International Journal of Optics and Applications 2014, 4(4): 110-113
DOI: 10.5923/j.optics.20140404.02

# Alhazen, the Founder of Physiological Optics and Spectacles

**Nāsir pūyān (Nasser Pouyan)**

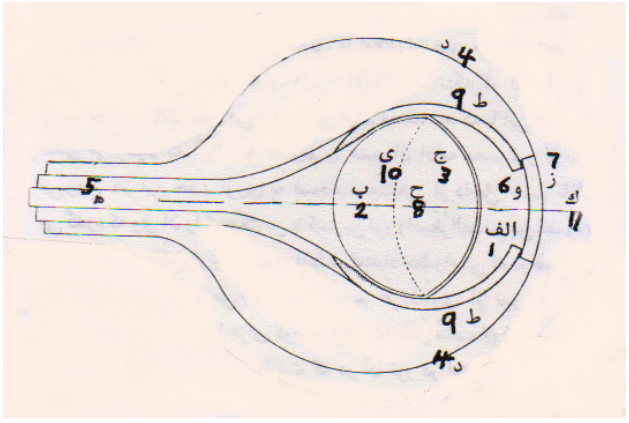
Tehran, 16616-18893, Iran

**Abstract** Alhazen (c. 965 – c. 1039), Arabian mathematician and physicist with an unknown actual life who laid the foundation of physiological optics and came within an ace of discovery of the use of eyeglasses. He wrote extensively on algebra, geometry, and astronomy. Just the Beginnings of the 13th century, in Europe eyeglasses were used as an aid to vision, but Alhazen's book "Kitab al – Manazir" (Book of Optics) included theories on refraction, reflection and the study of lenses and gave the first account of vision. It had great influence during the Middle Ages. In it, he explained that twilight was the result of the refraction of the sun's rays in the earth's atmosphere. The first Latin translation of Alhazen's mathematical works was written in 1210 by a clergyman from Sussex, in England, Robert Grosseteste (1175 – 1253). His treatise on astrology was printed in Latin at Basle in 1572. Alhazen who was from Basra died in Cairo at the age of 73 (c. 1039).

**Keywords** Optics, Basra, Cairo, Spectacles

Ibn al-Haytham (c. 965 – c. 1038), known in the West Alhazen, and Avenna than[1], who is considered as the father of modern optics. He was from Basra [1] (in Iraq) and received his education in this city and Baghdad, but nothing is known about his actual life and teachers. This Arab polymath was extremely famous in physics, mathematics, astronomy, medicine, especially in ophthalmology. In Basra, he was the minister of Buid (Buwayhid) of Iraq, but because of his intense interest in studying, teaching, researching, and writing, he decided to resign. Thus he presented his resignation, but the ruler of Iraq did not accept. Since continuation of his job was not possible for him, Alhazen pretended being insane and his madness cannot be cured. This time the governor gave in, and accepted his resignation. Alhazen, after his resignation received an invitation from one of the Fatimids of Cairo. He accepted it gladly and left Basra for Egypt. In Egypt, the Caliph al – Hakim appointed him as the sponsor of some engineers to work on the project of Nile channel, but soon after he quitted it. The Caliph filled with anger and sent him to prison, and confiscated his possessions [2].

After the death of Caliph al – Hakim in 1020, Alhazen who had pretended insane, once more was released from the prison and received his belongings, and never applied for any position.



**Section of eyeball according to Kitab al-Manāzir (Book of Optics): I-humour; 2- eyeball; 3- the crystalline; 4- conjunctiva; 5- optic nerve; 6- pupil; 7- cornea; 8- the center of iris; 9- iris; 10- vitreous humour; 11- simultaneous axis. (Ali Esmaeili. The Arab Men of Sciences. US, 2012, p.3.)**

## 1. Foundation of Physiological Optics

Alhazen conducted experiments on the propagation of light, colors, optic illusions and reflection. He examined the refraction of light rays through transparent medium (air, water) and documented the laws of refraction. Alhazen also carried out the first experiment on the dispersion of light into the colors. In detailing his experiment with spherical segments (glass, vessels filled with water), he came very close to discovery the theory of magnifying lenses which

* Corresponding author:
nasser_pouyan@yahoo.com (Nasser Pouyan)
Published online at http://journal.sapub.org/optics


[1] His full name is "Abu Ali Muhammad bin al – Hasan bin al – Hasan of Basra" (Elgood, Cyril, A Medical History of Persia and the Eastern Caliphate, p. 136). According to Encyclopedia of Islam, his complete name is: "Abu Ali al – Hasan (or Husayn) bin al – Haytham al – Basari al – Misri". (Vol.3, p.788). He was identified towards the end of the 19th century with Alhazen, Avennathan, Aventan of mediaeval Latin texts.

was developed in Italy three centuries later. It took another three centuries before the law of sines was proposed by Willebrord Senellius[**] and René Descartes (1596 – 1650), French philosopher, scientist, and mathematician.

In fact, Ibn al – Haytham was the first who laid the foundation of physiological optics, which concerns the optical principles of eyes and vision. He was also the first to study the properties of light and convex lenses. His Kitab al – Manazir (Book of Optics) included theories on refraction, reflection, and the study of lenses and gave the accurate account of vision. It also formed the basis for invention of spectacles, telescope and microscope [3].

Alhazen's first Latin translation of mathematical works was written in 1210 by a clergyman from Sussex in England, Robert Grosseteste (1175 – 1253) who became bishop of Lincon in 1235 [4].

His main treatise on optics in its Arabic form is disappeared, but the book which survives as the "Opticae Thesaurus" in its Latin translation by Witelo the Pole in 1720, "had great influence during the Middle Ages [5]." In this treatise Alhazen explained that twilight was the result of the refraction of the sun's rays in the earth's atmosphere [6].

Very little of his successors adapted his theory of vision, but al – Biruni (972 – 1048), Iranian mathematician and philosopher and pharmacologist, and Avicenna (980 – 1037), Iranian physician and called the prince of physicians, both agree independently and fully in Alhazen's opinions. In Alhazen's time, the only method of helping weak sight was that recommended by 'Ali bin 'Isa who says: "Those who do not see in the near, should use styptic medicine; those who see well in the near, but not in distance require medicine which gives moist nutrition and bring the moist principle to the eye. In fact, not only the modern physiological optics began by Alhazen's theory of optics, but also the whole science of modern optics coined [7]."

In 1270 the English Franciscan monk Roger Bacon (1214 – 1298) of Ilchester suggested the use of lenses to aid the sight of old people. The term spectacles was first used in 1307 by a Scottish professor at Montpellier, Bernard de Gordon [8]. The device is said to have been invented around 1250 by Savinus Aramatus or Salvino degli Aramati of Pisa[***].

His theory of vision was repeated and extended by Kamal al- din. He also observed the path of the rays in the interior of a glass sphere in order to examine the refraction of sunlight in rain drop. This led him to an explanation of the genesis of the primary rainbows [9].

[**] Willebrord Senellius (Snell van Royen), Dutch scientist discovered the law of refraction in 1621.

[***] The earliest illustration of spectacles, a Dominican friar using it for writing, pointed in 1360 by Tomaso de Modena is found in the Church of San Nicola in Treviso. A record of a church sermon given in 1305 by Giordano da Rivolta, contains a statement "It is only twenty years since the art of making spectacles was discovered." (Sebastian, Anton, A Dictionary of the History of Science, p. 310)

## 2. Other optical works

Alhazen's other optical works include Daw al- qamar ("On the Light of the Moon"), al- Hala wa qaws quzah ("On the Halo and the Rainbow"), Surat al – kusuf ("On the Shape of the Eclipse"): which includes a discussion of the camera obscura), and al – Daw' ("A Discourse on Light").

In his Hall shukuk fi kitab Uqlidis ("Solution of the Difficulties of Euclid's Elements"), Alhazen investigated particular cases of Euclid's theorems, offered alternative constructions, and replaced some indirect proofs with direct proofs.

## 3. Works

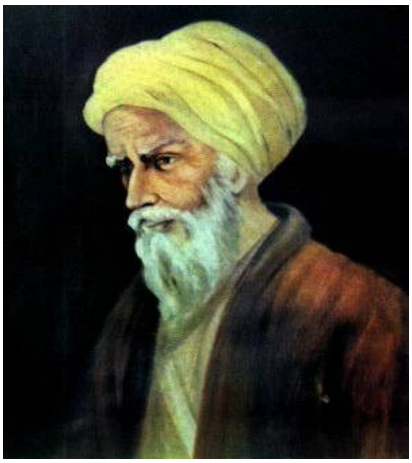
Alhazen wrote as many as 200 book and treatises, although only 55 have survived, and a number of them have not been translated from Arabic language. A selection of Alhazen's treatises on optics survived only through their Latin translation. Some of his works best known to us are as follows:

- Book of Optics
- Analysis and Synthesis
- Balance of Wisdom
- Corrections to the Almagest
- Discourse on Place
- Exact Determination of the Pole
- Exact Determination of the Meridian
- Finding the Direction of Qibla by Calculation
- Horizontal Sundials
- Hour Lines
- Doubts Concerning Ptolemy
- Maqala fi'l-Qarastun
- On Completion of the Conics
- On Seeing the Stars
- On Squaring the Circle
- On the Burning Sphere
- On the Configuration of the World
- On the Form of Eclipse
- On the Light of Stars
- On the Light of the Moon
- On the Milky Way
- On the Nature of Shadows
- On the Rainbow and Halo
- Opuscula
- Resolution of Doubts Concerning the Almagest
- Resolution of Doubts Concerning the Winding Motion
- The Correction of the Operations in Astronomy
- The Different Heights of the Planets
- The Direction of Mecca
- The Model of the Motions of Each of the Seven Planets
- The Model of the Universe
- The Motion of the Moon
- The Ratios of Hourly Arcs to Their Heights

- The Winding Motion
- Treatise on Light
- Treatise on Place
- Treatise on the Influence of Melodies on the Souls of Animals[****].

## 4. The Highlights

- Like Avicenna and al-Biruni, he established that rays of light start from object to travel the eye and not reverse as Euclid, Ptolemy and al-Kindi maintained.
- In a number of his works can be seen his profound knowledge of the Greek authors, notably Ptolemy who he edited, studied and criticized.
- In the Middle Ages, his works on cosmology were translated into Latin, Herbrew, and several other languages.
- In Mizan al – Hikmah (Balance of Wisdom), Alhazen discussed the theories of attraction between masses.
- His Al – Shukuk ala Batlamyus (Doubts Concerning Ptolemy or Aporias against Ptolemy), published sometime between 1025 and 1028. In this treatise, Alhazen criticized Ptolemy's Almagest, Planetary Hypothesis, and Optics, pointing out various contradictions he found in this works, particularly in astronomy.
- His famous Kitab al- Manazir was translated into Latin as "De aspetibus" in the late thirteenth century in Spain. Copies of the book circulated throughout Europe. Roger Bacon, who is sometimes credited as the founder of modern science wrote a summary of it entitled Perspectiva (Optics).
- The Crater Alhazen on the moon is named in his honour, as was the "asteroid 59239 Alhazen". Alhazen is a lunar impact Crater that lies near eastern limb of the Moon's near side. Just to the south – southeast is the Crater Alhazen.
- His Surat al – kusuf (On the Shape of Eclipse), includes a discussion on camera and obscura.
- In honor of Alhazen, the Aga Khan University in Pakistan, named its ophthalmology endowed chair as "the Ibn – e – Haitham Associate Professor and chief of Ophthalmology."
- Alhazen, by the name of the Ibn – e – Haytham, is featured on the observe of the Iraqi 10000 – dinar bank- note issued in 2003, and 10 – dinar notes, 1982.
- A research facilities that United Nations weapons inspectors suspected of conducting chemical and biological weapons research in Saddam Hussein's Iraq was also named after Alhazen.
- Alhazen had many pupils, but two of them were outstanding: Abu'l – Vafa Mubbashir bin Fatak, the author of "Mukhtar al – Hikam wa Mahasan al – kalam, and Suhrab (Surkhab). Fatak (Egyptian) learned mathematics. Suhrab a great scholar from Simnan (in Iran), who was his pupil for three years, paid him 100 dinars as tuition, each month. But at the end when his studies finished, Alhazen returned all the money that Suhrab had paid, and told him: "Since I found out that you have no aim but learning, for this reason, I return all the money to you [10]."




**Alhazen (965-1038), from Basra who founded the physiological optics and was the first to study the properties of light and convex lenses.**

## 5. Conclusions and Impact

The first authentic mention of the use of lenses for reading was made by Meissner (AD 1260 – 1280), who stated that would be advantageous to old people. In 1282, a priest used spectacles for signing an agreement. However, the use of magnifying glasses was probably known to Tyre and Sidon as far as 1800BC. Nero (37-68AD), Roman Emperor (54-68), and Lucius Annaeus Seneca (c.4BC -65AD), Roman statesman, philosopher, essayist and poet, were thought to have used ground and polished gems to help their defective sight.

[****] In addition to the works mentioned, see Brockelmann, 1, 469, Si, 851; Sarton, "Introduction to the History of Science", I, 721; Steinschneider, Aven Naton e la teoria dell' origine della luce lunate e delle stelle, in Bul. di bibliogr. e di storia delle scienze matematiche e fisiche, i, Rome, 1868, 33 – 40; Mustafa Nazif Bek, Ibn al – Haytham wa buhuthuhu wa – kushfuhu al – nazariyya, Cairo 1942 – 3, 2 vols; H.J.J.Winster, the optical researches of Ibn al – Haytham, in "Centaurus", iii (1954, 190 – 210; F. Bustani, Da'irat al màarif, iv, 128 – 30. (Encyclopedia of Islam, p. 789).

Afterwards, Alhazen made significant contributions to optical theories. His Kitab al – Manazir on refraction and reflections and study of lenses, formed the basis for the invention of modern spectacles, the telescope and the microscope. A record of a church sermon given in 1305 by Giordano da Rivolta, contains a statement "It is only twenty years since the art of making spectacles was discovered."

Although eyeglasses used in China prior to the 13th century it is not known whether they were worn at that time to improve vision or to bring good fortune. Beginning in the 13th century in Europe spectacles (eyeglasses) were worn as an aid to vision. Then, in nineteenth century, Dutch ophthalmologist and physiologist, Franciscus Cornelis Donders (1818 – 1889) introduced the use of prismatic and cylindrical lenses in the production of spectacles.

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[1] Sebastian, Anton. A Dictionary of the History of Science. The Parthenon Publishing Group, New York- London, 2001, p.14.

[2] Ibid. P. 14.

[3] Sebastian, Anton. Dates in Medicine. The Parthenon Publishing Group, New York- London, 2000, P.6.

[4] Sebastian, Anton. A Dictionary of the History of Science. P. 14.

[5] Encyclopedia International. Grolier, vol. 1, New York, 1975, p. 299.

[6] Ibid. P. 299.

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[8] Elgood, Cyril. A Medical History of Medicine and Eastern Caliphate. P. 137.

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[10] See also Ibn al – Haytham (Arab astronomer and mathematician), Ecyclopedia Britanica; Ecyclopedia of Islam, prepared by a number of leading orientalists, Leiden, 1980, pp. 788 and 789.