Amida (Ἀέτιος Ἀμιδηνός mid 5th to mid-6th CE) produced any original work on the nervous system but he makes copious references to Oribasius and Galen in his writings. In the chapter on *Epilepsy by Galen*, he writes [2]τρεῖς εἰσι τῆς ἐπιληψίας διαφοραί πασῶν δὲ αὐτῶν κοινόν ἐστι πάσχειν τὸν ἐγκέφαλον. (there are three different types of epilepsy, and they all have in common the brain's ailment). He goes on to say that he witnessed an episode of focal epilepsy in a young child, and he gives a detailed account of this observation, which started with clonus at the tibia and ascended through different parts of the body on the same side, reaching ultimately the head [23].

Paul of Aegina (Παῦλος ὁ Αἰγινήτης c. 625 – c. 690) was born on the island of Aegina in the Saronic gulf, close to Athens. His surviving works, focused primarily on surgery, a *Medical Compendium in Seven Books* (Ἐπιτομῆς ἰατρικῆς βιβλία ἑπτά) became standard reference not only in the Byzantium and Europe, but also in the Arab world. On epilepsy (Βιβλίον Τρίτον 30/ιγ) he writes, [2]Ἡ ἐπιληψία σπασμὸς οὖσα τοῦ παντὸς σώματος, μετὰ βλάβης τῶν ἡγεμονικῶν ἐνεργειῶν πῆ μὲν ἐν αὐτῷ τῷ ἐγκεφάλῳ συνισταμένην ἔχει την αἰτίαν πῆ δε ἐν ταῖς αὐτοῦ κοιλίαις ἁπάσαις. (Epilepsy is a seizure of the whole body, with damage of the hegemonic energies, caused either by the brain itself, or by all its ventricles). [24].

[2] In the original versions of these treatises accessible online from *Bibliothèque numérique* medica the letters σ and ς are represented at times by c; for reasons of authentication, they have not been converted.

Discussion

Some of the statements on the brain made by Alcmaeon, Hippocrates and others in antiquity are self-evident to the ordinary mind of the 21st century; but they were made longer than twenty-five centuries ago, when the world was a very different place, without CT scanners, encephalography or radioisotopes.

A number of interesting studies have been published recently addressing the contributions of the ancient Greeks to the study of the brain and nervous system [18, 25-29].

Golder and Golder studied the 431 case histories included in the Hippocratic Corpus for the diagnosis, treatment and prognosis of single persons and groups of patients suffering from neurological and psychiatric disorders; they report that in the 7 books of the Hippocratic Epidemics, they identified 128 patients in total, described with neurological and psychiatric symptoms [25].

Breitenfeld and colleagues estimated in 2014 that 10 % of neurological Pubmed and 7% of neuroscience Scopus reviews, mention the Hippocratic Corpus as one of the sources [26].

The present study supplements further, recent contributions by accessing sequentially the original Greek text of the authors of antiquity, engaged in the study of the nervous system.

Will Athene's νόησις and Alcmaeon's ἡγεμονικόν be replaced, one day, entirely by artificial intelligence, what in contemporary Greek is referred to as *τεχνητή νοημοσύνη*? Will such techne enhance, replace, or degrade the creativity of the ordinary man? The prospect is terrifying to some and inspiring to others. Time will tell…

Note

Translation into English of ancient Greek texts originate largely from the *Perseus Digital Library*, as cited. A small number of ancient texts in this communication, was translated or modified by this author.

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