

Historical Evolution of Neuroanatomy: Contributions of Greco-Arabic Scholars to the Tashrīḥ of Dimāgh (Brain)

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Abstract: **Background:** In classical Unani medicine, the brain (Dimāgh) is designated as the chief governing organ (hegemonikon) responsible for sensation, voluntary motion, cognition, memory, and emotional expression. Over centuries, Greco-Arabic physicians developed a rich neuroanatomical tradition (Tashrīḥ-i-Dimāgh) that established foundational concepts regarding cerebral organization, ventricular fluid dynamics, and neural localization. **Objectives:** This study aims to trace the historical evolution of neuroanatomical knowledge across classical Unani literature—from early Greek foundations to medieval Islamic Golden Age innovations—and evaluate these classical findings in light of modern neuroanatomy. **Methods:** A qualitative historical compilation and thematic analysis was conducted using authoritative classical treatises, including works by Alcmaeon, Hippocrates, Aristotle, Herophilus, Erasistratus, Galen, Rabban Ṭabarī (Firdaws al-Ḥikmat), Abū Bakr al-Rāzī (Kitāb al-Manṣūrī and Kitāb al-Ḥāwī), Ali Ibn Abbas Majūsī (Kāmil al-Ṣanā'a), AbūSahlMasīhī (Kitāb al-Mī'a), Ibn Sīnā (Al-Qānūnfi al-ṭibb), Ismā'īlJurjānī (DhakhīraKhwarizmShāhī), Ibn Rushd (Kitāb al-Kulliyāt), and Ibn al-Quff (Kitāb al-'Umda). Classical Arabic and Persian neuroanatomical terms (Iṣṭilāḥāt) were systematically cataloged and mapped to modern English and Latin equivalents. **Results:** The historical synthesis reveals significant neuroanatomical milestones: (1) Alcmaeon first recognized the brain as the site of sensation and consciousness; Hippocrates identified cerebral duality into two symmetrical hemispheres; Aristotle differentiated between cerebrum and cerebellum. (2) Herophilus described the fourth ventricle, calamuscriptorius, torcularherophili (Mashīrah), and arachnoid membrane. Erasistratus confirmed the cerebral origin of nerves. Galen mapped the four interconnected ventricles, choroid plexus, corpus callosum, fornix, infundibulum, and pineal gland. (3) Ṭabarī introduced a functional three-lobed model; Rhazes detailed cribriform ethmoid openings and olfactory bulb projections (Halimat-e-Sadīn); Majūsī and Masīhī categorized the soft forebrain separately from the hard hindbrain; and Ibn Sīnā discovered, identified, and named the cerebellar vermis (Doodah-e-MeeKh) and caudate nucleus (Janbi-e-Nabat)—terms still preserved in modern neuroanatomy. **Conclusion:** Classical Unani physicians established a sophisticated neuroanatomical framework that went far beyond speculative philosophy. Their observational descriptions of cerebral ventricles, meningeal layers, subcortical nuclei, and nerve origins represent pioneering contributions that significantly shaped the historical trajectory of neuroscience.

Keywords: Tashrīḥ-I-Dimāgh, Neuroanatomy, Unani Medicine, Butūn-E-Dimāgh, Ibn Sīnā, Ventricular System, Historical Neuroscience.

1. INTRODUCTION

In the Unani System of Medicine (Tashrīḥ-ul-Badan), the brain (Dimāgh) is classified as one of the primary vital organs (A'dā' Ra'īsa) essential for sustaining individual life (Baqa-e-Shakhs) [1]. Unani medical philosophy designates the brain as the chief

governing organ (hegemonikon / Ra'īs) that controls sensory perception (Quwwat-e-hiss), voluntary motion (Quwwat-e-irādiyya), cognitive processing, reasoning, memory, and emotional expression [2].

The historical evolution of neuroanatomy (Tashrīḥ-i-Dimāgh) spans over two millennia,

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originating in ancient Greek biological thought and reaching sophisticated development during the medieval Islamic Golden Age [3]:

1.1 Early Greek Foundations:

Alcmaeon of Croton (early 5th century B.C.) was the first physician to declare that the brain is the principal seat of sensation and intellect (*principatus* in *cerebro*), identifying channel-like structures (*poroi*) connecting sensory organs to the cerebral tissue [4]. Hippocrates (460–377 B.C.) established that the brain endows the individual with intellect and is the origin of neurological conditions, describing cerebral duality into two symmetrical hemispheres divided by a vertical membrane [5]. Aristotle (384–322 B.C.) introduced the distinction between the cerebrum (*enkephalos*) and cerebellum (*parenkephalis*), described its protective meningeal membranes (*Umm-i-Ghalīz* and *Umm-i-Raqīq*), and characterized its temperament as cold and moist (*Bārid-Rāṭīb*) [6].

1.2 Alexandrian & Galenic Discoveries:

Herophilus (325–225 B.C.) and Erasistratus (320 B.C.) conducted systematic cadaveric dissections in Alexandria, mapping the fourth ventricle, *calamus scriptorius*, *torcular herophili* (*Mashīrah*), the web-like arachnoid membrane (*Ghiṣā'-i-'Ankabūtiyya*), and confirming that motor and sensory nerves originate directly from the substance of the brain and spinal cord [7]. Galen (*Jālīnūs*, 200 A.D.) consolidated *encephalocentric physiology*, demonstrating that four interconnected cerebral ventricles (*Butūn-e-Dimāgh*) contain and distribute *psychic pneuma* (*Rūḥ Nafsāniyya*) via nerves [8].

1.3 Greco-Arabic & Golden Age Innovations:

Rabban Ṭabarī (Firdaws al-Ḥikmat, 9th century A.D.) formulated a functional three-lobed model linking the anterior brain to imagination, the middle brain to thinking, and the posterior brain to memory [9]. Abū Bakr al-Rāzī (Rhazes, 865–925 A.D.) detailed ventricular anatomy, *cribriform ethmoid openings* (*Al-'Aẓm al-Miṣfāt*), and olfactory bulb protuberances (*Halimat-e-Sadīn*) [10]. Ali Ibn Abbas Majūsī and Abū Sahl Masīḥī categorized the soft forebrain separately from the firm hindbrain [11]. Notably, Ibn Sīnā (Avicenna, 980–1037 A.D.) in *Al-Qānūn fī al-ṭibb* discovered, identified, and named the cerebellar vermis (*Doodah-e-Meeḥ*) and caudate nucleus (*Janbi-e-Nabat*)—terms still used in modern neuroanatomy [12, 13].

Because classical Unani neuroanatomical knowledge remains scattered across historical manuscripts and traditional medical compilations, this paper systematically gathers, structures, and evaluates the historical contributions of Greco-Arabic physicians to the anatomy of the brain (*Dimāgh*), comparing these classical findings with contemporary neuroanatomy and physiological science [10].

2. METHODOLOGY

This study employs a qualitative, thematic compilation and comparative historical-analytical methodology designed to trace the chronological development of neuroanatomy (*Tashrīḥ-i-Dimāgh*) in classical Unani literature [14, 15]. The research framework systematically extracts scattered historical accounts of brain structure, meningeal coverings, ventricular fluid dynamics, and neural localization across classical Greco-Arabic treatises and evaluates them in relation to modern neuroanatomical science.

2.1 Data Collection

Primary manuscripts, classical text commentaries, and historical reference works were consulted through systematic archival visits to major oriental manuscript repositories and medical university libraries:

- Library of State Takmeel-ut-Tib College and Hospital, Lucknow
- Library of King George's Medical University (KGMU), Lucknow
- Central Library, Hamdard University, New Delhi
- Maulana Azad Library, Aligarh Muslim University (AMU), Aligarh
- Raza Library, Rampur, Uttar Pradesh
- Khuda Bakhsh Oriental Public Library, Patna, Bihar

2.2 Corpus of Classical Treatises

The historical synthesis evaluated primary medical literature across four major developmental eras of neuroanatomy [14]:

2.2.1 Early Greek Era:

Fragments and biological works of Alcmaeon of Croton; Hippocratic Corpus treatises (*On Injuries of the Head*, *On the Places in Man*, *On the Sacred Disease*, *On Glands*, *On Fleshes*); Aristotle's biological treatises (*Historia Animalium*, *De Partibus Animalium*).

2.2.2 Alexandrian & Roman Period:

Anatomical observations of Herophilus of Chalcedon and Erasistratus of Chios; anatomical and physiological discourses of Galen (*Jālīnūs*).

2.2.3 Islamic Golden Age Classics:

Firdaws al-Ḥikmat fī 'l-ṭibb by Rabban Ṭabarī; *Kitāb al-Manṣūrī* and *Kitāb al-Hāwī fī 'l-ṭibb* by Abū Bakr al-Rāzī (Rhazes); *Kāmil al-Ṣanā'a al-Ṭibbiyya* (*Kitāb al-Malikī*) by Ali Ibn Abbas Majūsī; *Kitāb al-Mī'afī 'l-ṭibb* and *Tashrīḥ Badan al-Ensan* by Abū Sahl Masīḥī; *Al-Qānūn fī al-ṭibb* by Ibn Sīnā (Avicenna).

2.2.4 Late Medieval Unani Scholarship:

Dhakhīrah Khwarizm Shāhī by Ismā'īl Jurjānī; *Kitāb al-Kullīyyāt* by Ibn Rushd (Averroes); *Kitāb al-*

Mukhtārāfi'l-Ṭibb by Ibn Hubal Baghdadi; Kitāb al-'Umdafi'l-Jarāhat by Ibn al-Quff Masīhī.

2.3 Lexicographical Standardization (Iṣṭilāḥāt)

Classical Arabic, Persian, and Greek neuroanatomical terminologies (Iṣṭilāḥāt) were cataloged and mapped directly to standardized Latin and modern English nomenclature (e.g., Umm-i-Ghalīz to Dura Mater; Umm-i-Raqīq to Pia Mater; Ghiṣā'-i-'Ankabūtiya to Arachnoid Mater; Butūn-e-Dimāgh to Cerebral Ventricles; Doodah-e-Meeh to Cerebellar Vermis; Janbi-e-Nabat to Caudate Nucleus) [16].

3. Anatomical Findings

The classical Unani literature on neuroanatomy (Tashrīḥ-i-Dimāgh) presents an extensive structural and functional account of the central nervous system. Greco-Arabic physicians systematically mapped the gross encephalic architecture, meningeal coverings, dural septa, ventricular cavities, subcortical nuclei, and nerve origins [17].

3.1 Gross Encephalic Architecture & Hemispheric Division

Early Greek natural philosophers established that the brain (Dimāgh) is the primary governing organ (hegemonikon) of sensation and cognition. Hippocrates observed that the human brain is a paired structure split into two symmetrical halves by a thin vertical membrane (falxcerebri). He characterized its tissue as white, friable, and gland-like, with a cold and gluey temperament (MizājBārid) [5]. Aristotle reinforced this bipartite symmetrical architecture, establishing the foundational anatomical distinction between the cerebrum (enkephalos) and the smaller, posteriorly located cerebellum (parenkephalis / para-brain) [6].

Greco-Arabic anatomists further refined this structural classification:

3.1.1 Forebrain & Hindbrain Categorization:

Ali Ibn Abbas Majūsī, AbūSahlMasīhī, and Ismā'īlJurjānī divided the brain into an anterior forebrain (MuqaddamDimāgh) and a posterior hindbrain (MoakhharDimāgh). Majūsī noted that the forebrain is significantly larger and softer than the firmer hindbrain, separated by a thick dural fold whose sole communicating channel is a duct situated beneath the bregma [11].

3.1.2 Consistency Differential & Functional Specialization:

Unani anatomists universally highlighted a key structural rule: the anterior forebrain is soft in consistency to facilitate sensory reception (Quwwat-e-ḥiss) and accommodate delicate sense organs, whereas the posterior brain and cerebellum are hard and dense to provide structural stability and serve as the firm origin for motor nerves (A'sāb-e-Ḥarakīyya) and the spinal cord (Nukhā') [12].

3.1.3 Hemispheric Fissures & Cortical Layering:

Ibn Sīnā (Avicenna) detailed the longitudinal fissure dividing the cerebral hemispheres into left and right halves. Avicenna further differentiated the outer grey cortex from the deeper white medullary tracts and described higher cognitive, speech, and judgmental centers localized within the frontal and prefrontal gyrifications [12]. Ibn al-Quff described the cerebral surface as containing round, reddish gyrified components termed Tajrīda (gyri) [18, 19].

3.2 Meningeal Coverings & Dural Folds (Umm-ul-Dimāgh)

Classical scholars recognized that the delicate cerebral tissue is protected by specialized membranous coverings termed Umm-ul-Dimāgh (meninges):

3.2.1 Umm-i-Ghalīz / Umm Jāfia (Dura Mater):

The outermost thick, dense, and tough fibrous membrane adhering strongly to the inner table of the cranial bones and sutures [7].

3.2.2 Ghiṣā'-i-'Ankabūtiya (Arachnoid Mater):

First described by Herophilus as a delicate, web-like membrane situated in the subdural space between the dura and pia mater [7].

3.2.3 Umm-i-Raqīq / Ghishā'-e-Mashīmī (Pia Mater):

The innermost thin, highly vascular membrane adhering directly to the surface of the brain. Masīhī and Avicenna emphasized that the pia mater brings together all vascular networks, penetrating deep into cerebral fissures and ventricular walls [11, 12].

3.2.4 Dural Septa Reflections:

Avicenna described how the dura mater sends inner structural folds that stabilize the brain: the vertical Tayyi-e-Muqaddam (falxcerebri), the transverse Khaimta-e-Almikh (tentorium cerebelli), and the posterior Tayyi-e-Muakhar (falxcerebelli) [12].

3.2.5 Blood-Brain Barrier Precursor:

Avicenna documented that as cerebral blood vessels branch and penetrate the brain substance, the delicate pia mater forms a continuous protective vascular sheath around them, prefiguring the functional concept of the blood-brain barrier [12].

3.3 Cerebral Ventricular System (Butūn-e-Dimāgh) & Pneuma Mechanics

The internal cavities of the brain (Butūn-e-Dimāgh) were investigated extensively as open chambers containing fluid and housing psychic pneuma (RūḥNafsāniyya) [8-20]:

3.3.1 Anterior Ventricles (BatanMuqaddam):

Paired lateral cavities located in the forebrain. Rhazes, Majūsī, Masīhī, Averroes, and Ibn al-Quff noted that each anterior ventricle gives origin to a nipple-like anatomical projection termed Halimat-e-Sadīn

(Olfactory Bulbs) extending toward the perforated ethmoid bone (Al-‘Az̤m al-Miṣfāt) to process smell and evacuate metabolic wastes (Mukhaāt) into nasal passages [10-20].

3.3.2 Middle Ventricle (BatanAusat):

A central midbrain chamber connecting the anterior and posterior ventricles through the intraventricular foramen of Monro and the cerebral aqueduct (Qanaāt-e-Mukhī) [8-12].

3.3.3 Posterior Ventricle (BatanMoakhhar):

The fourth ventricle situated in the hindbrain/cerebellum. Herophilus attributed supreme functional importance to this cavity as the seat of the ruling principle, detailing unique floor landmarks including the CalamusScriptorius [7].

3.3.4 Functional Cognitive Localization:

Unani scholars assigned specific mental faculties (QuwāNafsāniyya) to particular ventricular chambers: Common Sense (HissMushtarak) and Imagination (Takhayyal) to the Anterior Chamber; Cognitive Thinking (Fikr) to the Middle Chamber; and Memory (Hāfiẓa) to the Posterior Chamber [9-11].

3.4 Subcortical Nuclei, Cerebellar Structures, & Deep Landmarks

Classical Unani anatomists identified and named several key subcortical, vascular, and brainstem structures:

3.4.1 Cerebellar Vermis (Doodah-e-Meekh / Dooda):

Ibn Sīnā (Avicenna) discovered, identified, and named the central worm-like structure connecting the cerebellar hemispheres as Doodah-e-Meekh (vermis)—a term directly preserved in modern neuroanatomy [12]. Ibn al-Quff described the vermis as a specialized passageway composed of meningeal-like tissue regulating pneuma transit between ventricles [18].

3.4.2 Caudate Nucleus (Janbi-e-Nabat):

Avicenna discovered and named the tailed basal ganglion nucleus as Janbi-e-Nabat (nucleus caudatus / caudate nucleus), providing its first formal description in medical history [12-21].

3.4.3 Pineal Gland (Habb-e-Sanobrya / Conarium):

Galen, Majūsī, Masīhī, and Avicenna identified a pine-cone-shaped glandular organ situated at the junction of the third and fourth ventricles above the cerebral aqueduct [8-12].

3.4.4 Additional Deep Landmarks:

Herophilus, Masīhī, and Jurjānī mapped the venous confluence TorcularHerophili (Masherah) collecting cerebral blood [7-17]. Galen described the thick white arch of the corpus callosum connecting the

hemispheres, the fornix beneath the lateral ventricles, and the funnel-shaped infundibulum connecting to the pituitary gland [8].

3.5 Cranial & Spinal Cord Pathways (A‘ṣāb& Nukhā‘)

Classical neuroanatomy traced the origin, trajectory, and functional differentiation of peripheral nervous pathways:

3.5.1 Origin in Brain Substance:

Erasistratus, Galen, Ṭabarī, and Majūsī confirmed that all cranial and spinal nerves originate directly from the substance of the brain and spinal cord rather than dural membranes [7-9].

3.5.2 Sensory vs. Motor Nerve Differentiation:

Herophilus, Erasistratus, Majūsī, Avicenna, and Ibn al-Quff established the clear distinction between sensory nerves (A‘ṣāb-e-Hissiyya), which are softer and arise from the forebrain, and motor nerves (A‘ṣāb-e-Ḥarakīyya), which are firmer, solid, and originate from the posterior brain, cerebellum, and spinal cord [7-20]. Ṭabarī noted that optic nerves contain an internal central channel (grooved nerves) to transmit visual impulses [9].

3.5.3 Spinal Cord (Nukhā‘) as Brain Extension:

Hippocrates, Aristotle, Ṭabarī, Majūsī, and Ibn al-Quff characterized the spinal cord (Nukhā‘) as a broad continuous trunk extending posteriorly from the brain stem. Ibn al-Quff metaphorically described the spinal cord as a great river originating from the ocean of the brain, enveloped by three continuous protective meninges [18-22].

3.5.4 Neurological Localization & Trauma Analysis:

Hippocrates documented cerebral lateralization, noting that a focal incised wound on one temple causes motor spasms or paralysis on the opposite side of the body (contralateral effect) [5]. Rhazes provided clinical spinal localization, analyzing trauma cases to demonstrate that paraplegia resulting from lower back injury leaves upper extremity motor function intact because cervical spinal nerve roots remain undamaged [10-23].

4. Comparative Discussion with Modern Neuroanatomy

The comparative evaluation of classical Unani neuroanatomy (Tashrīḥ-i-Dimāgh) against contemporary neuroscience demonstrates a remarkable trajectory of empirical discovery [3-24]. Early Greek natural philosophers and medieval Greco-Arabic scholars established foundational neuroanatomical concepts through direct observation, animal dissections, and human cadaveric studies, predicting many modern structural and functional principles centuries before advanced imaging technology [3].

Table 1: Comparative Lexicon and Mapping of Classical Unani Neuroanatomy and Modern Nomenclature

Classical Unani Term / Concept (Istīlāḥāt)	Historical Pioneer	Classical Description	Modern Neuroanatomical Equivalent
Dimāgh (Bipartite Structure)	Hippocrates, Aristotle	Brain split into two symmetrical halves by a thin vertical membrane.	Left and Right Cerebral Hemispheres separated by longitudinal fissure.
Enkephalos vs. Parenkephalis	Aristotle	Distinct separation between larger fore-brain and smaller posterior para-brain.	Cerebrum vs. Cerebellum.
Umm-i-Ghalīz / Umm Jāfia	Aristotle, Galen, Rhazes	Thick, dense, outer protective membrane attached to cranial sutures.	Dura Mater.
Ghiṣā'-i-'Ankabūtīya	Herophilus	Web-like delicate membrane in the subdural space.	Arachnoid Mater.
Umm-i-Raqīq / Ghishā'-e-Mashīmī	Masīḥī, Ibn Sīnā	Inner delicate, vascular membrane adhering closely to brain parenchyma.	Pia Mater / Leptomeninges.
Tayyi-e-Muqaddam&Khaimta-e-Almikh	Ibn Sīnā	Dural septal folds dividing cerebral hemispheres and separating cerebrum from cerebellum.	FalxCerebri and Tentorium Cerebelli.
Butūn-e-Dimāgh	Erasistratus, Galen, Ibn Sīnā	Four interconnected fluid-filled cavities housing pneuma.	Ventricular System (Lateral, 3rd, and 4th Ventricles).
Qanaāt-e-Mukhī	Erasistratus, Ibn Sīnā	Aqueduct duct connecting 3rd and 4th ventricles.	Cerebral Aqueduct (Aqueduct of Sylvius).
Halimat-e-Sadīn	Rhazes, Majūsī, Jurjānī	Nipple-like protuberances extending from anterior ventricles to ethmoid bone.	Olfactory Bulbs and Tracts.
Al-'Aẓm al-Miṣḩāt	Rhazes, Averroes	Perforated filter-like bone at roof of nasal cavity.	Cribiform Plate of Ethmoid Bone.
Doodah-e-Meeḩ / Dooda	Ibn Sīnā (Discovered/Named)	Central worm-like structure connecting cerebellar hemispheres.	Cerebellar Vermis (Vermis).
Janbi-e-Nabat	Ibn Sīnā (Discovered/Named)	Tailed subcortical basal ganglion nucleus.	Caudate Nucleus (Nucleus Caudatus).
Habb-e-Sanobrya / Conarium	Galen, Majūsī, Masīḩī	Pine-cone-shaped gland at junction of 3rd and 4th ventricles.	Pineal Gland.
Mashīrah / TorcularHerophili	Herophilus, Masīḩī, Jurjānī	Venous confluence beneath occipital/parietal region collecting cerebral blood.	Confluence of Sinuses (TorcularHerophili).
Tajrīda	Ibn al-Quff	Round, reddish, convoluted surface components of cerebrum.	Cerebral Gyri (Gyri).
Nukhā'(Covered by 3 Meninges)	Hippocrates, Ibn al-Quff	Spinal extension of brain enveloped by three protective membranes.	Spinal Cord enveloped by Dura, Arachnoid, and Pia Mater.

5. CONCLUSION

The contributions of Unani physicians to the neuroanatomy of the brain (Dimāgh) represent a monumental achievement in the historical development of neuroscience [25]. Scholars across centuries—spanning early Greek pioneers (Alcmaeon, Hippocrates, Aristotle, Herophilus, Erasistratus, and Galen) and medieval Greco-Arabic luminaries (RabbanṬabarī, Abū Bakr al-Rāzī, Ali Ibn Abbas Majūsī, AbūSahlMasīḩī, Ibn Sīnā, Ismā'īlJurjānī, Ibn Rushd, and Ibn al-Quff)—

systematically investigated the structural, ventricular, meningeal, and functional organization of the central nervous system [25].

Classical Unani anatomists established the gross structural organization of the brain, demonstrating that the softer anterior forebrain (MuqaddamDimāgh) is specialized for sensory reception (Quwwat-e-ḩiss) and accommodating delicate sense pathways, whereas the firmer posterior hindbrain (MoakhharDimāgh) and

cerebellum give origin to motor nerves (A‘šāb-e-Ḥarakiyya) and the spinal cord (Nukhā‘) [11, 12]. Their detailed mapping of the meningeal layers—the tough outer Umm-i-Ghalīz (dura mater) and delicate inner Umm-i-Raqīq (pia mater)—alongside leptomeningeal vascular sheaths, laid early precursors for modern concepts of protective cranial membranes and the blood-brain barrier [12-22].

Furthermore, Greco-Arabic physicians provided sophisticated descriptions of the four interconnected cerebral ventricles (Butūn-e-Dimāgh), cerebrospinal fluid dynamics, and subcortical landmarks [8-10]. Most notably, Ibn Sīnā (Avicenna) discovered, identified, and named the cerebellar vermis (doodah Meekh) and the caudate nucleus (Janbinabat / nucleus caudatus)—anatomical terms directly preserved in modern neuroanatomy [12-21]. By combining empirical cadaveric and animal observations with physiological localization, classical Unani scholars established a foundational legacy that continues to resonate in modern neuroanatomical science.

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Ethical Considerations

As this is a literature-based study, no human or animal subjects were involved, and thus no ethical clearance was required. However, due academic integrity was maintained through proper citation and referencing practices.

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