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REVIEW

ALKMAION'S DISCOVERY THAT BRAIN CREATES MIND: A REVOLUTION IN HUMAN KNOWLEDGE COMPARABLE TO THAT OF COPERNICUS AND OF DARWIN

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Abstract—Without special examination the brain offers no clue that it is the organ of the mind. From the dawn of time man thus either ignored the problem as to the source of thought, or attributed it to a variety of anatomical structures, usually the heart. The brain held no place in such intuitions, and in most languages it is analogized to bone marrow. Furthermore, nothing in early medical systems claimed any intellectual capacity for the brain; and the Egyptians, so fastidious in care for their afterlife, heedlessly discarded the brain in funerary practice. It was thus a unique event in world history when Alkmaion of Kroton (Alcmaeon, ca. 500 BC), based on anatomical evidence, proposed that the brain was essential for perception. Although no writings of Alkmaion survived, it was probably via a fortuitous linkage that his idea of the mental primacy of the brain was transmitted to, and preserved within, the teachings of the Hippocratic school. Nothing, of course, was secure as to mechanism, two millennia unfolding until the search for mind passed from the ventricles to the cerebral cortex. Nonetheless, Alkmaion was the beginning, and the ensuing understanding that he initiated is still transforming humanity's perception of the natural world, and their place within it. © 2007 IBRO. Published by Elsevier Ltd. All rights reserved.

Key words: history, Greece, Hippocrates, cerebral ventricles, philosophy, mind.

Contents

Equipped with present scientific understanding, the fact that thought and conscious experience depend upon the brain is now an automatic and almost universal assumption. Little heed is paid to the fact that this relation proceeds without the slightest subjective experience of location as to the origin of thought per se. While the neuroscientist in reading these lines can contemplate the ensuing multimillion cellular processes involved: photon capture, elaborated through ionic/cellular cascades, digitally propelled into a dedal tangle of fatty threads that, over countable milliseconds, parse the signals within the intricacies of the cerebral cortex, neither scientist nor savage perceives a source from which the attendant perceptions and deductions emanate. The locus of mind is not betrayed and, until the epochal discovery of Alkmaion (Alcmaeon, ca. 500 BC) in the city of Kroton in Magna Graecia, humanity was free to assign thought and mental experience to whatever entity they chose, anatomical or otherwise.

Most commonly, and for several defensible reasons, this assignment has been held by the heart; and still often remains so in common parlance. The brain was not a candidate. It was simply recognized as a type of bone marrow. This understanding survives in many languages (Doty, 1965), from Russian, which is prototypical, головной мозг ("*golovn̲oy mozg*," "brain" or the culinary dish "brains," but literally "head marrow"; Knyaz'kova, 1957), to Maori ("*roro*," "brains," but basically meaning "marrow"; Tregear, 1969), etc. In some languages, as in Greek or Chinese, "brain" was simply the "stuff inside the skull," εγκεφαλος (*egkephalos*, from *kephalos*, "head"), or 腦 (the older character for "nǎo," "brain"; but see below); and this was distinguished from "marrow" (μυελος/*muelos*) or 骨髓 (gusui, "bone marrow"). The character, 腦, is somewhat pictographic. Its first component, 骨髓, is derived from "肉" for "ribs" (Sears, 2006); but the "shorthand" form "月," signifying "flesh," was probably adopted ca. AD 1100, when human dissection and renewed interest in anatomy was initiated in China (Miyasita, 1967). 月 is now commonly the lead component of characters for anatomical terms. Earlier, the first component in 腦 was the character "匕" instead of "月," and in some contexts "匕" has the interesting connotation of "spoon" or "dagger" (T. H. Yin, Department of Physiology and Biophysics, National Defense Medical Center, Taipei, Taiwan; personal communication). Although "匕" also has the shorthand meaning "man" (R. Sears, Chinese Etymology Organization; personal communication), the connection with eating utensils is of considerable interest (as above, in the culinary allusion in the Russian dictionary). The other components of 腦 indicate "hair," and "an enclosed object," thus, in essence, representing the "material inside the head," as per the usage in Greek. However, in Morohashi's (1955) great Japanese/Chinese dictionary (1957–1959), the fourth def-

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inition of "腦" is "marrow" (Y. Kayama, Department of Physiology, Fukushima Medical University, Fukushima, Japan; personal communication). Hence, even in Chinese usage there is the idea that the mass inside the head, presently used in the current Western sense as "brain," originally may have held no particular significance beyond its culinary equivalent to bone marrow (also see Veith, 1966).

Prior to Alkmaion, and indeed for many centuries thereafter, the systems of medicine in Mesopotamia (Contenau, 1938), Egypt (Bryan, 1930; Desroches-Nobelcourt, 1963; Halioua and Ziskind, 2005), Persia (Brandenburg, 1969), India (Kutumbiah, 1962; Filliozat, 1964), China (Veith, 1966; Needham and Lu, 1969; Rall, 1970), and the Hebrew bible (Clarke, 1963a) held not the slightest indication that mental activity of any kind was to be associated with the brain. It was only after later western ideas began to penetrate the Orient, as with missionaries writing western medical texts in Chinese, e.g. Matteo Ricci in 1595 (Veith, 1966), that the present association of brain with mind became recognized in that part of the world. It is the Egyptians, however, up to and beyond the time of Alkmaion, who most dramatically reflect the utter disregard of brain. Ever meticulous in providing the dead with the necessities for their afterlife, they carefully preserved the heart, lungs, etc. in canopic jars, inflated the flaccid penis and, through the nose, rasped out and discarded the bothersome brain (Bryan, 1930; Desroches-Nobelcourt, 1963; Leca, 1971; Halioua and Ziskind, 2005, and Herodotus, as per Waterfield and Dewald, 1998). Thus, millennia of pharaohs went brainless into their celestial life.

THE BACKGROUND AND SETTING OF ALKMAION'S DISCOVERY

The 6th and 5th centuries BC in the Greek world were particularly tumultuous (Adkins and Adkins, 1997), and Alkmaion's city of Kroton (present day Crotone, Italy, Fig. 1) had its share of deadly events. Founded ca. 700 BC by Achaean colonists, it became a thriving part of Magna Graecia. Particularly notable was its dedication to athletics. The most famous athlete of all time, Milo, was their consistent Olympic winner and, putatively, warrior as well. In 510 BC Kroton, during Alkmaion's likely residence, defeated and utterly destroyed their larger and wealthier neighbor, Sybaris, renowned even today for its lavish, sybaritic lifestyle. The ruins of Sybaris were flooded with the river Krathis, and today remain inaccessible beneath the water table (Bullitt, 1969). Something of the magnificence of Sybaris, and of Magna Graecia generally, remains at Poseidonius (present day Paestum, Fig. 2), an allied city associated with Sybaris and refuge for many of its defeated citizens (Pedley, 1990). Herodotus, born 484 BC, spent much of his life in Thurii, the successor city to Sybaris.

Two facts are noteworthy in evaluating the origin and propagation of Alkmaion's work: Greek dialects, and the existence of a famous medical school at Kroton. The Dorian Greek dialect was spoken at Kroton, as well as on the island of Kos, off the coast of present day Turkey, subsequent home of the renowned Hippocrates. Athens and much of mainland Greece maintained the Ionian dialect. While these dialects were mutually understandable, there is a natural inclination to affiliate with one's linguistic cognates, and in this case there is strong historical evi-

Fig. 1. Crotone, Italy, site of the city of Kroton in Magna Graecia where, in 500 BC Pythagoras held forth with his semi-religious cult, and of the famous medical school where Alkmaion developed his wholly unique idea that the brain was the organ of perception. (Photo by the author, 2 May 2006).