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Transferring the Observations of Ibn Sina's Contributions to Ophthalmology through the Works of Prof. Dr. Fuat Sezgin to the World of Science

İbn Sina'nın Oftalmoloji Bilimine Katkıları Konusundaki Tespitlerin, Prof. Dr. Fuat Sezgin'in Çalışmalarıyla Bilim Dünyasına Aktarımı

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ABSTRACT

The great scholar Ibn Sina (Avicenna) is renowned for his vast contributions to the fields of medicine and philosophy. His Canon of Medicine influenced the way medicine was practiced and taught as late as the 17th century in the East and the West. As such, it is regarded as the best medical work produced in the feudal age. Ibn Sina's literature was translated from Arabic into Latin on several occasions by various translators and physicians in the 11th-13th centuries, giving medieval European medical practitioners access to the text. More recently, the remarkably detailed work Ibn Sina carried out in Ophthalmology is beginning to gain appreciation as well. It has become apparent, for example, that European physicians, like Ibn Sina, were not believers in Galen's extramission theory, which holds that eye rays emitted from the eyes enable sight. This could be attributed to the importance of Ibn Sina in his medieval and Renaissance medical texts and training. Some of the most important investigations into Ibn Sina's work in ophthalmology were conducted in the late 19th century and early 20th century by German scientists in the Western world, such as Juan Cueva in 1899, Paul Uspensky, Theodor Bernikow and Elias Michailowsky in 1900, and Julius Hirschberg and Julius Lippert in 1902. One of the most influential historians of science to date, Prof. Dr. Fuat Sezgin, explored the work conducted by these prominent scientists and has rendered them accessible for use by scientists.

This paper presents the great Ibn Sina's contributions specifically to the field ophthalmology, by including brief descriptions made by Ibn Sina, how they were reflected in the works of the above mentioned scientists and the invaluable efforts of Professor Fuat Sezgin to collect these for use by scientists today.

Keywords: Ibn sina, ophthalmology, history of medicine, history of science, Fuat sezgin

ÖZ

Tıp ve Felsefe alanlarındaki muazzam katkıları ile tanınan İbn Sina'nın Kanun'u, hekimlerin uygulamalarını ve aldıkları ve eğitimi hem Batı hem de Doğu'da 17. yüzyıla kadar etkilemiştir. Dolayısı ile feodal dönemde ortaya çıkan en önemli tıp kaynağı olarak bilinmektedir. İbn Sina'nın eserleri 11-13. yüzyıllarda çok çeşitli çevirmenler ve hekimler tarafından Arapça'dan Latince'ye tercüme edildiği için ortaçağ Avrupasının hekimleri için önemli bir kaynak haline gelmiştir. Her geçen gün daha iyi anlaşılan büyük âlim İbn Sina'nın Oftalmoloji (Göz Hastalıkları) bilimine yaptığı katkılar da dikkat çekicidir. Örneğin Avrupalı hekimlerin Galen'in savunduğu gibi görmenin gözlerden ışınlar yayılarak gerçekleştiğine inanmamasının sebebinin, bunun aksini savunan İbn Sina'nın ortaçağ ve Rönesans döneminde Avrupalı hekimler üzerindeki etkisi olduğu söylenebilir. Bu konuda Batı dünyasında 19. yüzyıl sonu ile 20. yüzyıl başında Alman bilim insanlarının yoğunluklu olarak çalıştıklarından da söz etmek gerekir. 1899'da Juan Cueva, 1900'de Paul Uspensky, Theodor Bernikow ve Elias Michailowsky, 1902'de Julius Hirschberg ile Julius Lippert'in çalışmaları dikkat çekicidir. Prof. Dr. Fuat Sezgin, bir bilim tarihçisi olarak bu çalışmaları bir araya toplayarak bilim insanlarının hizmetine sunmuş, erişilebilirliğini kolaylaştırmıştır.

Bu çalışmada, büyük bilgin İbn Sina'yı, özel bir alan olan oftalmolojiye yaptığı katkıları, adı geçen bilim insanlarının çalışmaları ve Fuat Sezgin Hoca'nın değerli çabaları kısa özetlerle anılmaya çalışılacaktır.

Anahtar Kelimeler: Ibn sina, göz hastalıkları, tıp tarihi, bilim tarihi, Fuat sezgin

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Introduction

"How mistaken are modern men in thinking

that physicians before them knew nothing."

Avicenna (980-1037)

One may think that knowledge about the anatomy and function of the eyes and ocular health is recent, while, in fact, there are notes on the eye dating back to the early days of written history. Over time, further work was done on the anatomy and physiology of the eye, with significant discoveries made, leading to all that we know about the eyes and ocular health in modern times.

1. Brief History of Ophthalmology

Thanks to the efforts of archaeologist Ebers, ancient Egyptian papyri mentioning the prevalence of common eye disorders such as conjunctivitis and trachoma have been found dating back as early as 3,400 years ago. As far as documentation shows, the papyri were compiled by medical priests of the 18th Century BC from one or more books written many centuries earlier. One particular papyrus reveals a collection of 700 prescriptions for many diseases of the eye (MacCallan, 1927).

The earliest forms of surgery were conducted during prehistoric times, when bleeding wounds would be controlled by applying pressure or by suctioning. The earliest known papyrus describing surgical procedures is the Edwin Smith papyrus (1600 B.C.), and ophthalmology is known to have been one of the most important areas in Islamic medicine (Russel, 1982, p. 176) .

Records show that in 800 BC, 76 ocular diseases were described by the Indian surgeon Sushruta, in addition to various techniques and instruments used in ophthalmology. In fact, Sushruta is reputed to have been the first cataract surgeon. Little was actually known about the anatomy of the eye in ancient times. It was observed that the sclera and cornea formed part of the external layer of the eye, and the middle part contained the pupil and ocular fluid. Interestingly, it was supposed that the eyes were connected to the brain by a tube, which helped the fluid flow to the brain. Later, when Aristotle performed dissections on animals and their eyes, he reported the existence of three layers within the eye (Bujarborua, 2015).

There have been various interpretations since antiquity that conflict with each other. One of the prominent ideas about the eye was that it was active. In the 4th century BC, for example, Plato put forth that the eye emanated light and caught objects with its rays. Later, Theophrastus, who was one of Aristotle's disciples, mentioned that the eye had "*the fire within*"(MacCallan, 1927).

Galen, in the 2nd century AD, developed at least two more theories of the eye. He thought sight depended upon an optical power that flowed through optic nerves from the brain to the eyes through extramitted rays. In fact, Galen's description of the anatomy and physiology of the eye made it until the 17th century. He took as a basis the work carried out by anatomists who had carried out dissections in Alexandria, one of whom was Rufus of Ephesus, describing the various parts of the eye such as the retina, cornea, iris, uvea, tear ducts, as well as the eyelids, not to mention two humors, or fluids: the vitreous and aqueous humors. He also specifically remarked upon features of sight such as binocular vision. Galen also talked about a round lens in the middle of the eye, the crystalline lens, saying, "*the crystalline lens is the principal instrument of vision, a fact clearly proved by what physicians call cataracts, which lie between the crystalline humor and the cornea and interfere with vision until they are couched*."(MacCallan, 1927).

During medieval times (the so-called Dark Ages of the 5th -17th centuries), after the fall of the Roman Empire in A.D. 476, the dissection of cadavers was illegal, punishable by death. Only in the event of a mysterious death was examination allowed, though merely by inspection and palpation. However, in the 6th century, when the plague epidemic ran rampant, a few necropsies and dissections were allowed so that the cause of the disease could be identified.

In the 3rd century, a medical school was founded in a town in Persia called Gundeshapur, which became inhabited by Nestorian Christians, whose renowned physicians were invited to Baghdad for consultations by the Caliphs of the time. This medical school contributed to medicine through the translation of the works of Hippocrates and Galen into Syriac.

The Prophet Muhammad's (PBUH, 571-632) followers, after his death, spread the Muslim word as far as India, the entire Northern African countries and to Spain. In 763, Baghdad was founded and soon became the Saracen Empire's capital. In the 10th century, once the Abbasids became the Caliphs, a great deal of Greek science and medicine related texts were translated into Syriac and Arabic by scholars and physicians, which ensured the transfer of knowledge into the following centuries.

Islamic culture in the medieval times took a particular interest in the eye, both medically and philosophically, as is apparent by the dozens of written works on ophthalmology in the 9th-14th centuries. It is seen that Galen was a major influence during the 9th century on many Islamic scholars like al-Kindi and Hunain ibn Ishaq, who agreed with the extramission theory. In fact, in his work called *Ten Treatises on the Eye* and the *Book of the Questions on the Eye*, Hunain ibn Ishaq described in detail the series of tunics located behind the vitreous humor, and included a great deal on the retina, the function of which he described as a source for nourishing the vitreous humor and as a vessel for the visual spirit through the hollow optic nerve (MacCallan, 1927).

In the field of ophthalmology, there were many disputes among physicians in the Islamic culture regarding the details of the eye, such as how many tunics there are and whether the eye emits eye rays; i.e., the theory of extramission. At the beginning of the 10th century, the pupil and how it contracts and dilates was first noticed by the great al-Razi (Rhazes), a clinician from Baghdad. Nearly 100 years later, photosensitivity was mentioned by al-Haythan (Alhazen), in his *Book of Optics*. These thinkers opined that it was not the eye that affected light, but rather the other way around. Another contradicting opinion (of Galen's account) came from Ibn Sina, one of Alhazen's contemporaries, who was in agreement with Aristotle. He did not believe eye rays were emitted by the eyes, rather the opposite, although he did agree with most of Galen's anatomy –the hollow nerves and crystalline lens– (MacCallan, 1927). Interestingly, it also seems that Ibn Sina was among those Aristotelians who later made an effort to distance themselves from Aristotle in terms of the theory of the rainbow, light and colors (Sezgin & Neubauer, 2011).

2. Ibn Sina's Studies on The Structure of The Eye

Ibn Sina, or Avicenna (980-1037), one of history's greatest polymaths as a thinker, scientist, physician, poet and statesman has become renowned as the "Father of Science". He contributed a great deal to science by putting in writing the most pressing issues in the second half of the medieval era. Although he wrote over 200 works, his masterpiece is his *Canon of Medicine* (*Al-Qanun fi al-Tibb*, 1020 AD), the 1st and 3rd volumes of which contain important details about the structure, anatomy, physiology and illnesses of the eyes.

Within a 1, 300 year window, between Galen's time (120–200) until Vesalius (1514–1564), Ibn Sina made the greatest contributions to anatomy. He was an influential researcher, physician and teacher who made use of his predecessors' findings but also included new observations and descriptions of diseases in his Canon. The Canon is testament to his talent for integrating existing knowledge and building upon it such that it has not just survived but influenced the practice of medicine for centuries (Keskinbora & Keskinbora, 2016). While it is not known for certain if Ibn Sina personally dissected cadavers, the anatomical descriptions he wrote were new for his time. There are those who argue he must have secretly performed human dissections (Farhadi, Behzadian Nejad, & Bagbanzadeh, 1996). His Canon of Medicine contains a systems-based approach to anatomy as he begins each chapter, which he then follows by describing the diseases that afflict that system. Modern clinical anatomy follows this approach to this day. He believed that the best way for novice physicians to learn was to explore '*the general principles of medicine, analyze the diseases that affect different organs'* and learn about the anatomy of the organs in each system (Naderi, Acar, Mertol, & Arda, 2003).

Written nearly 1,000 years ago, Ibn Sina's *Canon of Medicine* was used around the world by physicians and educators as the quintessential textbook, often referred to as the bible of medicine (M. & MA Raheem, 1981). Translated into Latin and Hebrew by various scholars, it was also used in Europe for 500 years. One particular scholar that translated it into Hebrew around 1280 was Nathan-ha-Meati from the library in Parma. A Latin treatise with the name *"Magistri Davidi Armenici compilatio in libros de oculorum curationibus Accanomosali"* is referred to by various manuscripts, the oldest being from the 13th century (Sobotka, 1957).

Ophthalmology was a developed specialty among Muslims scholars and many other physicians have contributed to it. In fact, Muslim physicians are known to have performed almost all types of operations on the eye (Mathur & Rao, 1982, p. 227). Ibn Sina covered ophthalmology in great detail in the first and third volumes of his Canon, including detailed descriptions of anatomy and diseases as well as physiology, pathology and treatments (Amr & Tbakhi, 2007). His studies on the eye contributed a great deal particularly to its anatomy and care (Price, 2001).

Ibn Sina, in the Canon of Medicine, described sight as one of the five external senses ("Ophthalmology In Medieval Islam," 1997). In fact, the Latin word "retina" is derived from Avicenna's Arabic term for the organ ("Ophthalmology In Medieval Islam," 1997). Some significant contributions the Canon made to ophthalmology in medieval Islam were the descriptions and explanations of the physiology of eye movements, which, to this day, are considered the fundamentals of modern ophthalmology. Furthermore, his descriptions of the optic nerves, iris, and central and peripheral facial paralyses remain important.

Another interesting contribution Ibn Sina made was the idea that the optic nerves cross (Stanley, 1994, p. 70). In his description of the anatomy of the eye, he stated that that the optic nerves are short and cross as they go to the contralateral side of the brain. His depiction mentions that the eye has 6 muscles and describes their function. Ibn Sina is also known to have taught his pupils about strabismus and double vision (M. & MA Raheem, 1981). Finally, he was the first physician to use probing in order to treat lachrymal fistula and syringing the lachrymal sac. He also mentioned that cataracts occurred due to lens opacity (Mathur & Rao, 1982, p. 227).

He provided great detail in his description of the eye muscles, including all of the muscles involved as well as their function. The Canon also contains exact depictions of six extra-ocular muscles as well as the trigeminal nerve. He describes the eyelid muscles separately. Ibn Sina utilized cautery for lesions in the ocular area to prevent destructive lesions, remove putrefaction and to stop hemorrhage. He recommended that gold instruments be used for this procedure, urging care and use only on visible tissues, and warned against blind usage (Beg, 2015).

Ibn Sina stated that nerves and tendons are different anatomical structures, a first in medical history. The practice of tendon repair was another medical practice he was the first to popularize (Al-Qattan, 2006). Ibn Sina observed that the occlusion of an excretory duct of the body caused an adjacent gland to swell (Farhadi et al., 1996).

2.1. Ibn Sina's Description of Corneal Edema

Corneal edema is an illness of the eyes that can be traced to two main causes: increasing intraocular pressure due to glaucoma and the decompensation of endothelium, including the inflammatory and non-inflammatory types. It is known that outer layer of the cornea (epithelium) is damaged due to viral impact, causing loss of glassiness in the cornea (Hamrah et al., 2012). Though this disorder is sometimes thought to be a new concept in medicine, it appears that Ibn Sina put forth a phenomenon describing eye cancer (*Saratan-e-Cheshm*; *Saratan* means cancer; *-e-* means of; and *Cheshm* means eye) in the 6th chapter of the 3rd volume of the Canon of Medicine (Levenson, 1975) that bears remarkable similarity to this disorder he indicated that this disorder would be located on the outer layer of the cornea. He also described the sign and symptoms of this disorder as pain, elongated eye vessels, pricking sensation, redness, headaches and anorexia (Avicenna, 2010). These symptoms bring to mind corneal edema. Today we know that the signs and symptoms of corneal edema include pain in the eye and headaches as well as blurred vision due to increased pressure in the eye and inflammation

(Behrens, 1978). Also, ocular inflammation can cause redness in the eyes (Tarff & Behrens, 2017). Other symptoms are vasospasm (Flammer, Pache, & Resink, 2001), irritation and seeing colored haloes as well as decreased sharpness in vision (Aquavella, 1973; Sood, Goyal, & Sood, 2010). On the other hand, ocular HSV infection causes photophobia (Whitley & Roizman, 2001) and irritation, and photophobia impacts the quality of life adversely and leads to anorexia nervosa, which in turn can also cause vision problems (Gaudiani, Braverman, Mascolo, & Mehler, 2012). This could be considered as the first complete description in history of corneal edema as a sole ocular disorder.

2.2. Ibn Sina's Description of Goiter and Thyroid-Related Orbitopathy

Modern medicine credits Robert Graves (1795–1853) and Carl von Basedow (1799–1854) with first describing thyroid-related orbitopathy, currently known as Graves' disease (Nabipour, Burger, Moharreri, & Azizi, 2009). Although it was not until the 19th century that they established Graves' disease as a clinical entity by showing the pathophysiologic link, Ibn Sina clearly depicted the association of goiter and exophthalmos in the year 1,000, to be repeated by Al-Jurjani around 1100. Therefore, the association between exophthalmos and goiter seems to have been discovered many centuries ago, with Ibn Sina also deserving credit.

The Canon contains descriptions of the swelling in the front of neck (goiter) in patients with increased and insatiable appetite (Al-Qanoon, Book III, part 9, chapter 6) as well as drawing a link between swelling in the neck and protruding eyes (Book III, part 3, treatise 2, chapter 15 and Book III, part 3, chapter 4). In fact, in the chapter on exophthalmos, Ibn Sina mentions differential diagnosis of proptosis, saying that exophthalmos could be due to pressure from the back of the orbit and observed corneal edema, chemosis, orbital fat, and lassitude of extraocular muscles in patients with exophthalmos. He described the ocular outcomes that take place when exophthalmos is due to the lassitude of extraocular muscles (Al-Qanoon, Book III, part 3, treatise 2, chapter 15).

2.2.1. Neuroanatomy and Neurophysiology

Ibn Sina not only discovered the cerebellar vermis, but he coined the term "*vermis*". He also discovered the caudate nucleus, which he named "*tailed nucleus*" or "*nucleus caudatus*". Both of these terms are used to this day in neuroanatomy and neurophysiology. Ibn Sina was also the first to note that it is mostly because of deficits in the brain's middle ventricle that intellectual dysfunctions occur, and that common sense and reason are mediated in the frontal lobe of the brain (Aydın, 2001).

2.3. Western Scientists' Studies on The History of Ophthalmology in The Late 19th - Early 20th Century: Hirschberg, Meyerhoff and Wiedemann

While it would require several papers to fully describe all of the historical investigations on Muslim eye surgeons who wrote treatises or textbooks, any paper on the history of ophthalmology would be incomplete without mentioning a few notable historians. Julius Hirschberg (1843-1925) and Max Meyerhoff (1874-1945) were both important ophthalmologists and medical historians who studied Ibn Sina's work on ophthalmology. Physicist and science historian Eilhard Wiedemann (1852-1928) also investigated Ibn Sina's work, but from a physics perspective.

Hirschberg was a famous Greek and Latin scholar who translated many Arabic writings in collaboration with Lippert and Mitwoch after working in Arabic for twenty years. Hirschberg (Leipzig, 1902) translated the eye section of the Canon with the aid of Lippert. Realizing there were many mistakes in the Latin translations, he thought to use the Greek sources; Oribasius and Aetius and Galen. Ultimately, Hirschberg was able to create a glossary of Arabic in Greek and German.

In agreement with Hirschberg, another ophthalmologist and medical historian of note from the 19th century with substantial knowledge about Muslim scientific history, Max Meyerhof (1874-1945), stated that the Canon remained the best ophthalmological textbook in the Orient or the Occident until the early 18th century (Pollock, 1946).

Well before Ibn Sina wrote the Canon (1020), Abu Zaid Hunain lbn lshaq (809-877) was the first to write a systematic text-book of ophthalmology that has remained until today. Hunain translated 39 books into Arabic by Galen, and many volumes by Hippocrates, Oribasius, Paulus Aegineta, Dioscorides, Rufus, and the Septuagint (the Greek Old Testament). Over 30 years (830-870), Hunain collected all the notes he had made on eye related subjects and wrote *The Book of the Ten Treatises on the Eye*, which would become the first systematic textbook of Ophthalmology. While Hirschberg's efforts to locate a copy of the *Ten Treatises* failed, he found numerous quotations in Al-Razi's (850-932) great *Medical Encyclopedia* as well as other textbooks of ophthalmology written later, as many eye experts had quoted from the work for at least 500 years. He discovered that two mediaeval Latin textbooks, *Liber de Oculis Constantini Africani* (1515) and *Galeni de Oculis Liber a Demetrio translatus* (1541) were in fact not originals as claimed, but exact translations of Hunain's work.

Mohammed ibn Zakarijah Abubekir Al-Razi (850-932) came after Hunain, becoming one of the greatest Arabic medical scholars. He produced a massive work that incorporated a wealth of information from the Greek, Latin, and Indian medical traditions, as well as those of his own time, into his immense textbook, "*The Content of Medicine (al-Hawi)"* and complemented this with his own experience. This was translated into Latin, as was his less lengthy "*al-Mansuri*", which also includes a section on the eye. This section, found in the second book, included Hunain's Treatise and information from Greek sources, and remarkably defined the reaction of the pupil to light and dark, which he seemed to discover for the first time. It would be a century later that Ibn Sina would write "*The Canon*", which, in addition to the wealth of information it contains, is acclaimed for its style of writing as well (Pollock, 1946).

In 1876, Eilhard Wiedemann (1852-1928) began his half-century long work as a physicist and technologist. He later developed an interest in almost all branches of Islamic science, based on his book published by Wolfdietrich Fischer entitled *Aufsätze zur arabischen Wissenschaftsgeschichte* (Hildesheim and New York, 1970). His writings appeared in over 200 articles and monographs, which were subsequently collected in five volumes and have greatly influenced the history of natural sciences. Wiedemann also studied the instruments Ibn Sina produced, particularly for scientific observation and wrote a book about them.

2.4. The Contribution of Ibn Sina to The Training of New Scientists

Ibn Sina was a true product of Muslim society during a time at which scientific discovery peaked. His *Book of Cures (al-Shifa)* contains an important chapter on mineralogy and meteorology, presenting a detailed picture of the knowledge of geology at the time. It became famous in Europe during the Renaissance with its Latin translation, which inspired the founders of geological thought in Europe such as Leonardo da Vinci in the 15th century, Nicolas Steno in the 17th century and James Hutton in the 18th century. It should be mentioned that there were also other Muslim scholars like Ibn Sina that were pushing the boundaries of knowledge (Al-Hassani, 2012).

2.5. Prof. Dr. Fuat Sezgin's Efforts to Preserve Historical Scholarly Work on Ophthalmologic Research

One of the world's most highly regarded science historians, Professor Fuat Sezgin, collected Hirschberg and his students' work on the history of ophthalmology into a book in an effort to render these works accessible to science historians today. The following works by Professor Sezgin are about ophthalmologic studies in the Islamic Civilization and the contributions made by Muslim physicians:

1) Julius Hirschberg, Das Aussaugung des Stars, eine Radical-Operation der Araber, *Centralblatt für praktische Augenheilkunde*, 28 (1904) 225–35 (reprinted in Fuat Sezgin (ed.), *Augenheilkunde im Islam. Texte, Studien und Übersetzungen* (Frankfurt am Main 1986), 3:272–82);

2) Julius Hirschberg, *Geschichte der Augenheilkunde*, vol.2, *Geschichte der Augenheilkunde im Mittelalter bei den Arabern* (Leipzig 1908), 47–57 and 226–38 (reprinted in Fuat Sezgin (ed.), *Augenheilkunde im Islam. Texte, Studien und Übersetzungen* (Frankfurt am Main 1986), 3:55–64 and 234–46);

3) Emilie Savage-Smith, The practice of surgery in Islamic lands. Myth and reality, *Social History of Medicine*, 13 (2000), 307–21;

4) A partial translation of *K. al-Muntakhab* into four languages (Spanish, English, French, and German), based on a single Cairo manuscript, was published by Max Meyerhof, *Las operaciones de catarata de 'Ammâr ibn 'Alî al-Mausilî* , Barcelona 1937; and reprinted in Fuat Sezgin (ed.), *Augenheilkunde im Islam. Texte, Studien und Übersetzungen* (Frankfurt am Main 1986), 3:590–711.

5) A complete German translation (using a copy in the Escorial and an incomplete Hebrew version) was published by Julius Hirschberg, Julius Lippert, and Eugen Mittwoch, *Die arabischen Augenärzte nach den Quellen bearbeitet* (Leipzig 1905), 2:1–152; and reprinted in Fuat Sezgin (ed.), *Augenheilkunde im Islam. Texte, Studien und Übersetzungen* (Frankfurt am Main 1986), 1:558–718.

2.5.1. Juan Cueva's Preface to "The Ophthalmic Medicine of Ibn Sina"

One of the students of Julius Hirschberg, Juan Cueva, produced remarkable works in 1899 among others such as Paul Uspensky, Theodor Bernikow and Elias Michailovwsky in 1900, and Julius Lippert in 1902. A passage from Cueva's PhD dissertation provides a good example of the contributions of Ibn Sina:

> The historical influence of Islamic medicine is so important that Europeans could not comprehend Islamic medicine without consulting the Arabs. In the 16th century, the medical instructors were divided into two as Anti-Arab Medicine and its supporters because of their studies in Arabic medicine going back to ancient Greek sources.
>
> The historical and cultural importance of Arabs can be clearly understood only when the formation of Arab-Islamic Medicine is deeply analyzed.
>
> I am assigning myself to study this part of ophthalmic medicine through the help of "The Canon of Medicine" of Ibn Sina known as the Prince of Physicians.
>
> Ibn Sina has written a huge quantity of articles not only medical but also philosophical, mathematical and astronomical works.
>
> It is rightful to regard Ibn Sina as the main representative of Islamic Medicine. He is as important for Islamic Medicine as much as Galen is for Greek Medicine.
>
> Galen formed the integration and regulation of Pergamon physicians and Greek Medicine in a system, and then Greek and Arab medicine was formed on the system of Galen, especially by Razi and Ali Abbas.
>
> Not only the content of his work, but also the external form and the logical weave of Ibn Sina's crazy and nightmarish ideas deserve full praise. But the most important feature of his works is that they are independent and unique to those who preceded him, for example, in comparison with Razi.
>
> Ibn Sina's Law (Kanun) has been an ideal Medical Work for centuries. Furthermore during this time, it causes the most famous medical works to be forgotten.
>
> Scholars of both western and eastern countries such as famous physician Ibn Rushd and authors have been inspired and influenced by works of Ibn Sina.
>
> He has also had a greater influence in Islamic schools in the west. Thanks to The Canon of Ibn Sina because of which the articles of Hippocrates and Galen had started to get lost in oblivion.
>
> **…..**

The 5 Volumes of the Canon

Volume I: Theories of medicine: definition and function of medicine, relationship with philosophy, elements, humors and characters, organs; detailed anatomical parts based on the findings of Aristotle and Galen; general diseases, causes and symptoms of diseases; nutrition and prophylaxis.

Volume II: Simple medicines, in particular those with metal contents, metal salts, metal oxides; lead, mercury, arsenic, antimony, silver and gold preparations; (the toxic properties of all of these drugs were little known and their effects were feared, so they were recommended for external use); powdered glass for eye infections as well as for internal inflammations (as astringents); many aromatic and resinous foods like Aloe and Coloquinthen; narcotic opium especially for diarrhea and eye inflammation; many repulsive drugs like animal feces and urea;

Volume III: Diseases by area; first anatomical evaluation then sections on internal organs and external sensory organs. In general, old Greek and Arabic texts are repeated in this section.

Volume IV: Febrile diseases; told in traditional style; dislocation, fractures and dislocations.

Volume V: Compound and sophisticated drugs.

The main difficulty with understanding the Canon and ophthalmology in general was the lack of Latin translations at the end of the Middle Ages and at the beginning of the Renaissance. There were also issues of old and new language differences in Arabic expressions. Even Europeans who spoke Arabic at the time could not benefit from these translations due to such language related challenges and mistranslations. They required the help of Arab philosophers to understand the incomplete Latin translations as well as to understand the contradictory / suspicious expressions. Therefore, my own translation is merely an attempt to fulfil the task I set myself.

2.5.2. Other Works By Professor Sezgin

Other works by Professor Sezgin pertain to the design of instruments used by Muslim scholars. In his five volumes of encyclopaedic study named *Science and Technology in Islam, Dr. Sezgin* presented various historical models used or described by Muslim scholars as well as new models he designed himself to enable a comparison. The following examples are optic instruments designed by Ibn Sina as mentioned by Dr. Sezgin.

3. The Main Instrument of the Observatory of Alauddaula

Ibn Sina, as a polymath interested in medicine, philosophy and astronomy, was invited by Alauddaula, the Emir of Esfahan to create instruments for an observatory. The main instrument was intended to accurately determine astronomical altitudes. It had long arms to enable an observational result read off in degrees as well as in minutes and seconds. Ibn Sina designed the length of the arm to be around 7 meters (Schmidt, 1935; Sezgin, 1970).

Discussion and Conclusion

Abu ‘Ali al-Husain Ibn Sina, better known in Europe by the Latinized name Avicenna, is probably the most significant philosopher in the Islamic tradition and arguably the most influential philosopher of the pre-modern era. He is best known as a polymath and as a physician whose major work the Canon of Medicine (*al-Qanun fi’l-Tibb*) continued to be taught as a medical textbook in Europe and in the Islamic world until the early modern period, as well as a philosopher whose major *summa* the *Cure* (*al-Shifa’*) had a decisive impact upon European scholasticism and especially upon Thomas Aquinas (d. 1274). Ibn Sina had a role in the transmission of knowledge over centuries along with other Islamic scholars, who have quoted their sources in a detailed manner, mentioning their respectful gratitude to their predecessors especially the Greeks. It is thus that they have rendered Greek knowledge and instruments, which might have remained otherwise unknown, knowable or ensured that fragments of Greek writings survived.

The purpose of this study is to emphasize the contribution of this great scholar on the field of ophthalmology and Professor Sezgin's efforts to ensure Ibn Sina's contributions carry on into future generations. One of Ibn Sina's prominent books, the 5-volume Arabic text of the Canon of Medicine (*Qanun fil tibb* or *Law of Natural Healing*) was translated into Latin by Gerard of Cremona as *Canon medicinae* in the 12th century. From then on, the *Canon* became the main guide for Western medical scientists, going as far as influencing scholars such as Leonardo da Vinci. The elaborately detailed content, the remarkably systematic arrangement of information and its philosophical outline made it one of the most respected pieces of medical literature and education in Europe, a place previously occupied by Galen. It was used as late as 1650 to train medical students at Montpellier and Leuven, and was described by Arnold C. Klebs at one point in time as one of the most significant intellectual phenomena of all times. Dr. William Osler has been known to say that the Canon *was* "the medical bible" for longer than any other known work.

The Canon distinguished anatomy "from other aspects of medicine by its need for a different methodology", saying, "*As for the parts of the body and their functions, it is necessary that they be approached through observation (*hiss*) and dissection (*tashrih*), while those things that must be conjectured and demonstrated by reason are diseases and their particular causes and their symptoms and how disease can be abated and health maintained*."

In summary, the contributions of the *Canon* to ophthalmology in medieval Islam include its descriptions and explanations on the physiology of eye movements, which still form the basis of information for modern ophthalmology. He also provided useful information on the optic nerves, iris, and central and peripheral facial paralyses. Another contribution the *Canon* made to ophthalmology was the suggestion that "the optic nerves did cross."

Professor Fuat Sezgin's presentation entitled *Introduction to the History of Arabic-Islamic Sciences* is an important attempt to chronologically present relevant conclusions from historical research. His work is crucial for broadening the existing research into Islamic natural sciences.

Finally, to quote Professor Julius Hirschberg's speech at the American Medical Association in 1905:

During this total darkness in medieval Europe they (the Arab Muslims) lighted and fed the lamps of our science (ophthalmology) - from the Guadalquivir (in Spain) to the Nile (in Egypt) and to the river Oxus (in Russia). They were the only masters of ophthalmology in medieval Europe." (Haq & Khatib, 2012)

And to quote the European physician De Poure on Ibn Sina, more generally:

"Medicine was absent until Hippocrates created it, dead until Galen revived it, dispersed until Rhazes (al-Razi) collected it, and deficient until Avicenna (Ibn Sina) completed it." (Al-Hassani, 2012).

References

Al-Hassani, S. T. S. (2012). *1001 Inventions : the enduring legacy of Muslim civilization* (3rd ed.). National Geographic.

Al-Qattan, M. M. (2006, March 1). History of anatomy of the hand and upper limb. *Journal of Hand Surgery*. Elsevier. https://doi.org/10.1016/j.jhsa.2005.12.001

Amr, S. S., & Tbakhi, A. (2007, March). Ibn Sina (Avicenna): The prince of physicians. *Annals of Saudi Medicine*. https://doi.org/10.5144/0256-4947.2007.134

Aquavella, J. V. (1973). Chronic corneal edema. *American Journal of Ophthalmology*, *76*(2), 201–207. https://doi.org/10.1016/0002-9394(73)90160-8

Avicenna. (2010). *Avicenna. The Canon of Medicine*. (Translated and edited by Sharafkandi, Ed.) (3rd ed.). Tehran: Soroosh.

Aydın, İ. H. (2001). Avicenna and modern neurological sciences. *Journal of Academic Researches in Religious Sciences*, *1*(2), 1–4. Retrieved from https://scholar.googleusercontent.com/scholar.bib?q=info:J0xLEsNip2kJ:scholar.google.com/&output=citation&scisdr=CgXPz2QmEIH005lVXlA:AAGBfm0AAAAAXUdQRlDjQ0AEC-KQwZZ4rHWU2PdJSxcO&scisig=AAGBfm0AAAAAXUdQRjgheHg9eUt8Rfr4zXnKUcRjcbAb&scisf=4&ct=citation&cd=-1

Beg, H. (2015, June 20). Surgical principles of Ibn Sina (Avicenna). *Bangladesh Journal of Medical Science*, *14*(3), 217–220. https://doi.org/10.3329/bjms.v14i3.22776

Behrens, M. M. (1978). Headaches Associated with Disorders of the Eye. *Medical Clinics of North America*, *62*(3), 507–521. https://doi.org/10.1016/S0025-7125(16)31789-8

Bujarborua, D. (2015). Ophthalmology in ancient india, Sushruta's time and the modern era. *Eye News*, *22*(2). Retrieved from https://www.eyenews.uk.com/media/10884/eyeas15-bujarborua.pdf

Farhadi, M., Behzadian Nejad, G., & Bagbanzadeh, A. (1996). Papers of the international congress of the history of medicine in Islam and Iran. *Iranian Institute for Science and Research Expansion, Tehran, Iran*. Retrieved from https://scholar.googleusercontent.com/scholar.bib?q=info:0i8GJtxPoYgJ:scholar.google.com/&output=citation&scisdr=CgXPz2QmEIH005lBraU:AAGBfm0AAAAAXUdEtaVjAo32YfBbr81j6u15rR1tBCDy&scisig=AAGBfm0AAAAAXUdEtZM28o1EK0etL9yJE55coL3aX-AM&scisf=4&ct=citation&cd=-1

Flammer, J., Pache, M., & Resink, T. (2001). Vasospasm, its Role in the Pathogenesis of Diseases with Particular Reference to the Eye. *Progress in Retinal and Eye Research*, *20*(3), 319–349. https://doi.org/10.1016/S1350-9462(00)00028-8

Gaudiani, J. L., Braverman, J. M., Mascolo, M., & Mehler, P. S. (2012). Lagophthalmos in Severe Anorexia Nervosa: A Case Series. *Archives of Ophthalmology*, *130*(7), 928. https://doi.org/10.1001/archophthalmol.2011.2515

Hamrah, P., Sahin, A., Dastjerdi, M. H., Shahatit, B. M., Bayhan, H. A., Dana, R., & Pavan-Langston, D. (2012). Cellular Changes of the Corneal Epithelium and Stroma in Herpes Simplex Keratitis: An In Vivo Confocal Microscopy Study. *Ophthalmology*, *119*(9), 1791–1797. https://doi.org/10.1016/J.OPHTHA.2012.03.005

Haq, I., & Khatib, H. A. (2012). Light through the dark ages: The Arabist contribution to Western ophthalmology. *Oman Journal of Ophthalmology*, *5*(2), 75–78. https://doi.org/10.4103/0974-620X.99367

Keskinbora, K., & Keskinbora, K. (2016). A systematic review of Ibn Sina s (Avicenna) studies: reflections on anatomy. *Eur J Anat*, *20*(1), 99–105. Retrieved from https://www.researchgate.net/profile/Kadircan_Keskinbora/publication/301360701_A_systematic_review_of_Ibn_Sina's_Avicenna_studies_Reflections_on_anatomy/links/580a57d908aeef1bfee3f63f/A-systematic-review-of-Ibn-Sinas-Avicenna-studies-Reflections-on-anatom

Levenson, J. E. (1975). Corneal edema: Cause and treatment. *Survey of Ophthalmology*, *20*(3), 190–204. https://doi.org/10.1016/0039-6257(75)90002-8

M., I., & MA Raheem, R. (1981). Anatomy of eye and the mechanism of vision according to Avicenna. *Bulletin of the Indian Institute of History of Medicine (Hyderabad)*, *1–4*, 146–151. Retrieved from https://europepmc.org/abstract/med/11616390

MacCallan, A. F. (1927). The Birth of Ophthalmology and Its Development in Early Arabic Literature. *British Journal of Ophthalmology*, *11*(2), 63–67. https://doi.org/10.1136/bjo.11.2.63

Mathur, S., & Rao, G. S. R. (1982). Contribution of Muslim scientists toward surgery(March-April 1402/1982). In *Bulletin of Islamic Medicine, Vol. III* (p. 227). K.F.A.S., State of Kuwait.

Nabipour, I., Burger, A., Moharreri, M.-R., & Azizi, F. (2009). Avicenna, the First to Describe Thyroid-Related Orbitopathy. *Thyroid*, *19*(1), 7–8. https://doi.org/10.1089/thy.2008.0299

Naderi, S., Acar, F., Mertol, T., & Arda, M. N. (2003). Functional anatomy of the spine by Avicenna in his eleventh century treatise Al-Qanun fi al-Tibb (The Canons of Medicine). *Neurosurgery*, *52*(6), 1449–1454. https://doi.org/10.1227/01.NEU.0000064811.30933.7F

Ophthalmology In Medieval Islam. (1997).

Pollock, W. B. (1946). ARABIAN OPHTHALMOLOGY. *The British Journal of Ophthalmology*, *30*(8), 445–456. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18170243

Price, M. (2001). History of Iran: History of ancient Medicine in Mesopotamia & Iran. Retrieved August 5, 2019, from https://scholar.googleusercontent.com/scholar.bib?q=info:NpIVE12fQoEJ:scholar.google.com/&output=citation&scisdr=CgXPz2QmEIH005lUMNI:AAGBfm0AAAAAXUdRKNISfAZY655iLpCNfdGN4GGqGUt0&scisig=AAGBfm0AAAAAXUdRKFvhzIXYDxryJ72Ffvj84-U7s-9B&scisf=4&ct=citation&cd=-1

Russel, G. (1982). The anatomy of the eye: Ibn Al-Haytham and the Galenic tradition(March-April 1402/1982). In *Bulletin of Islamic Medicine,Vol. III* (p. 176). K.F.A.S., State of Kuwait. Retrieved from https://scholar.googleusercontent.com/scholar.bib?q=info:aYrdrorNJBQJ:scholar.google .com/&output=citation&scisdr=CgXPz2QmEIH005kYMDI:AAGBfm0AAAAAXUcdKDLuWRp7cDGVNSSXrnPbwV42skVK&scisig=AAGBfm0AAAAAXUcdKD6MhPUjRQV_cFOmUgyigPrdQUvE&scisf=4&ct=citation&cd=-1

Schmidt, F. (1935). Geschichte der geodatischen instrumente und verfahren im altertum und mittelalter. *Neustadt an Der Haardt, Pfalzische Gesellschaft Zur Forderung Der Wissenschaften*. Retrieved from http://adsabs.harvard.edu/abs/1935QB281.S35.....

Sezgin, F. (1970). Geschichte des Arabischen Schrifttums. III-VII. *V, Leiden*, *1971*. Retrieved from https://scholar.googleusercontent.com/scholar.bib?q=info:3vJGc0nyw5MJ:scholar.google.com/&output=citation&scisdr=CgXPz2afEIH00_VHwwY:AAGBfm0AAAAAXStC2wbdsL00erTAbQFXYUarWDJOzVYj&scisig=AAGBfm0AAAAAXStC29Bpo0jhSflVpIssdUFIx9HEiFH0&scisf=4&ct=citation&cd=-1

Sezgin, F., & Neubauer, E. (2011). Sci*ence and technology in Islam*. Institut Für Geschichte Der Arabisch-Islamischen Wissenschaften an Der Johann Wolfgang Goethe-Universität.

Sobotka, H. (1957). Ophthalmology During the Middle Ages. *A.M.A. Archives of Ophthalmology*, *57*(3), 366–375. https://doi.org/10.1001/archopht.1957.00930050378008

Sood, D., Goyal, D., & Sood, N. N. (2010). Open angle glaucoma-trends in management. *Journal International Medical Sciences Academy*. Retrieved from http://medind.nic.in/jav/t10/i3/javt10i3p158.pdf

Stanley, F. (1994). *Origins of Neuroscience: A History of Explorations Into Brain Function*. Oxford University Press.

Tarff, A., & Behrens, A. (2017). Ocular Emergencies: Red Eye. *The Medical Clinics of North America*, *101*(3), 615–639. https://doi.org/10.1016/j.mcna.2016.12.013

Whitley, R. J., & Roizman, B. (2001). Herpes simplex virus infections. *The Lancet*, *357*(9267), 1513–1518. https://doi.org/10.1016/S0140-6736(00)04638-9