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# INTRODUCTION: GREEK SCIENCE AND THE RECOGNITION OF NERVE AS A CHANNEL

Before the dawn of civilization, primitive man believed, as does primitive man today, in animism, magic, and supernatural forces to account for events in the world he experienced.[1] The powers of nature are seen when, after the death of vegetation in winter, its rebirth occurs in spring. Storms with their lightning and thunder, wild animals, and the unpredictable and often turbulent behavior of man in relation to man were powers anthropomorphized through the action of spirits who were either beneficent or malevolent. The emotions felt within himself, man projected to other men, to other living beings, and even to inanimate objects moved by unseen forces.

With the rise of Greek philosophy and science, another view of nature and man arose: the belief that the cosmos and man are ruled by impersonal laws, that the gods do not take a providential interest in the affairs of man. As scientific knowledge evolved and the structures and functions of the various body organs became recognized, the nerves were singled out as having an integral relation to sensation and body movements. In some of the earliest accounts of nerve, they were thought of as channels carrying a spiritual influence to the brain in which consciousness and willed motor control over the body was located.

## THE EARLY CONCEPTION OF NERVE CONFOUNDED WITH TENDONS

The artifacts and cave drawings left by prehistoric man attest to his powers of observation. In the course of hunting or warfare, he would have seen muscles become lax and limbs made useless by the severing of large tendons. But the tendon was not clearly identified. It could be muscle tendons (such as those of the hamstrings) or a major nerve (such as the sciatic). In the archaic Greek civilization represented in Homer's epic *The Iliad*,[2] the word *neuron*

[1] (Frazer, 1922).
[2] c. 8th century B.C., probably first written down in the sixth century.

was applied both to tendons and nerves, and analogized to a bowstring taut with tension applied to it or lax when severed. The standard dictionary definitions in use to this day attest to the order of its ancient derivation. Under the dictionary heading of "nerve," we find the first meanings given are "sinew" and "tendon," with the idea of putting forward the utmost exertion, as to "strain every tendon."[3] The later meaning given is that it is "cord-like or filamentous tissue connecting parts of the nervous system and organs of the body." It was defined in 1606 as, "A fibre or bundle of fibres arising from the brain, spinal cord, or other ganglionic organ, capable of stimulation by various means, and serving to convey impulses (especially of sensation and motion) between the brain, etc., and some other part of the body."[4] A number of other meanings given for its modern use relate to its original meaning as a tendon, namely as subserving vitality, force, physical strength, fortitude, vigor, endurance, and also curiously its inverse, oversensitiveness and nervous weakness.[5]

In the *Old Testament*, reference is made to "the sinew present in the thigh" with some confusion with blood vessels, as in the translation "the principal vein of the leg which is in the thigh, commonly the sciatic nerve" and, to the "sinew of the thigh-vein or thigh-nerve." That the nerve was implicated is indicated when, in the struggle of Jacob with a strange man (Angel or God?), Jacob was "touched on the hollow of his thigh, which lamed him."[6] This is why it is said that, "the Israelites to this day do not eat the sinew of the nerve that runs in the hollow of the thigh." From the era of the Patriarchs, eating the flesh of that part of the leg (the rump) containing this nerve (the sciatic) was forbidden, and this proscription was maintained as part of Kosher law. However, the flesh may be eaten if the nerve is first removed

[3] (Webster's, 1966).

[4] (Oxford, 1944). In earlier dictionaries devoted to medicine (Castelli, 1761), the latin term *nervus* derived from the Greek *neuron* while described in relation to tendons and ligaments, the bulk of the definition dealt with its then modern role as channels conveying animal spirits to support sensation and motion.

[5] (Oxford, 1971). Samuel Johnson gave as the first meaning for nerve an organ of sensation, the second the use by poets for sinew and tendon, and the third for force and strength (Johnson, 1827). It is interesting that in our time only by the eighth definition do we find reference to nerve as a fiber or bundle of fibers arising from the brain and acting to convey impulses of sensation or motion. Another relation of the term nerve to tendons comes from the early experiences with stringed instruments. The strings, when stretched, give rise to a higher note on plucking them. Thus, an individual, if overly sensitive or nervous, is said to be high strung.

[6] (Bible, 1970), Genesis 32:31–32. This is variously translated. The New English Bible has it that a dislocation at the hip occurred. Translating the passage from the Latin Vulgate, "He touched his (Jacob's) *nervum femoris* (femoral nerve)." But, the femoral nerve supplies the anterior surface of the thigh, and the reference is clearly to the hollow of the thigh. Continuing, the passage reads, "immediately (the nerve or leg) became feeble" (reading *emascuit*-withered or feeble).

in the process known as *porging*.[7] The custom of porging appears to have been carried out in an old, isolated Jewish enclave in China by the Jews who lived in Kaifeng (K'ai-feng), the old Capital city of the province of Honan,[8] where the Chinese referred to them as the *T'iao-chin chiao*, the people who "pick out the tendons."[9]

An analogy to the biblical injunction against eating the rump because of the sciatic nerve within it was the practice carried out among some North American Indian tribes of regularly cutting out and throwing away the thigh muscles containing the nerve.[10] The reason given by the Cherokee Indians was that the "tendon," when cut, retracts, with the muscles becoming lax; and they did not wish to expose themselves to the danger of also becoming weakened if they were to eat it. The notion is clearly based on sympathetic magic.[11] The struggle of Jacob in Genesis may very well also have had a similar origin in sympathetic magic that was later given a mythic interpretation.

## PRIMITIVE ANIMISTIC BELIEF IN SPIRITS ANIMATING THINGS, AS WELL AS LIVING BEINGS

An insight into the thought of the ancient man was given by the studies of aboriginal peoples in Polynesia and elsewhere in remote corners of the world by explorers, evangelizers, and anthropologists. An extraordinary opportunity to directly study the thinking of a primitive man came about when in 1911 an Indian, Ishi, emerged from the foothills of a remote mountain in northern California. He was the last of an isolated Stone Age tribe that had completely died out but for him.[12] Ishi was patient, cheerful, good-natured, with the capacity to learn equal to that of modern man. He

[7] (Klein, 1979).

[8] Jews entered China via the Silk Road as traders in a number of places in China, perhaps as early as during the Han dynasty (206 B.C.–220 A.D.) (White, 1966), p. 52, though the earliest tangible evidence of their presence is around 718 with a settled Jewish community in Kaifeng more definitely attested to by a synagogue built in 1163.

[9] (White, 1966) ref. to (Lépine, 1894), Part 1, p. 51, Part 2, note 18, p. 24 and p. 110. The term "T'iao" refers to jumping, "chin" to the tendon or nerve, the jumping nerve, and "chiao" to a hollow, wherein by digging the sciatic nerve could be removed from the rump and thigh muscles.

[10] (Gaster, 1969), pp. 210–211.

[11] Ibid., pp. 211–212.

[12] (Kroeber, 1994), pp. 23, 78. Hungry, sick, and alone, Ishi came into the hands of two California anthropologists: T. T. Waterman and Alfred L. Kroeber. With the assistance of an Indian from a bordering Indian tribe who had a dialect close to that of the Indian and the linguist Edward Sapir, he was able to communicate the story of his life. Ichi was a Stone Age man who had stepped out of the remote shadows of the past. He lived on for four plus years of his life quartered in the museum transmitting his language and culture. He demonstrated how he made obsidian knives and arrowheads, bows and arrows. He also fished and hunted. While housed in a hospital, Ishi witnessed a number of surgeries. These did not

lived at ease with the supernatural and the mystical, which for him were so pervasive in all aspects of his life, feeling no need to differentiate mystical truth from directly observed evidential or "material" truth, the supernatural from the natural.

Anthropologists have described the primitive's belief that the world is ruled by spirits, with the power to do him harm or good.[13] To the primitive mind, there are no accidents. Everything has a cause. A falling rock or a swaying tree was directed by some hidden force.[14] Misfortunes and diseases are attributed to malevolent agencies.[15] These include taboo violation, disease-object intrusion, spirit intrusion by sorcery, and soul loss. When human ghosts feel lonesome or if disrespect has been shown to its body after death, they can cause disease. The power of the wind was of importance, and the meaning given to it by American Navajo Indians gives some insight into what prehistoric man may likely have understood of the world. The chants of the singers transmitted the traditional sacred lore in which the term *Nił ch'i*, meant Wind, Air, or Atmosphere, which was conceived by the Navajo to be endowed with powers.[16] Suffusing all of nature, *Holy Wind* gives life, thought, speech, and the power of motion to all living things, and serves as the means of communication among all elements in the living world. By the winds of the East, West, North and South, man is given direction to life, to movement, thinking, and action to carry out his plans; these external winds are the same as "the wind standing within us."[17] The great force of the wind is shown by its power to knock down large trees. The wind was also thought by the ancients to have procreative power. Mares were reported to become impregnated by facing their hind quarters into the wind; and, at a relatively later time, the Roman writer Varro (116–127 B.C.) affirmed it as certain truth "that about Lisbon some mares conceived by the wind, at a certain season, as hens conceive what is called a 'wind egg.'"[18]

trouble him but for the induction of anesthesia. He thought that during sleep, the soul leaving the body might have difficulty in returning.

13 A short discussion of animism given by Clodd included the various terms given for the concept around the world (Clodd, 1905). See also (Vogel, 1970).

14 (Frazer, 1922). 15 (Rivers, 1924).

16 (McNeley, 1981), p. 1. By carefully cross-checking various oral versions, McNeley was able to determine what the Indians generally understood by the concept of "wind." The relative isolation of the Navajo subjects on the reservation, uncontaminated with modern Western notions and his personal participation in Navajo culture makes his account an important document. The concepts he described could very well represent a deposition of earlier thought reaching back to the Stone Age.

17 Ibid., p. 16.

18 (Oxford, 1971), p. 3786. The wind-egg is an imperfect or soft-shelled egg that is unproductive. This term was used by Plato in the dialogue Theaetetus for an argument or a concept that was unproductive (Cornford, 1935), p. 163.

The belief in powers that control the world and man was the basis of magical practices. If followed in exact accordance with the laws of those powers, a desired end – such as the cure of a disease – could be brought about. An important distinction was made by Fraser between the practice of magic and religion.[19] The magician acts to bring about the desired end by following his belief in the immutable laws of nature as he understood them. In this sense, his thought process is analogous to that of the scientist – the difference being that, for the scientist, those laws and the understanding of them can evolve and be replaced by others. Religion, on the other hand, is the belief that superhuman agencies, the gods, take a personal interest in man. The function of the priest is to intervene to bring about a desired end by placating the gods or to make them turn from their foreordained detrimental purposes. In the course of the development of man's thought, the offices of magician and priest were combined. The priest could, as in ancient Egypt, not only placate, but also compel the highest of gods to do his bidding.

To primitive man, the dramatic transformation of a living man or animal, warm and moving, into a cold immobile form when dead, appeared to be due to the loss of an internal "spirit" or "soul" essential for life. The very term *spirit* is related to breath, which confers life. The ancient Egyptians describe how Isis, by breathing on the dismembered body of Osiris, brought him back to life. In the *Old Testament*, the Hebrew word for spirit, *neshuma*, encompasses the concept of breath and wind. It is written in Genesis 2:7 that man formed from clay (or dust) was inert until "God breathed into his nostrils the breath of life and he became a living soul." In the book Ezekiel 36:2–11, the prophet was put down in a plain full of bones. Prophesy to these dry bones he was told and hear the word of the Lord:

> I will put breath into you and you shall live. There was a rustling sound and the bones fitted themselves together. Sinews appeared, flesh appeared and skin covered them but there was no life. Prophesy to the wind to come from every quarter that they might come to life. Breath came into them. They came to life, and rose to their feet a mighty host.

In the Egyptian Coptic rite, the priest immediately after baptism breathes on the face of the infant saying, "Receive the Holy Ghost"; and their priests are ordained by the reigning bishop breathing on the new prelate's face. And, by inhaling a dying breath capture its power.

*Pneuma*, the ancient Greek term cognate with the Latin *spirit*, was thought to suffuse the cosmos, with wind being the expression of its presence and power. To the Vedic Indians, the cognate term *prana* was used to indicate

[19] (Frazer, 1922), pp. 56–69.

the presence of breath-giving life:

> The cosmic wind that blows in the atmosphere motivates and regulates the normal course of things or the cosmic order in the same way that the breath in living beings motivates life. Thus, wind is the breath of the cosmic person and the dead person's spirit (*atman*) goes to the wind.

This *pneumatological* belief is widespread. It is the basis of the practice of Yoga in India[20] and in Chinese and Japanese medicine where the term *qi* is cognate with the Greek term pneuma and its Latin equivalent spirit (*spiritus*).[21]

The word *soul* used in the *New Testament* is the translation of the Hebrew word for spirit that embraces a complex of ideas extending the idea of spirit. The soul can have appetites, hunger, and thirst. It is the seat of emotions, desires, and can experience sorrow or joy. It can show volition and think; it is the self-conscious manifestation of life. The Homeric Greeks pictured the soul as thin and impalpable, a shadow haunting a ghostly realm, a replica of the human body that resembles its former self.[22] According to Tylor, "nothing but dreams and visions could have ever put into men's minds such an idea as that of souls being ethereal images of bodies."[23] To the primitive mind, the dream is no less real than the waking state, and the dreamer may accuse another of a crime he saw committed in a dream.[24]

## ANCIENT BELIEF IN POWERS RESIDING IN THE HEAD INDICATED BY TREPANATION

The association of important spiritual powers residing in the brain is seen by practices such as those of the head hunting cannibals of Dutch New Guinea and adjacent islands who took their enemies' heads to gain the powers felt to reside within them. In the 27 skulls found by Lord Moyne in an abandoned village on the Bloemen River region in Dutch New Guinea, enlargements were made around foramen magnum at the bottom of the skulls "that shows the effect of a deliberate and successful removal of a large part of its base to facilitate the extraction of the contained brain, for use either for food or for ritual purposes."[25] Cave quotes Frazier who gives examples of the eating of the brain of a vanquished warrior to "acquire thereby his virtues

[20] (Zysk, 1995). [21] (Kuriyama, 1995).

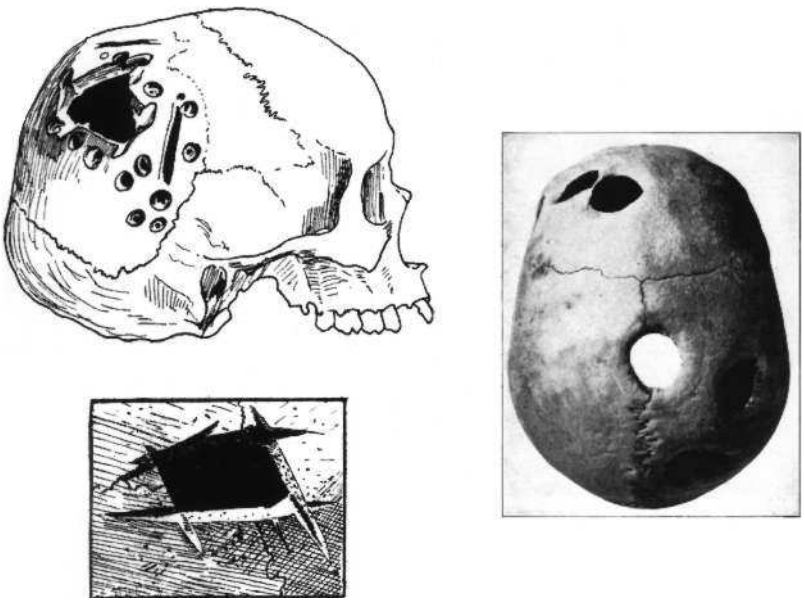
[22] This is strikingly described in the *Iliad*, when Achilles falls asleep and Patroclus' ghost visits him in a dream, looking exactly as he had while alive. He asks to be "buried without further ado so that I can win admittance to the Underworld." Achilles "stretched out both arms, but the phantom evaded his clutch, turning to vapor and sinking through the earth with a shriek." Achilles leaped up, horror-stricken: "Then it is true!" he exclaimed. "There are spirits of the dead in Hades' kingdom; active minds, though unsubstantial and lifeless! Yet, how marvelously Patroclus' ghost resembled his living self when it stood lamenting and pleading with me" (Homer, 1997).

[23] (Tylor, 1871). [24] Ibid. and see also (Clodd, 1905). [25] (Cave, 1937), p. 15.

and qualities."[26] Among primitives in the Celebes, it was to acquire the victim's bravery, among those in the Philippines it was to obtain courage, and among those in the New Guinea territory it was to procure strength. In Southern Guinea, "the decayed brain of a wise man is consumed in the belief that his wisdom passes to the consumer. . . ."[27] Some additional ritualistic reasons for the practice of taking the brains other than that of vanquished warriors is indicated by the presence among Lord Moyne's collection of the skulls of children 4–8 years of age that had similarly been broken into at the base. In recent years, transmission of the disease called *kuru*, a form of Creutzfeldt-Jakob disease affecting the brain, was traced to the practice of eating brains.[28]

The loss of consciousness and prostration or death following a blow to the head and convulsions must not have been an uncommon observation made by prehistoric and primitive man. This could well have suggested the idea that the head plays an especially powerful role in controlling conscious life, as well as controlling the lively vigor of the body leading to the ancient practice of *trepanation*, the opening of holes in the skull of a living subject.[29] The first example of trepanned skulls that had been made in ancient times was discovered in France in 1834. Subsequently, such skulls were found elsewhere in Europe, North Africa, parts of Asia, and America, with greatest frequency in the highlands of Peru and Bolivia.[30] That these openings had incurred in life was shown by the healed edges of the holes. Also testifying to the subjects outliving the operation are skulls found with two, three, or more holes in them (Figure 1.1). Perhaps epileptic attacks, chorea, insanity, or some other aberrant behavior could have led to the thought that an indwelling evil spirit was responsible and had to be let out. That the basis for the operation was magical is indicated by the portion of bone removed from the trepanated skull, the *rondel*, being used as an amulet. With the dawn of the science of medicine, Hippocrates describes trepanation as a surgical procedure in the treatment of head injuries. It is of interest that trepanation, outside of its use in surgical interventions, was still carried out in various remote places in Europe and the Americas on into the nineteenth century and exists today as a bizarre cult practice performed in supposedly normal people.[31]

[26] (Frazer, 1922), pp. 576–578. The sympathetic magic practice of eating various parts of slain valiant enemies is to absorb their virtues: strength, bravery or to thereby acquire skills, intelligence, and wisdom.
[27] Ibid., p. 16. [28] (Gajdusek, 1977).
[29] (Guiard, 1930). See also (Lisowski, 1967) and (Margetts, 1967), pp. 673–701.
[30] (Hrdlička, 1939).
[31] A site on the Internet advances the use of trepanation for rejuvenation, supposedly by reversing the falloff of brain blood volume and metabolism associated with aging and offers instructions for self-trepanation!



**1.1.** Examples of trepanation. Different types of openings made into the skulls with signs of healing seen at their edges. The skull on the right reveals five round holes. An example of a square hole is shown at the bottom left. From (Guiard, 1930), Plates 1 and 8, Figures 1 and 2.

## The rise of Greek philosophy and science

It was the genius of the ancient Greek thinkers of the sixth and fifth centuries B.C. that replaced animistic belief in spiritual powers, magic, and the supernatural anthropomorphic religion expressed by Homer and Hesiod (c. ninth and eighth centuries B.C.) with philosophy and science.[32] The gods were no longer thinly veiled anthropomorphic powers controlling human events. They were replaced by physical forces and entities operating by inexorable laws. The impetus was the search for the *arche*, the principle underlying things and the basic "stuff" of which all things are made. In the Platonic dialogue *Timaeus*, at the onset all was chaos out of which the Demiurge (a lesser god) made the world. This was presented as a fable, what we may call a hypothesis, one that could undergo modification. In contrast, in the religious account given in Genesis, God created the world from nothing,

[32] It should not be thought that the philosophers struggled only against the mythic gods of Homer and Hesiod. The more archaic, darker, animistic beliefs in the supernatural, mysticism, magic, fetishism, and irrational practices and rituals were endemic in the population (Harrison, 1962), (Dodds, 1951), and (Macchiori, 1930). These irrational beliefs remain with us today, not only in primitive societies, but also in somewhat altered forms in the most highly civilized nations of the world.

*ex nihil* (by divine fiat),[33] and continues to intervene in the affairs of men – a providential God. In the Greek philosophical accounts, the whole of *physis* (nature) of the *Cosmos* that encompasses all – the earth, sea, and sky with its heavenly bodies of the sun, moon, and stars and the earth and its living creatures – is ruled by impersonal fixed law.[34] Some of the earliest of these thinkers, the *physiologists*,[35] appeared in the important commercial Greek city of Miletus at the western shore of Anatolia, now Turkey, facing the Aegean Sea.[36]

Among them was *Thales of Miletus* (c. 640–546 B.C.), who taught that water was the fundamental substance, the concept likely inspired by its necessity for life. For *Anaximenes* (fl. 546 B.C.), the fundamental substance was *aer* (air), which includes pneuma (breath or spirit), the term later extended to include the *psyche* (soul) present in animate beings.[37] In us the soul enables life: "Just as our soul being air, holds us together, so do breath and air encompass the whole world."[38] The term then further extended to include the concept of the mind. Philosophers appeared in other city states of the Greek world. *Pythagoras of Samos* (c. 580–489 B.C.) founded a mystical philosophical brotherhood at Croton, a Greek colony located at the foot of Italy. He taught that the world could be understood on rational principles, on mathematical laws, and considered the world to be made of four elements: earth, water, air, and fire. His pupil *Empedocles* (490–430 B.C.) advanced the concept that, under the opposing forces of "love" and "strife," the four fundamental elements of earth, air, fire, and water become transformed into one thing or another.[39] *Anaxagoras* (500–428 B.C.) viewed the cosmos as being formed by *nous* (mind or reason) from an infinite number of different elements. These come together on the basis of "like coming together with like," just as "fluid" merging with other "fluid" forms the oceans, the various parts of the body are formed the same way with bone formed from

[33] (Burnet, 1948), (Zeller, 1931).
[34] The world order was called the *Cosmos* in the fifth century B.C., but likely could have been referred to as such earlier, in the sixth century B.C. (Hussey, 1972), p. 18.
[35] The term "physiologist" was at first used for those who study *physis*, nature. The term was then extended to include additional meanings, making it necessary to assess the use of the term used at a given time (Peters, 1967). The term *physiologist* is now used for those who study animate nature, with the term *physicist* reserved for those who study inanimate nature.
[36] Miletus at the time was the greatest metropolis in the East. It was on the western coast of modern Turkey and was rich from its commerce and trade both inland with the Persian Empire and via the sea with the port cities of Greece and other peoples around the Mediterranean Sea.
[37] (Peters, 1967).
[38] Kirck & Raven, 1971). See Chapter IV, and (Hankinson, 1998), and (Russell, 1945), p. 28.
[39] (Freeman, 1957).

elementary bone, flesh from elementary flesh, and so on. As Greek thought developed, the special role played by air, the term originally given as spirit, was extended to soul as the animating principle responsible for life and then extended to encompass the mind by nous, the cognitive (*noetic)* function, whereby things, their number, harmony, and their relations to one another could be understood.[40] Nous was not only deemed a property of the mind of man, but it was also revealed by the cosmos with the regularity of the movement of the stars, sun, and moon in the heavens expressing by the regularity of their progression in the skies harmony and order, the presence of intelligence. This was the *anima mundi*, the immortal animated world, the cosmos that included the air, the sky, and the heavens; the *macrocosm* that is related to man, the *microcosm*. The divine air of the cosmos, from which all things take their origin and are held together by its invisible organizing principle, is taken in by respiration to animate the body, hold it together, and regulate changes within it.[41]

The concept that inspired air carried in the carotids confers consciousness and thought in the brain was taught by *Diogenes of Apollonia* (412?–323 B.C.). He took air to be the source of all things, identifying the warm air within the body (apparently carried by the arteries) to mix within the brain where the soul is located. Perception arises there with the psyche acting as the mediator between sensation and cognition.[42] This relationship of the intelligence of the cosmos brought in by air to man, the microcosm, was clearly expressed when he wrote,

> And it seems to me that that which has Intelligence is that which is called Air by mankind; and further, that by this, all creatures are guided, and that it rules everything; for this in itself seems to me to be God and to reach everywhere and to arrange everything and to be in everything. And there is nothing which has no share of it; but the share of each thing is not the same as that of any other, but on the contrary there are many forms both of the Air itself and of other Intelligence; for it is manifold in form: hotter and colder and dryer and wetter and more stationary or having a swifter motion; and there are many other differences inherent in it and infinite (*forms*) of savor and color. Also in all animals the Soul is the same thing, (namely) Air, warmer than that outside in which we are, but much colder than that near the sun.[43]

## CONCEPTION OF NERVES AS CHANNELS FOR SENSATION AND MOTION

With *Alcmaeon of Croton* (fl. fifth century B.C.), a pupil of Pythagorus, the differentiation of science from philosophy was widened. He is credited with carrying out animal dissections, which led to his proposing that special

[40] (Peters, 1967). [41] (Rusche, 1933). [42] (Solmsen, 1961).
[43] (Freeman, 1957), p. 88.