

On science and the construction of identities: Remembering Ibn al-Haytham (965–1039)

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Summary. Ibn al-Haytham (965–1039), best known as Alhazen, is one of the main figures of medieval Arabic science. He worked on mathematics, astronomy, optics, logic, philosophy and medicine, and, as a “modern” scientist, questioned previous theories, challenging, for instance, the Ptolemaic theory of vision. His works on light and optics, based on experimentation, established the basis for the development of Newton’s physics. Due to his great influence on the development of human knowledge, especially on the fields related to light, Ibn al-Haytham must be remembered during the commemorations of the United Nations International Year of Light and Light-based Technologies 2015. [*Contrib Sci* 11(1): 95-102 (2015)]

“All knowledge that is about human society, and not about the natural world, is historical knowledge, and therefore rests upon judgment and interpretation. This is not to say that facts or data are nonexistent, but that facts get their importance from what is made of them in interpretation.”

Edward Said, *Covering Islam. How the Media and the Experts Determine How We See the Rest of the World*. Random House, London 1997 (e-book)

Introduction

The history of human culture or, more specifically, the history of science, established outright that the transmission of ideas has been essential to achieve the current level of technology and sophistication we enjoy—or suffer. It makes no sense to think about the Western world as a unique star

in the sky of knowledge, simply because it is not true. On the contrary, scientific thought has been developing for centuries throughout many regions. Sadly, the Arab contribution to this evolution is commonly forgotten, which is why the idea of remembering the figure Ibn al-Haytham (965–1039) in 2015, chosen by the United Nations as the UN International Year of the Light and Light-based Technologies (IYL2015), can be seen

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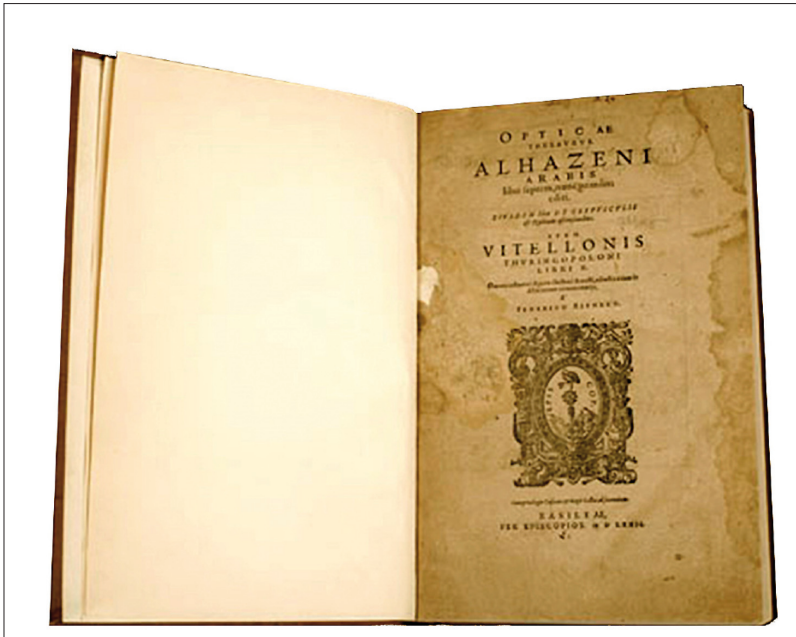


Fig. 1. Title page of Sabra's edition of *Kitāb al-Manāẓir*, by Ibn al-Haytham.

as an initiative that brings some justice to this noisy silence. One thousand years ago, around 1015, Ibn al-Haytham wrote his *Kitāb al-manāẓir* (*Book on Optics*) (Fig. 1).

There are two key words that typify the beginning of the 21st century: “We” and “Now”. In a time when neo-colonialism tends to construct a “We” identity opposed to “They” (where most of the time “We” are the Western world and “They” are the Muslim world), history teaches us that concepts such as “science” and “evolution” are in debt to the Arab and the Muslim world. From photography to astronomy, much of the knowledge (and many of the techniques) we have were made possible thanks to Arabic scientists. In addition, history also teaches us that the preservation of memory is essential for a deep understanding of the present.

In the era of globalization, some icons are extensively (and broadly) shared while others remain local. Arabic scientists, for instance, are a good example of incomprehensibly ignored figures, and for this reason, Ibn al-Haytham is still a complete stranger to most Western citizens. This perception, however, can change depending on where the subject lives, not necessarily because Ibn al-Haytham is studied, but because he is perceived as a key part of a specific identity. Ibn al-Haytham would be an uncommon name for a hospital in Europe, but there is one in Amman. It is also the name of one of the most important pharmacies in Qatar. There are Ibn al-Haytham avenues and streets in the Arab world, and his face has been printed on banknotes and stamps (Fig. 2).

These examples show that he is considered a celebrity

in many countries but, by contrast, he is virtually unknown in others. The global concept of the “We/They” identities can change, and Arabic scientists—and writers, economists and musicians, among others—should be integrated into a common and universal imaginary for a richer, more complete understanding of the history of humanity. First of all, however, this should be done in a scientific way, avoiding the creation of new and ahistorical myths that only serve political purposes. Ibn al-Haytham was a great medieval scholar, so it is not necessary to attribute to him the fatherhood of milestones he did not achieve. Secondly, commemorating Ibn al-Haytham in the Year of Light has been a great idea, although included in its core is an orientalist paradox. It seems that the *Book of Optics* was written around 1015, but in fact the actual date is unknown. Besides, the celebration of a thousand years from 1015 also denotes a Christian way of measuring time. Indeed, the year 1015 AD corresponds to the years 405/406 of the Hijra. Moreover, this is not the first Ibn al-Haytham 1000th anniversary, as the first took place in Karachi and Lahore from 1st to 10th November 1969 [20].

All civilizations (either Arab-Islamic, Chinese or Maya, for instance) have contributed in one way or another to the progress and development of science. Throughout the centuries these contributions have been—or are still—irregular, but also essential to human knowledge. To construct a barbaric “Other” in opposition to a rational and scientific “We” is an absolute mistake, and the figure of Ibn al-Haytham, like many others, shows why.



Fig. 2. (A) Iraqi dinar with the inscription “Al-Alim al-Arabiyy al-Hasan bin al-Haytham” (the Arab Scientist al-Hasan bin al-Haytham) by the National Bank of Iraq. [Source: <http://banknote.ws/COLLECTION/countries/ASI/IRQ/IRQ0071.htm>]. (B) Stamp issued by Qatar in 1971. [Source: <http://jeff560.tripod.com/stamps.html>]. (C) Stamp issued by Jordan in 1971. [Source: <http://jeff560.tripod.com/stamps.html>]. (D) Stamp issued by Malawi in 2008. [Source: <http://jeff560.tripod.com/stamps.html>]. (E) Stamp issued by Pakistan in 1969. [Source: <http://jeff560.tripod.com/stamps.html>].

Ibn al-Haytham (965–1039)

Abū ‘Alī al-Ḥasan Ibn al-Ḥasan Ibn al-Haytham al-Baṣrī al-Miṣrī [24] was commonly known in Latin texts as Alhazen, Avennathan or Avenetan, although it was not until the end of the 19th century when these names were identified with the great Arab physicist. There is scarce information about his life, but his *nisbas* (or demonyms) al-Baṣrī and al-Miṣrī give some clues about him. Al-Baṣrī tells us that he was born in the city of Basra (now Iraq). In that time it was ruled by the Buyid dynasty (934–1062), the royal power under the Abbasid Caliphate. Al-Miṣrī means that Ibn al-Haytham lived in Egypt, where he died.

Ibn al-Haytham studied sciences in Basra and Baghdad

(the capital of the empire) before moving to Cairo. In fact, as a medieval scholar, he had an education that included religion, literature, language, philosophy, mathematics and astronomy, among other disciplines. In Cairo, he worked in the service of the caliph al-Ḥākim (996–1021), who founded the great library *Dār al-‘Ilm*. Cairo was then a new city, founded in 969 near the ancient al-Fustat, the capital of the Fatimids, a Shiite caliphate that lasted more than two centuries (909–1171) in Egypt and North Africa. In fact, at that time, there were three caliphates in the Arab world; the other two were the Abbasid (750–1258), and the Umayyad (929–1031). Although the Abbasid was the central and most important (with its capital in Baghdad), Abbasid caliphs had lost political control over the territory, ruled by several

dynasties (like the above-mentioned Buyids). Western Islam was under the auspices of the Umayyad caliphate of al-Andalus (929–1031) and had a key role in the transmission of scientific and philosophic ideas to the Christendom. It was a time of political fragmentation, but very profitable from a scientific point of view, as it was very easy to find sponsors in the different local elites throughout the territories. In fact, this period is considered the Scientific Golden Age for Islamic civilization.

It should be not forgotten that Arab civilization played an essential role in the circulation and development of ideas and in the progress of knowledge. In the 9th century, Baghdad, with its House of Wisdom, was the center of a translation movement and scientific development designed and promoted by its rulers, especially al-Ma'mūn (ruler between 813 and 833). Following the orders of the caliph, books from China, India and the Byzantine Empire were bought, studied and translated. As a matter of fact, without the Arabic translations, Europe could not have read most of the classics, without which the Renaissance would not have happened. The translation role does not mean, however, that Arab scientists "limited" their contributions simply to transportation or quotation. The evolution of several fields (including astronomy, mathematics, optics, medicine, philosophy or even music) is in debt to essential figures like al-Kindī (801–873; Alkindus in Latin texts) or al-Khwārizmī (ca. 780–ca. 850). A century later, Ibn al-Haytham was not, by any means, an isolated case of scientist, as his contemporaries include the Persian Ibn Sīnā (980–1037; known as Avicenna) or al-Bīrūnī (973–1048) who worked in Ghazna (nowadays Afghanistan).

Ibn al-Haytham is a good example of what a well-rounded education meant in the Medieval Ages: he had solid knowledge of Greek astronomy, philosophy and medicine; thus, he frequently mentions Ptolemy, Euclid or Aristotle as authorities but his originality lies in that he does not follow them blindly. On the contrary, his contributions made essential improvements, especially in the field of optics. Actually, he earned a living by copying the *Almagest* and Euclid's works.

It is very interesting and significant that whether Ibn al-Haytham was Sunni, Shiite or even a follower of another religious division it is not known. Contrary to what is often believed, dividing the Muslims into different incompatible groups is a very contemporary approach to Islam. Of course, this does not mean that specific conflicts were explained as religious conflicts, but it was a long way from reality or, at least, was not a "natural" nor a "historical" cause. For

centuries, the "religions of the Book", and of course the different sects of Islam, have been worshiped in the Islamic world under the protection of the law in force.

A modern scientist

One of the characteristics that make Ibn al-Haytham a modern scientist is that his scientific method was characterized by experimentation, i.e., he always tried to prove what he wanted to demonstrate.

Once in Cairo, he tried to regulate the flow of the Nile River and, following the legend of Ibn al-Qiftī (ca. 1172–ca. 1248), he pretended to have a mental illness to avoid prison (or a death sentence) from the Caliph when he failed to find a proper solution. It is well known that the Nile River flooded its banks every year, which was excellent for agricultural purposes, but it had negative consequences when the flood level lowered. Ibn al-Haytham believed he could build a dam to control it, but he realized he lacked the technical means to do it. Moreover, when he was there, he assumed that if it were possible, the architects of the Pharaohs would have built it. So he hid to avoid the Caliph al-Ḥākim's anger, which gave him time to write his more important works. Curiously, the place where he was going to build the dam is the location of the present-day Aswan Dam, designed by Sir William Willcock in 1902.

In the mid-13th century, the great physician and biographer Ibn Abī 'Uṣaybī'a included Ibn al-Haytham in his *Lives of the Physicians (Uyūn al-Anbā' fī Ṭabaqāt al-Aṭibbā)* [4], listing more than ninety of his works. A prolific author, Alhazen wrote more than one hundred books, most of them about mathematics, astronomy or optics, as well as about logic, philosophy and medicine [12], although most of the latter appear to be lost, while others are known through translations.

Some of his most relevant scientific books are the *Book on the Configuration of the World (Maqāla fī hay'at al-'ālam)*, a cosmography of the Universe that had a major influence on authors such as Ibn Rusd (1126–1198; known as Averroes) and also outside the Arab world, thanks to its Latin and Hebrew translations [5]; the *Book on the Light of the Moon (Maqāla fī daw' al-qamar)*, on light, colours and celestial movements; *Book on Parabolic Mirrors (Maqāla fī marāyā l-muḥriqa bi l-quṭu')* [6]; *Book on the Form of Motions of Each of Seven Planets (Maqāla fī hay'a ḥarakāt kull wāḥid min al-kawākib sab'a)*; *Book on the Properties of the Circles (Maqāla fī khawāṣṣ al-dawā'ir)*; *Discussion on the Light of*

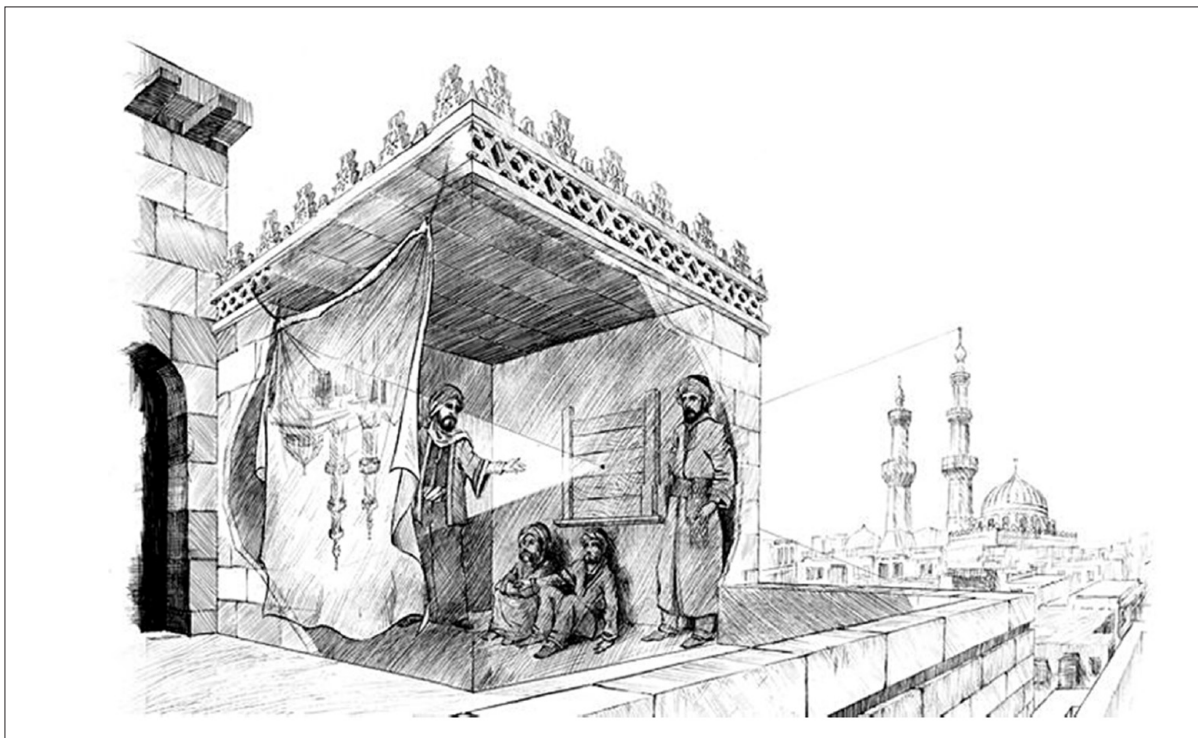


Fig. 3. The principles of the device *Al-bait al-muẓlim*, translated into Latin as *Camera obscura*. [Source: <http://www.ibnalhaytham.com/discover/who-was-ibn-al-haytham/>]

the Stars (Qawl fī aḍwa’ al-kawākib); and *Discussion on the Property of Shadows (Qawl fī kayfiyya al-aẓlāl)*. He also wrote a treatise on magic squares and made some contributions to commercial mathematics [25].

Ibn al-Haytham made several important discoveries in the field of mathematics. He neatly resolved the problem of al-Mahanī, a Persian mathematician of the 9th century, that tried to solve the Archimedean problem (i.e., to divide a sphere by means of a plane into two segments being in a given ratio of volume). And it is thanks to Ibn al-Haytham that we know the Book VIII of the *Conics* of Apollonius of Perga (ca.262–ca.190 BC). Being one of the fundamental works of ancient Greek geometry, this seminal book appeared to be lost until a manuscript was discovered in Turkey around 1970, with Ibn al-Haytham’s *Completion of the Conics*, in which he reconstructed Apollonius’ work [3]. In the *Book on the qibla (Maqāla fī istikhraj samt al-qibla)*, devoted to obtaining the direction of Mecca, he established the theorem of the cotangent [1]. Finally, he resolved what is known today as “the Alhazen problem”.

In the *Book on the Image of Eclipses (Maqāla fī ẓurat al-kusūf)*, he mentioned the use of a dark chamber (Fig. 3). The Arabic expression *al-bait al-muẓlim* was translated into Latin as *camera obscura*, and it has been used often to cite

him as one of the forefathers of photography. In spite of his contribution to the field, he was not the first to use the aforementioned mechanism, which entails observing the image of an object through a hole.

Optics, al-Haytham’s main contribution

Ibn al-Haytham’s most important work is the *Book of Optics (Kitāb al-manāẓir)*, commented on by, among others, al-Farīsī (?–1320). Its main aim is to clearly surpass Euclid and Ptolemy. The text was widely known in Medieval Europe due to a Latin translation made in the 12th–13th century, *De Aspectibus*. In fact, it also had indirect influence mainly through Jean Peckham, Thierry de Fribourg, Vitellius (who made a paraphrase of the seven volumes of the book) and Roger Bacon [26]. Although there were some previous studies [7–9], it was not until the end of the 20th century when the seven volumes of the Arabic text were edited, translated and studied properly by Prof. Abdelhamid I. Sabra (1924–2013) [2,17,19]. And it was not until the beginning of the 21st century that an in-depth work on the Latin version of the *De Aspectibus* [22,23] was published.

The *Optics* is divided into several sections: (a) on the

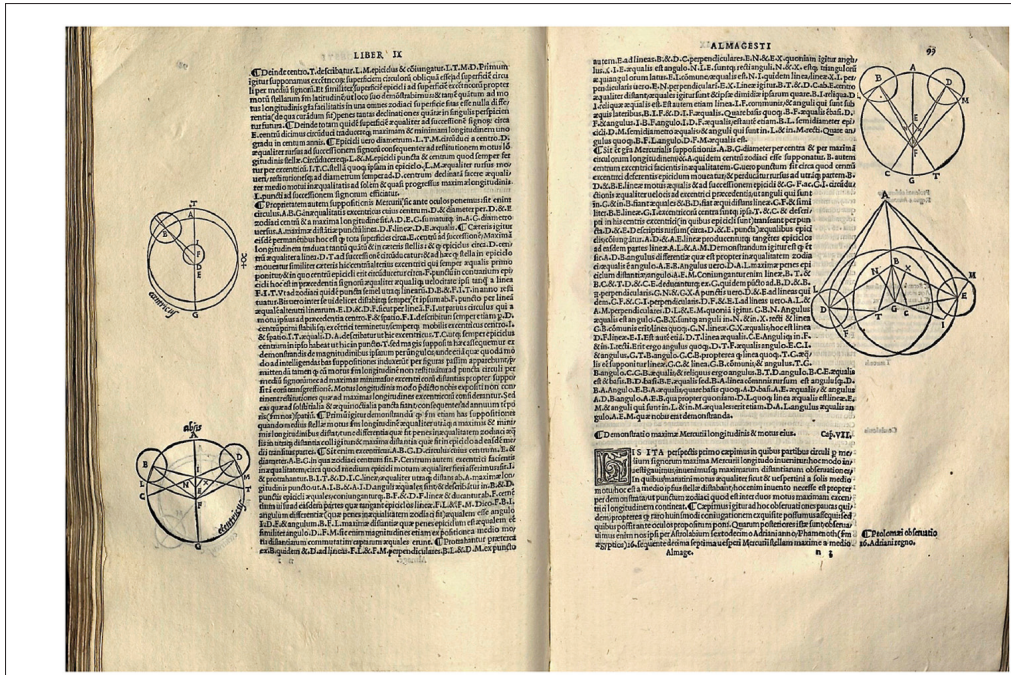


Fig. 4. Two pages of Book IX of Ptolemy's *Almagest*.

manner of vision in general; (b) on the visible properties, causes and perceptions (distance, shape, size, number, motion, etc.); (c) on errors of vision and their causes; (d) on reflection of light; (e) on problems and solutions of images created by reflection; (f) on optical illusions by reflection; and (g) on refraction of light. An experimental researcher, Ibn al-Haytham practiced dissection on the eye in order to obtain a complete description of it. Crystalline, aqueous humor, vitreous humor and retina are names Ibn al-Haytham gave to this body part that we still use today.

Thanks to Ibn al-Haytham, the debate between extramission and intromission theories was over. For centuries, scientists such as Plato, Aristotle, Euclid, Ptolemy, al-Kindī, al-Bīrūnī and Ibn Sīnā (Avicenna) tried to explain how vision was produced. The first theory, extramission, claimed that the eye radiated rays that were the source of the vision. On the contrary, intromission theory stated that it was the eye that received the rays. Ibn al-Haytham's experimentation confirmed that sight required light rays—but also an eye without physical problems and, even more importantly, a brain that played an essential role on the final result. Thanks to his research based on a physical conception of sight, he could explain how the eye moves and how binocular vision functions [11]. Even though extramission was refuted by Ibn al-Haytham, as it has been mentioned, G.A. Winer [27] found that 50% of American college students still believed in extramission theory.

After *Optics*, Ibn al-Haytham wrote *Doubts about Ptolemy* (*Shukūk 'alā Baṭlamyūs*), in which he questioned Ptolemy (*Almagest*, *Planetary Hypotheses*, and *Optics*) [14]. The book includes doubts posed by Abū al-Qāsim ibn Ma'dan to Ibn al-Haytham; in it he tries to establish why Ptolemy was wrong in his understanding of the enlargement of celestial magnitudes, or the moon's parallax, among other subjects [18] (Fig. 4). But he was not the last of the link in the chain, because the Andalusian Ibn Bajja (1070–1138: known as Avempace, in turn, criticized *Doubts about Ptolemy*, claiming that Ibn al-Haytham lacked deep knowledge of astronomy [21].

Circulation of *Optics* was irregular. In al-Andalus, for instance, it was not introduced until the second half of the 11th century. On the other hand, the *Liber de crepusculis et nubium ascensionibus* was attributed to Ibn al-Haytham by mistake until it was identified correctly as one of Ibn Mu'adh al-Jayyānī (989–1079) works, translated by Gerard of Cremona (1114–1187) [15].

To conclude it seems appropriate to include a sample of Ibn al-Haytham innovative research by his explanation of the “moon illusion” included in the Book VII of *Optics*. In the very last chapter, devoted to the “errors of sight” due to refraction, he introduces a psychological explanation of the phenomenon that makes things appear larger at the horizon than at higher positions:

“We say: It has been shown in Book II of this work, in our discussion of size, that sight perceives size from the magnitudes of the angles subtended at the center of the eye and from the magnitudes of distances of the visible objects and from comparing the magnitudes of the angles to those of the distances. [...] We showed there, too, that when sight fails to ascertain the distance of an object, then it makes a guess in regard to the distance’s magnitude by likening it to the distances of familiar objects at which it can perceive objects similar to that object in form and figure, then perceives the size of that object from the magnitude of the angle subtended by it at the eye-center as compared to the distance it has conjectured. But the distances of the stars do not extend along near bodies. Sight does not, therefore, perceive or ascertain their magnitudes, but merely conjectures their magnitudes by assimilating the stars’ distances to the distances of very remote earthly objects which it can perceive and whose magnitudes it conjectures. [...]

The enlargement of heavenly objects at the horizon may frequently have another cause. This cause occurs when a thick vapor stands between the eye and the star positioned at or near the horizon, if the vapor is at or near the horizon and does not continue to the middle of the sky but rather forms a section of a sphere whose center is the centre of the world because it surrounds the earth. If such a section terminates before [reaching] the middle of the sky, then the surface of it that faces the eye will be plane. But if the surface of the vapor facing the eye is plane, then the form[s] of the stars (and intervals between them) will be seen behind the vapor as larger than before the vapour occurred (Sabra: 237–238)” [16].

Ibn al-Haytham was a great scientist, but he was also the last innovator in the field of mathematics in the Arab world [10]. From him on, progress should follow another way. The theory of optical reflection and refraction he founded in the 11th century was developed by Descartes (1596–1650) and transformed by Newton (1643–1727), thanks to whom it reached a terminal point [13].

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