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Lighting the Torch of Knowledge in The Darkness of The Middle Ages: The Arab-Islamic influence on Ophthalmology

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Abstract

The eyes have fascinated scholars for millennia. From anatomy and disease to the process of vision, many have contributed to the present understanding of optics. The difficulty lies in establishing the origins of discoveries. Obtaining original manuscripts is arduous as texts have been lost in wars, conflagrations and disasters. Praise for developments is sometimes ascribed to early scholars who may have inspired later academics. Greek luminaries such as Aristotle and Galen laid strong foundations which the Arabs built upon, keeping the candle of knowledge burning in the Middle Ages, a time when Europe was in darkness. This article aims to review the Arab-Islamic impact on optics by presenting ancient theories, the contributions of prominent Arab scientists and exploring how the rise of Islam allowed them to flourish and influence optics.

Introduction

Historically, the study of the eye has often involved two different but related approaches. Mathematicians, physicists and even philosophers explored the physics of light, vision, and optics whereas physicians sought to understand the anatomy and related pathology. Historically scholars acquired a wide knowledge base, before focusing on specific interests. In fact, many were generalists not oculists. Ophthalmology as a distinct specialty only became recognised in the 19th century in the United Kingdom.[1]

However, the medical treatment of the eye is referred to in the Ebers Papyrus, an Egyptian scroll dating back more than 3000 years.[2] It is not until the ancient Greeks that reliable records are found.

The ophthalmoscope was not invented until the 1800's, so a direct internal view was not possible to ancient physicians. They were limited to observing the external eye or cadaveric dissection, therefore understanding of the anatomy of the inside of the eye remained relatively constant for centuries.[3] Some authors have argued that the Romans offered little new input and the encyclopaedias of medicine they did gather, were described as "Not a medium for the communication of an expanding knowledge; rather, they were repositories for a static body of ancient wisdom".[4]

The Arab-Islamic empire, referred to by this name due to the universally spoken Arabic language and Islamic rulers, expanded substantially after the passing of Prophet Muhammad (PBUH, 570-632 AD) reaching India, North Africa and even Spain.[2] At its height physicians and scientists flourished with a particular interest in the eyes.[2]

This paper will discuss the key figures in the Middle Ages, between 500-1500AD and their influences.

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Ancient theories

Alcmaeon of Croton c. 500 BC is thought to have been the first to dissect the eye and describe its contents although this is disputed as there is no remaining evidence of his works.[5] Herophilus, born 335 BC is reported to have been the first to describe the layers of the eye: an outer cornea and sclera, a grape-skin like iris, choroid and the inner retina.[6]

With regard to vision, Empedocles (c. 493-433 BC) proposed that there were two different emanations: light radiating from the eyes to the outside world, often referred to as the emission or extramission theory, and also reflection from objects travelling to the eye, the intromission theory. He was unable to explain how the light in extramission and intromission were reconciled into a singular image.[4] Plato (c. 427-348 BC) believed in the extramission theory but this was rejected by Aristotle (c. 384-322 BC), arguing that emissions from the eye itself would require a body of some kind which did not exist or had not been discovered.[7] Aristotle noted an interesting concept whereby objects in direct contact with the eyeball or in a vacuum could not be seen. This led him to focus on the properties of the medium between the eye and objects concluding that it must be transparent and continuous with the surface of the eye such as air. The eyeball must then contain a watery component receptive to the incoming light and colour from the external medium.[4,7]

Euclid (c. 300 BC) persisted on the path of extramission optics but as a mathematician, devoted his attention solely to the geometry and physics of vision, excluding the anatomical components. It is said that Ptolemy in 2nd Century AD Egypt did consider these components, however his first book was lost in medieval times.[4] Only fragments of the work exist in Latin, translated from an earlier Arabic translation of the original Greek text. Galen, born 129 AD, developed Herophilus' anatomical theory and believed that the eye consisted of membranes: cornea, sclera, choroid, retina and conjunctiva; internally there were three sets of fluid: the albuminous, crystal and vitreous fluid.[8] In the literature it appears that Greco-Roman scientists after this time had little interest in ophthalmology, although it may be that works were destroyed in conflict or deemed unimportant to preserve.

The rise of Islam

The darkness in development was not restricted to ophthalmology. By the 6th Century the Roman Empire was a fracturing realm, Latin Western Europe losing connection to the Eastern Byzantine side rich in Greek philosophy and science.[9] Medicine was not mainstream, and patients were susceptible to "quacks and charlatans".[10] Conversely, Muslim armies post Muhammad (PBUH, 570-632 AD) conquered swathes of Western Asia and North Africa, gaining control of east Byzantine.[11]

By 661 AD the Umayyad Caliphate transferred the capital to Damascus but the integration between cultures began with the accession of the Abbasids c. 750 AD, heralding the Islamic Golden Age particularly under Caliph Al-Ma'mun (786-833 AD). He established 'The House of Wisdom' in Baghdad in a significant endeavour to translate Greek texts to broaden the Arab knowledge in astronomy, science and maths.[12,13] This translation movement partly flourished because people in Arab countries studied Greek to understand liturgical texts.

Historians have debated the motives behind the effort to assimilate Greek learning. For medicine, the Arab Caliphates were based on the teachings of Islam which places emphasis on good health. Farag reports Europe at the time was awash with charlatans capitalising on the ill, whereas Islam condemned them.[10] Ibn Majah reports the teachings of Muhammad PBUH: "Whoever gives medical treatment with no prior knowledge of medicine is responsible (for any harm done)".[14] Furthermore, the Quran states: "Whoever saves a life, it will be as if they saved all of humanity".[15] Islam held physicians in high esteem and encouraged the search for knowledge in all regards. The Sufi sect placed unique significance on the eyes, considering them to be mirrors to the soul.[16] Politics and geography also played a crucial role in Arab development. Nestorian Christians fleeing Byzantine persecution sought refuge in Muslim lands bringing with them Greek texts which they translated to Syriac and Arabic.[11] Shifting the capital from Damascus to Baghdad meant a reliance on local Byzantine civil servants and administrators further integrating the cultures and enabling scholars from different backgrounds to connect.[13,17] The Caliphate's tolerance to other religions, encouraged research and empiricism, at a time when the West was enforcing 'dogmatism'.[18] It is claimed that between 800-1400 AD, the number of manuscripts written in Arabic surpassed those in Latin, Greek and European languages combined, with almost 30 books on ophthalmology produced.[19] The Greeks did not produce a substantial ophthalmology textbook, only short works. It was the Arabs who were the first to introduce detailed encyclopaedic textbooks, with accurate descriptions of the symptoms, methods of diagnosis and treatment of diseases of the eye.[20]

Vol 17 - No. 6 | August 2024 | www.jbima.com
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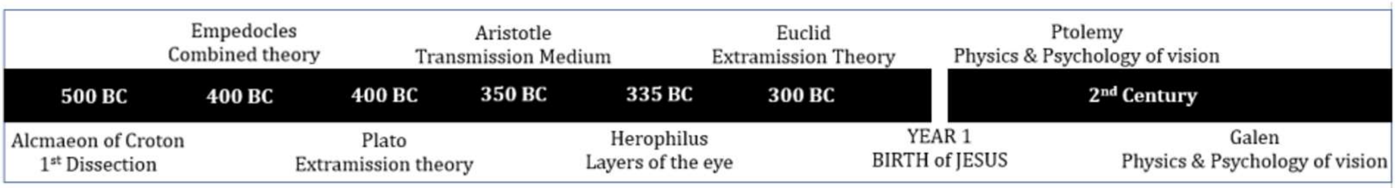

Figure 1. Approximated timeline of early works. Produced by Umar Ahmad

Perhaps one of the most substantial driving forces was disease. Egyptian Ophthalmia, otherwise known as trachoma or contagious keratoconjunctivitis, plagued the Middle East for millennia from the Pharaonic period to Napolean's arrival in Egypt in 1798 when tens of thousands of French soldiers were infected during the invasion.[21-23] Trachoma was a major cause of blindless in the Muslim world further increasing the interest in ophthalmology. Individual aspirations were an additional factor. Caliph al Ma'mun expressed a keen interest in Greek medicine sending delegations to Alexandria and Asia to obtain Greek manuscripts while taking esteemed scholar Hunain Ibn Ishaq with him on campaigns against the Byzantines.[11] It became customary for Caliphs to offer patronage to scholars and inviting them to position at their courts. This enhanced the leader's reputation whilst also giving them a personal physician and learned guide.[9]

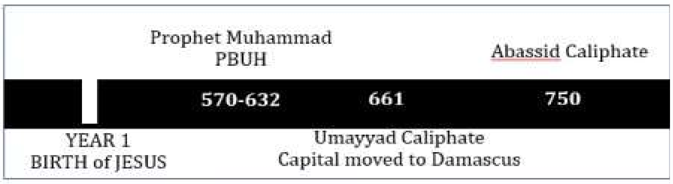

Figure 2. Timeline of Islamic Empire by Umar Ahmad

The Islamic golden age

Despite the different religious backgrounds, Yuhanna ibn Masawaih (Johannes, 777-857 AD) a Christian, was appointed the Caliph's court physician in Baghdad where he authored the first recognised monograph on ophthalmology in the Islamic world, Kitab Dagh-al-ayn or Disorders of the eye.[24]

To aid his immense translation efforts, Al Ma'mun employed philosopher Abu Yusuf Yaqub ibn Ishaq al Kindi (Alkindus, 801-873) who went on to serve his successors too.

Al-Kindi's desire was to compile historical knowledge in search of what he termed the truth. Although not an oculist, he did have an interest in vision.[4]

In his work 'De Aspectibus', Al-Kindi disagrees with Aristotle's medium theory. Aristotle had proposed that vision involved external objects generating 'motion', which travelled through a medium and 'impressed its form' on the eye. However, Al-Kindi highlighted that a circular object in the same plane as the eye was seen as a straight line and not circular meaning that the 'motion' produced did not mirror the object entirely.[4] He argued that light and visual rays travel in a straight line and he was also the first to explicitly state the concept that a luminous body emits light rays in all directions from every point on its surface.[4]

A contemporary of Al-Kindi, Nestorian Christian Hunain ibn Ishaq (Johannitius, 809-873) studied medicine under Ibn Masawaih. He wrote the first systematic textbook of ophthalmology covering anatomy, pathology and the physics of vision. The 'Book of the ten treatises on the eye', contains the first detailed drawing of the eye including the optic nerve and the six extraocular muscles.[19] He remained upon the Galen school of thought illustrating the outer layers as a continuation of the meninges.[16] Galen described the crystalline lens as an anterior component however Ibn Ishaq incorrectly positioned it in the centre of the eye suggesting all other parts were designed to nourish it.[16,25] The subsequent treatises discuss at length a multitude of eye diseases including trachoma, corneal ulcers and cataract. Explaining the optics of vision, Ibn Ishaq accepted Plato, Aristotle, and Galen, proposing that a spirit is emitted from the eye coinciding with light rays reflecting off objects.[25]

Revolution in Optics

Abu Ali al Hasan ibn al-Haytham (Alhazen, 965-1039 AD) referred to as the father of optics, was arguably the greatest writer in Arab ophthalmology. 'Kitab al Manazir' or Book of optics, the most renowned of his ninety texts, was an intrepid piece diverging from preceding Euclid, Ptolemy and al-Kindi's beliefs.[4] Al-Haytham refuted the extra mission ideology raising several critical objections. Firstly, light and visual rays could not emanate from within the eye otherwise humans would be able to see in the dark. Similarly, focal light in darkness only illuminates a fixed area. Lastly, we are able to see distant objects such as stars immediately without a delay which would be caused by light leaving and returning to the eye. He presented his exposition of the intromission theory using geometry to show that sight required perception of light rays travelling from objects towards the eyes not from them.[26] It is important to note here that Persian physician Al-Razi (865- 925) did possibly reject some of the prevailing theories about vision earlier than al-Haytham, but the manuscripts evidencing this have not survived.[4]

Interestingly, Ibn Sina (980-1037), a Persian polymath had independently arrived at similar conclusions to al-Haytham at a similar time.[4] Named Avicenna in the West, he is regarded as one of the most influential figures of the Islamic Golden Age. Often referred to as the 'Prince of Physicians', he penned The Canon of medicine, an encyclopaedia of medicine used as a standard and reference across Europe until the 18th Century. His work included a detailed description of the six extraocular muscles, similar to ibn Ishaq, and their roles in eye movement. Furthermore, he correctly stated that nerve fibres only partially crossed over at the optic chiasm.[16]

Quite possibly the most revolutionary yet overlooked finding came from Ibn Rushd (Averroes, 1126-1198). In both his works translated as 'Colliget' and 'Epitome of the Parva Naturalia' he refers to the 'final tunic' and 'innermost coat' i.e., the retina as the 'perceptive faculty', moving away from nearly a millennium of belief that the crystalline lens was the region of primary photosensitivity.[4, 17] However, German scientist Johannes Kepler (1571-1630 AD) is widely credited with the discovery that light is focused by the lens onto the retina then transmitted to the brain.[4] Interestingly, Kepler was inspired by Ibn al-Haytham who is considered to have pioneered the modern scientific method. His systematic recording and repeatable experimental designs are said to have influenced Kepler.[27]

Clinical Contributions

Cataract surgery is one of the oldest invasive procedures in history, yet tracing the origins is challenging due to the lack of verifiable literature. The earliest authentic records are of Sushruta, an ancient Indian from around 600 or 700 BC, referring to a method called couching whereby the lens is forced out of the visual field using a curved needle inserted at the limbus through the pars plana.[28,29] This method increased risks of glaucoma, posterior capsular rupture and blindness.[30] Nevertheless, the procedure was widely practiced in the world, until the 18th Century when Jacques Daviel performed a lens removal procedure (1747).[31] Even though he is credited as the inventor of cataract extraction, Arabs had developed this process much earlier. Al-Razi outlined the technique of an earlier physician Antyllos (2nd century AD Rome) in which a hollow tube is used to remove the lens. Ammar ibn Ali al-Mawsili in the 10th Century put this into practice after inventing a hollow needle to enable lens extraction and says he performed many of these operations.[13,28]

Eyelid surgery was mentioned a great deal in the Arab texts, and this often concerned the removal of various tumours and cysts, including lacrimal abscesses and fistulas. Symblepharon, (adhesion of eyelids) was also treated surgically. Intricate procedures were used for treating the consequences of Trachoma, including trichiasis and entropion. The Arabs may have been the first to describe peritomy to treat pannus caused by trachoma; while an instrument was used to keep the eye open, very small hooks were used for lifting and a very thin scalpel, scissors or a needle were used for the excision.[30]

Corneal surgery was also performed. El Zahrawi (Albucasis, 936-1013 AD) described a technique to treat pterygium which involved using a needle, horse-tail hair and removing the part of the cornea with a sharp, smooth blade.[32]

Another example of the Arab-Islamic contributions is the non-surgical treatment of amblyopia. George Comte de Buffon is often credited with the introduction of occlusion therapy for amblyopia in 1743, however Thabit Ibn Qurrah (836-901 AD), a polymath living in Baghdad, described the method to patch the normal eye before him in his book 'Vision and Perception'. In fact, Paulus de Aegina, a 7th century Byzantine, who was highly regarded by the Arabs, had previously attempted to treat strabismus using a perforated mask.[33]

The practice of Medicine and Ophthalmology

Medicine has tried to distance itself from quackery for centuries. The Arabs introduced the idea of qualifying examinations for admission to the medical profession.[34] In the case of malpractice, the family could start proceedings against the doctor, with witnesses and written prescriptions being produced in evidence. If found guilty, the doctor could be fined, barred from practice or both.[35] In ophthalmology Al-Razi strongly disapproved of charlatans and called on authorities to stop them.[36] Itinerant oculists were considered to fit into this category and Ibn Sina said that they "…go about from place to place attacking men's eyes with their lancets and applying worthless ointments. There is no honesty in them".[37] A Muhtasib, a type of 'Censor' who was appointed by the Caliph, ensured that the interests of the people were protected, and this included strict checks on oculists. Only if they were satisfied could the oculist continue in practice. One of their tasks was to examine practitioners on their knowledge of ibn Ishaq's Ten Discourses on the Eye, and also a practical examination. This tested competence in the handling of instruments, such as a hooks (for the removal of growths within the conjunctiva) and lancets for bleeding.[37] Unlike some of their predecessors, Arab Oculists were known for their compassion. In his detailed description of cataract couching, Ali Ibn Isa, teaches to "speak kind words to the patient so that his anxiety may be lightened".[20]

Conclusion

Sobotka described development in Europe during the Middle Ages as stagnating, impeded by schoolmen.[18] In contrast Arab-Islamic scientists were willing to stand on the shoulders of the giants that came before them. Al-Kindi states: "It is fitting then for us not to be ashamed to acknowledge truth and to assimilate it from whatever source it comes to us, even if it is brought to us by former generations and foreign peoples".[4] He continues: "First to record in complete quotations all that the Ancients have said on the subject, secondly to complete what the Ancients have not fully expressed".[4] The Arabs did not simply translate ancient Greek knowledge. They challenged existing ideas, developed theories, combined the physics of vision with anatomy to elevate their understanding and utilised their expertise in clinical practice. Arabic medical and scientific textbooks were translated into Latin and disseminated into Europe during the Renaissance, and some continued to be used for centuries.

The achievements of the Arab-Islamic world are summarised well by eminent German ophthalmologist and historian Julius Hirschbirg. In 1905, after 5 years of research, he addressed the American Medical Association remarking: "During this total darkness in medieval Europe they lighted and fed the lamps of our science- from the Guadalquivir to the Nile and to the river Oxus... they were the only masters of ophthalmology in medieval Europe."[38]

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