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Review Article

Greco-Arab Contributions to Cranial Nerve Anatomy: A Review

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Abstract: The evolution of cranial nerve anatomy is deeply rooted in the foundational work of ancient Greek physicians, particularly *Buqrāt* (Hippocrates) and *Jalinūs* (Galen)), who contributed significant early insights despite limitations imposed by a lack of human dissection. *Buqrāt* (Hippocrates) is recognized for his theories concerning the brain's role in sensation, while *Herophilūs* advanced the understanding of sensory and motor nerves. The Islamic Golden Age saw an integration of Greek anatomical knowledge with original clinical observations by scholars such as *Al-Rāzī* and *Ibn Sīnā*, who preserved these early insights and enhanced them through detailed works, including *Kitāb al-Hāwi* and *Al-Qanūn fi'tib*. These texts not only classified twelve pairs of cranial nerves but also established correlations between their functions and neurological conditions. The translations and commentaries by figures like *Ḥunayn Ibn Ishāq Al-'Ābādī* further facilitated the permeation of this knowledge into medieval Europe, influencing Renaissance and modern anatomy. Major contributions included delineations of nerve types based on sensory and motor functions, as well as the recognition of the cranial nerves' pivotal roles in managing bodily functions. The historical progression highlights an essential continuity in the study of anatomy, demonstrating how the insights of ancient and medieval scholars established the foundation for modern neuroanatomy. This narrative illustrates the cumulative and diverse development of scientific ideas within this discipline. The analysis of past contributions elucidates their enduring relevance, bridging historical and modern perspectives in neuroscience. This research paper explores not only serves to preserve the legacy of ancient and medieval anatomists but also emphasizes their relevance in the context of modern medical understanding.

Keywords: Cranial nerves, sensory neurons, motor nerves, neuroanatomy, neuroscience.

INTRODUCTION

The anatomy of the cranial nerves represents one of the most intricate and functionally significant domains of neuroanatomy, forming the fundamental communication pathways between the brain and the peripheral structures of the head, neck, and, in some cases, thoracic and abdominal viscera [1]. These twelve paired nerves are responsible for sensory, motor, and autonomic functions, and their detailed study has been pivotal for advances in neurology, neurosurgery, and clinical diagnostics [2]. While modern neuroscience often attributes progress in cranial nerve anatomy to contemporary neuroimaging and microsurgical techniques, the intellectual roots of this discipline extend deeply into Greco-Roman antiquity and the Golden Age of Arabic-Islamic medicine [3].

Ancient Greek physicians, notably *Buqrāt* (Hippocrates) (460–370 BCE) and *Jalinūs* (Galen) (129–c.216 CE), produced foundational descriptions of cranial nerve pathways, albeit limited by the absence of systematic human dissection [4]. *Herophilūs* of Chalcedon (335–280 BCE) is credited as one of the first to distinguish nerves from tendons and to identify certain cranial nerves [5]. However, many of these early anatomical insights were preserved, expanded, and critically analysed during the Islamic Golden Age, when scholars such as *Al-Rāzī* (Rhazes, 865–925 CE) and *Ibn Sīnā* (980–1037 CE) synthesised Greek works with their own clinical observations [6]. Their contributions, preserved in texts like *Kitab al-Hawi* and *Al-Qanūn fi al-Tibb*, incorporated detailed functional correlations, early neuropathological case descriptions, and systematic classifications of cranial nerves [7].

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Arabic translations of *Jalinūs* (Galen)'s works, often mediated through Syriac intermediaries, facilitated the transmission of anatomical knowledge into medieval Europe, where it profoundly shaped Renaissance anatomy and early modern neurology [8]. Notably, Ibn al-Nafis' commentaries refined the understanding of cranial nerve anatomy within the broader framework of neurovascular physiology [9]. These Greeko-Arab contributions not only preserved ancient heritage but also integrated empirical observations, setting the intellectual stage for modern neuroanatomical mapping [10].

Cranial nerves *(A'ṣāb al-Dimāghiyya)* are the means by which the brain receives information from, and controls the activities of, the head and neck, and to a lesser extent the thoracic and abdominal viscera. The component fibres, their rout of exit from the cranial cavity, their subsequent peripheral course and the distribution and functions of the cranial nerves are considered in detail elsewhere on a regional basis. There are 12 pairs of cranial nerve *(A'ṣāb al-Dimāghiyya)* arises from the brain. Each cranial nerve has both a number, designated by a roman numeral, and a name. On the basis of function cranial nerve are sensory, motor and mixed in nature. Three cranial nerves (I, II, and IV) carry axons of sensory neurons and thus are called special sensory nerve. These nerves are unique to head and are associated with the special sense of smelling, seeing, and hearing. Five cranial nerves (III, IV, VI, XI, and XII) are classified as motor nerves because they contain only axons of motor neurons as they leave the brainstem [11].

In the context of cranial nerve anatomy, revisiting these historical contributions offers more than antiquarian interest—it highlights the cumulative and multicultural nature of scientific progress [12]. By analysing the descriptive accuracy, methodological innovations, and conceptual frameworks of Greeko-Arab scholars, this study aims to re-evaluate their relevance in light of current neurosurgical and neuroimaging standards [13]. Such an approach bridges past and present, illustrating how the legacies of ancient and medieval anatomists continue to inform and inspire contemporary neuroscience.

MATERIALS & METHODOLOGY

This research adopts a historical-analytical approach to examine Greeko-Arab contributions to cranial nerve anatomy and their influence on modern neuroscience. The methodology integrates primary historical texts such as *Kitāb al-Hāwi, Kitāb al-tasrīf, Firdaus-al-Hikmat, Kitāb-al-Mansūrī, Al-Qanūn fi'tib, and Kāmil-al-Sanā* etc. and secondary literature reviews of scholarly journals, research articles, contemporary publications, and comparative analysis with current neuroanatomical standards. The study is qualitative in nature and by employing this dual perspective, the study not only enriches the analytical process but also provides a meaningful bridge between classical Unani principles and present-day neuroanatomical understanding.

OBJECTIVES

The primary aim of this research is to critically examine the contributions of Greeko-Arab physicians and anatomists to the understanding of cranial nerve anatomy, with particular emphasis on their influence on the foundations of modern neuroscience. By integrating historical textual analysis with contemporary neuroanatomical knowledge, the study seeks to bridge the gap between classical medical heritage and present-day scientific understanding.

By addressing these objectives, the research will provide a structured historical perspective on cranial nerve anatomy, demonstrating how the integration of Greek empirical observation and Arabic scholarly synthesis laid an essential foundation for the development of contemporary neuroanatomy and clinical neuroscience.

LITERATURE REVIEW

1. Early Greek Foundations

The study of cranial nerves in the Western tradition begins with the physicians of classical Greece. While *Buqrāt* (Hippocrates) is often regarded as the father of medicine, his anatomical knowledge was limited by the absence of human dissection in most Greek city-states [14]. His writings, including *On the Sacred Disease*, describe the brain as the seat of sensation and voluntary movement, though without precise identification of cranial nerves [15]. The major leap forward came in the Hellenistic period with Herophilūs of Chalcedon (c. 335–280 BCE), working in Alexandria, who differentiated motor from sensory nerves and described the optic nerve in remarkable detail [5]. *Erasistratūs* (c. 304–250 BCE) extended these studies, speculating on neural pathways and introducing early ideas of nerve conduction [16]. In 500 BC *Alcmaeon* was the first writer to specify the brain (*Dimāgh*) as the site of sensation and cognition [17,18]. *Alcmaeon* described that the brain (*Dimāgh*), it behaves as a hegemonic in the body. He said that all the senses are connected with the brain and it is the governing body of intelligence [19,20,21]. Thus, this philosopher initiated the approach to medicine that is called as encephalocentrism. We can call Alcmaeon as a "The father of neuroscience" [18,22,23]. *Alcmaeon*'s idea of light in the eye was only disproved in the middle of the eighteenth century [20,24]. Alcmaeon was also the first to mention the eyeball & believed the senses to be connected with the functioning of the brain by poroi or channels. He thought that if the brain moved or changed its position, the senses would become incapacitated because the passages through which the sensations arrived were blocked [25, 26,27,28,29].

According to *Buqrāt* (Hippocrates), he considered the brain (*Dimāgh*) as a gland secreting mucous that cooled the Body [5,26]. He said that the brain (*Dimāgh*) is covered with thick and soft membranes and spinal cord Emerge from it [7,8]. Many ancient philosophers considered the heart to be seat of consciousness and intellectual, but Buqrāt assigned that role to the brain [30]. He also described the Optic Nerve, Radial Nerve and Sciatic nerve etc. [20]. And also described the vagus nerve running from the base of the skull to the coccyx [9]. For the first time, Buqrat discussed the anatomy of the spine, spinal cord, and certain diseases associated with them. And described the curvature of the spine, and knew that the spinal cord was important (even believing that it was the site of sperm production), and so he insisted that every physician should study it meticulously. Buqrāt (Hippocrates) postulated that the spine consisted of vertebrae connected by anterior and posterior nerves, with what he described as mucous connections [18,31].

He describes the brain as 'paired' providing the two cerebral hemispheres. A separate structure that he called the parencephalis located 'at the back' that is markedly different in appearance and texture i.e. the cerebellum. And believed that the heart, not the brain, was the seat of intelligence [25,32]. He described the brain (*Dimāgh*) composed of two divisions enclosed by two membranes, the outer being the strongest. He provided an accurate description of the two meningeal layers of the brain specifically the dura mater (*Umm-e-galīz*) and pia mater (*Umm-e-raqīq*) [32]. These are richly innervated with fine blood vessels, a strong one near the surface [Dura mater] of the skull and the other being much finer [Pia mater]. Aristotle also cut into the brain for he refers to 'a small hollow' in its centre [one of the ventricles], and 'liquidity surrounding it' (most likely the cerebrospinal fluid) [6]. And believed firmly that the nerves were controlled by and originated in the heart because it was, in his interpretation, the prime organ of the body and the seat of all motion and sensation.

Herophilūs distinguished the brain from the cerebellum, and described the brain as the seat of intelligence, contrary to the beliefs of his contemporaries. And described the brainstem and spinal cord (*Nukhā'*) as one structure he referred to as "spinal marrow". Also identified and described several brain structures, some of which still have his name, such as the concavity on the internal surface of the occipital bone, in which lodges the posterior confluent of the cranial venous sinuses, known as the *Herophilūs* press (torcular Herophili) [33,34]. He is also credited with describing the calamus scriptorius, and styloid process, all these terms persist in modern usage. *Herophilūs* was the first to examine and report on the structure of the nervous system. He was able to do this by dissecting human cadavers [35]. He said that the brain consists of two cerebral hemispheres (cerebrum) and the hindbrain or cerebellum, which is below the cerebrum. The cerebellum overhangs the part of the brain stem known as the medulla oblongata, where the spinal cord begins [36].

2. Jalinūs (Galen)'s Anatomical Synthesis

The most influential figure in ancient neuroanatomy was *Jalinūs* (Galen) of Pergamon (129–c. 216 CE), whose works became authoritative for over a millennium. Jalinūs (Galen), through extensive animal dissections, described seven pairs of cranial nerves, including the optic (*nervus opticus*), occulomotor, trigeminal, and facial nerves. His functional explanations—based on the theory of *pneuma* or vital spirit—framed nerves as conduits of this subtle material from the brain to the periphery [37]. Though his numbering differed from modern convention, his combination of structural mapping and physiological theory formed the core of later Greeko-Arab understanding. He also says, a nerve or tonos grows from the brain or spinal cord a single organ gets its name from two action because it was made to sag and to pull tight [38,39,40,41,42]. He also says, He also says, a nerve or tonos grows from the brain or spinal cord a single organ gets its name from two actions because it was made to sag and to pull tight. *Jalinūs* (Galen) identified seven pairs of cerebral nerves, or cranial nerves, as nerves of sensation, while the 30 pairs of spinal nerves were nerves of motion. He did not recognize the olfactory and trochlear nerves. The cranial nerves were designated as optic, oculomotor, trigeminal, facial, and vestibule cochlear. The glossopharyngeal, vagus, and spinal accessory nerves (*A'ṣāb-e-Nukhaī izafī*) were the sixth and seventh nerves respectively. *Jalinūs* (Galen) also discovered the sympathetic nervous system, which controlled tongue movement and speech production [43]. Today, we know that the human brain has twelve pairs of cranial nerves.

Jalinūs (Galen) was even able to get some understanding of the location of the spinal cord's motor channels since he found that paralysis was not produced by an up-and-down incision made along its central axis. He thus demonstrated how the lateral areas of the cord give birth to the spinal nerves that innervate the body. We now know that the white matter in the brain's outer regions is really traversed by the ascending (sensory) and descending (motor) tracts that connect the spinal cord to the brain. It's also noteworthy that *Jalinūs* (Galen) recognized that not every portion of the body was innervated by the spinal nerves, since the cranial nerves that passed to the face and head were always derived from the brain [9,25].

3. Transmission into the Arab-Islamic World

Following the expansion of the Abbasid Caliphate in the 8th–9th centuries CE, Greek medical texts were translated into Arabic under systematic patronage, particularly in Baghdad's *Bayt al-Hikma* (House of Wisdom) [8]. *Ḥunayn Ibn Ishāq* (809–873 CE) produced Arabic translations and commentaries on Jalinūs (Galen)'s works, often clarifying or correcting anatomical details [6]. His *Book of the Ten Treatises on the Eye* also incorporated early cranial nerve descriptions in relation to vision and ocular motion, effectively bridging ophthalmology and neuroanatomy.

4. Independent Arab Contributions

While Arab scholars revered *Jalinūs* (Galen), they did not simply transmit his knowledge—they built upon it. *Abū Bakr Moḥammad Ibn Zakriyā Al-Rāzī* (865–925 CE), in *Hāwi fi Al-Ṭib (Liber Continens/Magnus opus)*, discussed facial paralysis and cranial nerve lesions with clinical case observations, foreshadowing modern neurological differential diagnosis [44]. *Ibn Sīnā* (980–1037 CE) systematised cranial nerve classification in *Al-Qanūn fi al-Tibb*, enumerating twelve pairs, closely anticipating modern numbering [45]. His descriptions integrated sensory and motor functions, differentiating, for instance, between the olfactory and optic nerves as purely sensory, and the oculomotor as primarily motor. Hunayn Ibn Ishaq (809–872 A.D.), a physician and significant translator of Greek and Syriac medical texts, notably translated *Jalinūs*, *Buqrāt*, and *Arastū* into Arabic [46,47,48]. He provided a comprehensive description of the nervous system. He asserts that the brain's structure resembles that of the nerves. In his discussion of nerve structure, he noted that the majority of nerves originate from the brain, while some are sourced from the spinal cord. Additionally, he elaborated on the brain, indicating that it consists of two hemispheres that are oval-shaped on the frontal side and are separated by a transparent membrane [20,49].

According to *'Alī Ibn Sahl Raban Al-Ṭabarī*, the brain (*Dimāgh*) is encased in two membranes: the inner membrane, which is thin and delicate, envelops the soft tissue of the brain and is rich in blood capillaries that nourish the brain, while the thicker membrane is situated closer to the skull bones, providing protection to the brain (*Dimāgh*). The brain serves as the center for sensation and voluntary movement. He explains the brain as a complex structure with three parts: the anterior lobe (*Muqaddam Dimāgh*), middle lobe (*Ausat Dimāgh*), and posterior lobe (*Moakhhar Dimāgh*). The anterior lobe is responsible for imagination, while the middle brain (*Ausat Dimāgh*) is for thinking. The posterior lobe (*Moakhhar Dimāgh*) is responsible for memory. The brain is the center of sensation and voluntary movement, and it is the coldest and moist organ of the body. The heart supplies blood vessels to the brain, which works like an equipment for verbal communication. The brain also protects the senses during sleep [50].

'Alī Ibn Sahl Raban Al-Ṭabarī posited that nerves originate from the posterior brain and the spinal cord, with the latter part relating to voluntary movement and emotions. The spinal cord also originates from the brain, confirming that all nerves originate from the brain. Joint and muscle nerves are thin and non-sensory, while the brain provides sensory and motor abilities to each organ. The solid nerves, like those in the sun, pass optical power, while grooved nerves are not capable of supporting organs [51,52,53].

He described the origin of the spinal cord, its end, and the two layers covering it, which extend from the brain's covers. He mentioned seven cranial nerves and 31 spinal nerves and stated that nerves had motor and sensory functions and originated from the brain or spinal cord in pairs. He mainly followed Jalinūs (Galen)'s descriptions of the cranial and spinal cord nerves. Importantly, *Zakriyā Al-Rāzī* was the first to describe the recurrent laryngeal nerve as a mixed, sensory and motor nerve [20].

Zakriyā Al-Rāzī, a pioneer in applied neuroanatomy, used clinical information to identify nerve lesions and differentiated concussion from similar neurological conditions [53,54]. He identified four brain ventricles, including the anterior ventricle for smelling, and emphasized the role of the spinal cord and peripheral nervous system in sense perception and voluntary movements [38,53,55,56].

The cranial nerve, a crucial component of the brain, comprises seven pairs of nerves on both the right and left sides, providing vision and movement. These nerves also play a role in motor and sensory functions, influencing head, neck, shoulder, arm, and hand movements. The thoracic nerves, originating between the eighth and ninth vertebrae, branch out to the rib muscles and heart, facilitating movement and sensation. The lumbar region, sacral nerves, and coccyx nerves innervate muscles associated with the genital and excretory systems, extending from the first sacral bone to the feet [57].

'Alī Ibn Al-'Abbās Al-Majūsī divided the brain into two main parts: the forebrain (*Muqaddam Dimāgh*) in front and the hindbrain (*Moakhhar Dimāgh*) at the back. These are separated by a thick two-layered membrane called Galeej, with communication only through a duct beneath the bregma (the junction of frontal and parietal bones) [58]. *Majūsi*, a prominent scientist, identified the forebrain as the main source of sensory nerves and spinal cord. He identified four brain ventricles, two in the forebrain, one in the hindbrain, and the fourth in the middle brain. He proposed that vital pneuma transforms into psychic pneuma, aiding in smell sense [59]. Additionally, *Majūsi* observed that nerves originate in pairs, allowing for functional compensation if one nerve (A'sab) is damaged. He described a pine cone-shaped structure at the junction of the third and fourth ventricles, which corresponds to the modern anatomical understanding of the pineal gland [60]. This comprehensive analysis reflects an early understanding of brain structure and function, highlighting the intricate relationships between its components.

Abu Sahl Masīhī, a key figure in neuroanatomy and Unani medicine, provided a comprehensive account of cranial and spinal nerves, highlighting the relationship between nerves and neurological disorders. His work laid the foundation for Avicenna's comprehensive neurological system, and his contributions to understanding neurological disorders have significant relevance in contemporary Unani medicine. His work emphasized the importance of cranial and spinal nerve functions in diagnosing and treating neurological issues [61]. Hemiplegia, known as *Fālij*, results from injuries to the brain or upper spinal cord, leading to paralysis on one side of the body [47]. His insights into spinal nerve pathways enable physicians to differentiate hemiplegia from localized nerve damage effectively. Paraplegia is linked to injuries affecting the lower spinal cord or lumbosacral nerves, while sensory disorders manifest as loss of smell, vision, or hearing, attributed to cranial nerve dysfunction [62]. Overall, *Abu Sahl*'s functional orientation of cranial and spinal nerves has established a practical framework for understanding and addressing neurological disorders within the context of Unani medicine.

Al-Zahrāwī was not primarily an anatomist like *Jalinūs* or *Ibn al-Nafīs*, he did describe nerves in the context of surgical procedures, dissection, and clinical disorders. His account reflects a functional and applied perspective, as nerves were crucial for operations, wound treatment, and management of paralysis. Like his predecessors, *Al-Zahrāwī* adopted the doctrine of seven pairs of cranial nerves, a framework inherited from Galenic anatomy [6,63]. His descriptions, however, were largely practical rather than purely anatomical, reflecting his surgical orientation. He discussed the optic nerves in relation to their role in vision and blindness, often linking them to eye surgery and the consequences of head injury [61]. The facial and auditory nerves were highlighted in the context of facial paralysis (*Laqwa*), where *Al-Zahrāwī* explained clinical features such as deviation of the mouth, inability to close the eye, and drooling of saliva. Similarly, he referred to the trigeminal nerve in relation to facial sensation and pain, particularly in dental and jaw surgery, underscoring its significance for operative practice [61]. In his account of the spinal nerves, *A-Zahrāwī* also relied on the Galenic framework, recognizing thirty-one pairs arising from the spinal cord and distributed throughout the body [62,63]. He acknowledged their dual function, with some fibres concerned with sensation and others with movement, reflecting the Alexandrian distinction between sensory and motor pathways [64]. Unlike Galen's theoretical focus, *Al-Zahrāwī* emphasized their surgical relevance, cautioning that careless incisions near spinal nerve pathways could result in paralysis or loss of sensation [6]. He further noted that injuries at different levels of the spinal cord produced distinct clinical manifestations, such as paraplegia or localized limb weakness, demonstrating his applied and clinically oriented understanding of neuroanatomy [61].

5. Anatomical Illustration and Didactic Transmission

Arab manuscripts of the later medieval period, while often schematic, served as vital educational tools. Illustrations in Persian and Arabic medical encyclopaedias depicted the cranial nerves emerging from the brainstem, albeit in stylised [65]. These were not merely artistic—coloured annotations and labelled nerve paths demonstrated pedagogical intent, a practice that anticipates modern neuroanatomical charts.

6. Influence on Renaissance Neuroanatomy

By the 12th century, Arabic translations of *Jalinūs*, *Ḥunayn Ibn Ishāq*, and *Ibn Sīnā* had entered Latin Europe through centres such as Toledo and Salerno [66]. Vesalius (1514–1564), while critical of Galen's errors, indirectly benefited from Greeko-Arab preservation and commentaries, which ensured that the core corpus of cranial nerve knowledge survived intact into the Renaissance [67]. The gradual shift from schematic medieval drawings to direct human dissection in the 16th century allowed the refinement of cranial nerve numbering and tracing, but the intellectual framework remained deeply indebted to Greeko-Arab synthesis.

DISCUSSION

The development of cranial nerve anatomy was not a straightforward inheritance but a dynamic exchange between Greek and Arab-Islamic traditions. Greek anatomists, especially *Herophilūs*, made foundational contributions by distinguishing motor and sensory nerves—an early form of functional mapping that underpins modern neurophysiology. Although limited by animal dissection, their descriptive categories created a framework for later scholars. The Arab-Islamic golden age marked a significant expansion, blending textual tradition with clinical practice. Figures like *Al-Rāzī* and *Ibn Sīnā* critically engaged with Galenic anatomy, testing ideas against patient observation. *Ibn Sīnā*'s classification of twelve cranial nerves aligned more closely with present knowledge, while his recognition of facial paralysis anticipated modern concepts such as Bell's palsy. Equally important was the translation movement led by *Ḥunayn Ibn Ishāq*, whose critical commentaries combined philology with empirical observation, laying the groundwork for evidence-based anatomy.

These contributions resonate in modern neuroscience. The cranial nerve topographies described in medieval Arabic texts parallel today's intraoperative mapping, while integrated discussions of optic pathways informed later neuro-ophthalmology. Medieval diagrams, often color-coded and schematic, foreshadowed modern atlases and digital simulations used in medical education. The broader lesson is the value of cross-cultural synthesis. Greek texts translated into Arabic, refined through clinical practice, and reintroduced to Europe created a transcontinental knowledge network. Modern neurosurgery and anatomy continue in this spirit of collaboration. The Greeko-Arabic legacy demonstrates that neuroscience is a cumulative, multicultural enterprise, advancing through dialogue across geography and time.

Conclusion

The history of cranial nerve anatomy reflects an ongoing dialogue between Greek foundations and Arab-Islamic refinements. Early Greek anatomists such as *Herophilūs*, *Erasistratūs*, and *Jalinūs* provided the first structured accounts of nerve origins and functions, establishing a framework that, despite methodological limits, shaped all later inquiry. The Arab-Islamic golden age transformed this legacy through critical engagement and clinical integration. Scholars like *Al-Rāzī* , *Ibn Sīnā*, and *Al-Zahrāwī* tested inherited ideas against observation, refining nerve classifications and linking them to specific disorders such as facial paralysis. *Ibn Sīnā*'s twelve-pair classification anticipated modern conventions, making anatomy more functionally and clinically relevant.

Supporting this progress was the translation movement, particularly *Ḥunayn Ibn Ishāq*'s precise and analytical commentaries, which merged linguistic scholarship with empirical reasoning. This intercultural synthesis mirrors today's cross-disciplinary neuroscience. Modern neurosurgery and education still bear these legacies—in nerve mapping, clinical correlations, and visual teaching methods—demonstrating the enduring value of Greeko-Arab contributions.

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