“De oculis”, a chapter on ocular anatomy by Constantinus Africanus

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Abstract

Purpose: The publication of the compendium Pantegni by Constantinus Africanus in the monastery of Monte Cassino in the eleventh century CE was a pivotal moment in the history of medicine in Western Europe. The work is predominantly based on the Liber regalis by Haly Abbas (Baghdad, tenth century CE). The earliest available manuscript of the Pantegni (KB 73 J6) is handwritten and has been supervised by Constantinus himself. It includes a chapter on ocular anatomy. In this paper we try to distill the anatomic description by Constantinus.

Methods: The chapter “de oculis” on ocular anatomy as found in chapter 13 of book 3 in KB 73 J6 is interpreted in the historical context and translated into Modern English.

Results: We present an English translation of the concerning chapter.

Conclusion: Constantinus bequeathed a compact but comprehensive account of the anatomy of the eye, which can be rendered into a contemporary representation with use of the historical context.

Keywords

Pantegni; Constantine the African; anatomy, history; ophthalmology, history.

Introduction

The history of European medical knowledge has a turning point in the middle of the eleventh century CE. A significant role at this moment has been played by Constantinus Africanus, the first translator of medicine from Arabic to Latin. He produced more than 30 different texts, whereas in the three ages before in Western Europe in total only about 70 different medical texts circulated with only minor impact (Glaze, 2019). One of the texts by Constantinus Africanus is the Pantegni, which reached an impressive circulation and remained influential for ages (Green, 2018). In the Royal Library of The Hague lies the oldest available version of the Pantegni (KB 73 J6).

Recently, more and more about this specific parchment manuscript has been elucidated (Green, forthcoming; Hogewind and Coebergh, 2021; Kwakkel and Newton, 2019). KB 73 J6 is written by known Cassinese scribes, supervised by Constantinus himself. He based this work predominantly on the Arabic medical compendium Al-Kitāb al-Malakī (Latinized name Liber regalis; Figure 1) by ‘Ali ibn al-’Abbas al-Majusi (Latinized name Haly Abbas, Baghdad, tenth century CE), although he did not refer to Haly...
Figure 1. Digitalised scan of chapter 13 from book 3 of the Al-Kitāb al-Malākī by ‘Ali ibn al-‘Abbas al-Majusi, Leiden University Library, Or. 94 a, 176-180. The scanned manuscript is an undated paper copy, written in the 13th century (Voorhoeve, 1980; Witkam, 2007).
Abbas (Zargaran et al., 2013). In order to evaluate the extend of the impact of the *Liber regalis*, Russell (1994) extensively studied how Haly Abbas addressed the ocular anatomy. She thereto analyzed part 1, discourse 3, chapter 13 in the Arabic text as edited by de Koning (Majūsī, 1903) and exposed the underlying distinguishing concepts of ʿAbū Zayd Ḥunayn ibn ῾Īshāq al-ʿIbādī (Latinized name Johannitius, Baghdad, ninth century CE [Dalfardi et al., 2016]) and Galen (Rome, second century CE [Laios et al., 2016]). The purpose of this paper is to elucidate what Constantinus wrote on ocular anatomy.

**Materials and methods**

We accessed the *Pantegni*, manuscript KB 73 J6, via the website of the Royal Library of the Netherlands and we transcripted book 3, chapter 13 (Africanus, circa 1080c). In cases where legibility was impaired because of the handwriting, abbreviations or wormholes, we used as cross-reference the transcription of another manuscript of the *Pantegni*, which has been dated back to the same era (Kaltio, 2011 and 2020). Hereafter we distilled the content and translated the text into Modern English.

**Results**

Figure 2 shows a scan of the relevant chapter. Below we respectively depict the transcription in Latin and the translation of the text.

![Figure 2. Digitalised scan of chapter 13 “de oculis” from book 3 of the medieval parchment manuscript *Pantegni*, Dutch National Library, KB 73 J6, folio 15v and 16r. Written around 1080 AD under supervision of Constantinus Africanus in the abbey of Monte Cassino, Italy (Kwakkel and Newton, 2019).](image-url)
Chapter 13, about the eyes

The eyes are the instruments of vision. There are two of them, so that if one were to suffer, the other can take over. Each of the two consists of ten components: three humours and seven tunics. Yet not all realize vision, only one does; all other parts are supportive elements.

The only instrument we use to see is a humour, not quite spherical since its surface is somewhat flattened, and which is clear and shining as crystal. This fluid is called cristalleidos, by its Greek name. It is situated in the middle of tunics. It is somewhat spherical, making it less susceptible to damage. Its surface is a bit flattened, so as to better encompass all that is to be perceived. Moreover, if it was spherical all-around, it would be unstable and not firmly fixed in place. The cristalleidos is clear and bright, enabling it to quickly change into the different colours confronting it; it is centred between tunics so as not to lack the support from the surrounding structures.

The cristalleidos itself is covered by two humours and seven tunics. Of these humours one, situated behind the cristalleidos, is very clear, translucent as molten glass is; it was made like this by nature to nourish the cristalleidos. Whereas other parts of the body are nourished by the blood, the cristalleidos is an exception, nature has made the humor vitreus to receive blood, change it into the essence of the cristalleidos and so, altered and purified, to deliver it to the cristalleidos as a clear fluid.

The other humour is situated in front of the cristalleidos, to prevent it becoming desiccated by the air. This fluid is clear and whitish and is being compared to albugo ovi [egg white]. It is called euagaidos. Its second function is to prevent a rough contact of the cristalleidos with the tunic. Of the seven tunics three find themselves in front of the
De oculis by Constantinus Africanus


Blood coming from veins and arteries out of the retina, is provided to the humor vitreus. Since the humor vitreus and the cristalleidos are devoid of veins and arteries, they attract blood by suction. The humor vitreus from the rete, and the cristalleidos from the humor vitreus. Both the meninges of the nerves are from the two meninges of the brain. Of these the thinner covers the rete and is attached to it where the rete is attached around the cristalleidos. This layer serves to nourish the rete by the veins, and to supply natural warmth by the arteries. This tunic is also called the secundina, just as the pia mater from which it originates, is sometimes called secundina [second brain covering [Gerard Baader 1967]]. This secundina is covered by a fairly thick coat, which is tightened where it joins with the secundina and the rete. This layer was needed to keep the eyes located as well as to protect them from the hardness of the bone. It is called scliros.

He sunt postremę tunice, perfectissime sibi et uitreo humorus atque cristalleido solidate inmedio. Qui locus uocatur yreus, quia in colorum diuersitate ei assimilatur, et incircuisionibus.

These are the posterior tunics, they are firmly connected with one another and with the humor vitreus and the cristalleidos, exactly halfway [at the equator]. This spot is called yreus, because in its variety of col-
Three more tunics are positioned in front of the euagaidos. One of these veils the albugineus and its form is that of the inside of a grape. It is smooth anteriorly and it’s furrowed inside lies against the albugineus. The colour is in between black and blue. It is called uvea and originates from the secundina. This structure has three supportive functions. One is to nourish the cornea, to which end the uvea contains multiple veins. The second function is to keep the cornea separated from the cristalleidos, so as to prevent the cornea being injured by the hardness of the cristalleidos. For that reason the area needs to be moist. The third function is to ensure, by its blackness, to keep the spiritus visibilis (on the use of spiritus visualis and spiritus visibilis see Russell [1994]) collected so that it does not get scattered by the air. After all, black is the colour in which by nature all light comes together, whereas it is scattered by white.

Therefore, if too much light hampers vision, one closes the eyelids a bit, so only a little vision effuses from the uvea, after which the spiritus visibilis emerges amplified. For that reason nature has provided an abundance of light in the cavity that is formed by the uvea. Since it is perforated, the spiritus visualis can directly exit to reach the perceived object. The uvea is furrowed, so that if water descends to the eyes, it swallows it.
at. Dura, atque subtilissimam esse oportebat.

Coniuntiua tunica subtilis est, et alba inomnibus oculi lateralibus solidata, non operiens corneam sed circumdatis. Hec illa est albedo quæ uidetur in oculo et exiens apanniculó, qui inter cutaneus suppositus est cráneo. Eius necessitas, quia undique ossibus oculum circumligat, et lacertos operit quibus mouentur oculi.


Hæ sunt omnis oculi partes. Tres humo-

re, vitreus, cristallinus, et albugineus. vii. tunice Rete, secundina atque dura araneę tela, uvea, cornea, et conjunctiva.

ed to protect the cristalleidos from external injury. It is clear and transparent, and to avoid any loss of the spiritus visualis to the outside, it needs at the same time to be hard and very delicate.

The coniunctiva has a fine structure and is white, everywhere firmly attached to the sides of the eyes, including around the cornea, but not covering it. It is the white of the eyes that one sees, which derives from the membrane underneath the skull. It’s function is that it binds with the bone all around the eye, additionally it covers the muscles by which the eyes are moved.

These are the three tunics positioned in front of the albugineus ovi. The seventh tunic is very delicate and lustrous, and of a bright white colour. It is placed underneath the albugineus ovi. It covers only that part [of the cristalleidos] that ought not to be touched by the humor vitreus. It is called tela arachnoidea [spider’s web] since it very much resembles it. This [the tela arachnoidea] is what we see in the eye, every time we watch in a mirror. It is of the most transparentness and is dissolved even by the brightest light.

These are all parts of the eye. Three humours: humor vitreus, cristalleidos and albugineus. Seven tunics: rete, secundina, dura, tela arachnoidea, uvea, cornea and conjunctiva.
Discussion

First of all, the interpretation of ancient texts is a hazardous challenge, requiring a thorough historical comprehension (Hogewind et al., 2013). However in the recent years ample insights have been gathered on the setting and the period that Constantinus supervised the writing of this specific manuscript KB 73 J6 (Hogewind and Coebergh, 2021; Kwakkel and Newton, 2019). Nonetheless, although we attempted to choose the most accurate Modern English words for anatomical terms in the translation in order to obtain a contemporary rendering, the right historical interpretation of words like blood, nerve, meninx, orbit, artery, vein, eyelid, skull and muscle remains of course an important caveat.

As to the form, Constantinus identifies two cerebral meninges around the optic nerve and describes the eyeball as an elongation of these membranes which envelope three so called humours (humor vitreus, cristalleidos and euagaidos). The outer meninx or dura mater continues as the scliros, which on its turn continues as the cornea. The inner meninx or pia mater perpetuates as the secundina till the equator of the eye and is perpetuated as the uvea anteriorly of the equator. The optic nerve itself prolongates within the eyeball as the rete encompassing only one humour: the humor vitreus. Rete, secundina, scliros and humor vitreus are intertwined with each other at the circumference of the cristalleidos. This junction lies at the equator of the eyeball and is called yreus (De Konig, 1903). (Note that Constantinus positions the cristalleidos in the centre of the eye, whereas the crystalline lens is located more anteriorly [Leffler et al., 2016]). Anteriorly of the cristalleidos is the euagaidos and the two are separated by a thin membrane called tela arachnoidea. Anteriorly the euagaidos is covered by the uvea. The frontal outside of the eye is formed by the cornea (which is the continuation of the scliros as described above). The sides of the eye are wrapped together with the extraocular muscles by the white conjunctiva, which tightens the eye to the orbital bones.

To understand what Constantinus writes on the function of the eye and its parts, it helps to read discourse 4, chapter 11 “de virtute visus” (Africanus, circa 1080d). Here Constantinus describes the concept that eyesight is realized by the spiritus visibilis which arises in the ventricles of the brain and travels through the hollow optic nerves to the cristalleidos. By effusing this spiritus visibilis, the cristalleidos makes contact with the object that is seen and subsequently changes itself in the objects colour, after which the conceptualized consciousness in the brains ventricles perceives this colour and intrinsically the form of the object (Ierodiakonou, 2014; Russell, 1994).

With this background information we can distill that Constantinus explains that the spiritus visibilis travels from the ventricles of the brain through the hollow optic nerves via the rete (which is a prolongation of the optic nerve) to the cristalleidos and then through the euagaidos and the perforation (or pupil) in the uvea through the cornea to make contact with the visualized object (Jordan, 1990; Reeves and Taylor, 2004; Salmón, 1996). Subsequently the clear cristalleidos adapts to the colour which is perceived by the effused spiritus visibilis.

Constantinus meticulously explicates the efficiency of the eye handling the spiritus: the spherical lens is somewhat flattened to maximize the passage of spiritus visibilis, the cornea prevents leakage of spiritus visibilis, the dark colour of the uvea facilitates storage of the spiritus visibilis within the eyeball and in case of bright light the palpebral aperture is decreased (de Konig, 1903).
Constantinus also addresses the blood supply. The ocular blood vessels stem from the cerebral pia mater’s vessels, enter the eye in the secundina and continue in the uvea and in the rete. Constantinus distinguishes arteries and veins, which are required for

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**Table.** Etymological origins for ocular anatomical names as used by Constantinus Africanus in the *Pantegni*, book 3 chapter 13 (Africanus, circa 1080c).

<table>
<thead>
<tr>
<th>Name by Constantinus Africanus</th>
<th>Constantinus’ etymological explanation</th>
<th>Greek word as used by Galen in <em>De usu partium</em></th>
<th>Rendering in the contemporary anatomical equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gelaidon</td>
<td>sicut uitri liquor</td>
<td>τὸ υαλοειδὲς υγρόν$^\circ$</td>
<td>vitreous body</td>
</tr>
<tr>
<td>Humor vitreus (synonym for gelaidon)</td>
<td>sicut uitri liquor</td>
<td>τὸ υαλοειδὲς υγρόν$^\circ$</td>
<td>vitreous body</td>
</tr>
<tr>
<td>Cristalleidos</td>
<td>lucens sicut cristallus uocatur cristalleidos</td>
<td>τὸ κρυσταλλοειδὲς υγρόν$^\circ$</td>
<td>crystalline lens</td>
</tr>
<tr>
<td>Euagaidos</td>
<td>albus oui albugini assimilator</td>
<td>τὸ ώσειδὲς υγρόν$^\circ$</td>
<td>aqueous humour</td>
</tr>
<tr>
<td>Albugineus (synonym for euagaidos)</td>
<td>albus oui albugini assimilator</td>
<td>τὸ ώσειδὲς υγρόν$^\circ$</td>
<td>aqueous humour</td>
</tr>
<tr>
<td>Rete</td>
<td>ex retis tantum similitudinem$^\circ$</td>
<td>ὁ ἀμφιβληστροειδῆς χιτῶν$^\circ$</td>
<td>retina</td>
</tr>
<tr>
<td>Secundina</td>
<td>sicut et mater pia unde processit est uocata$^\circ$</td>
<td>ὁ χοριοειδῆς χιτῶν$^\circ$</td>
<td>choroid</td>
</tr>
<tr>
<td>Scliros</td>
<td></td>
<td>ὁ σκληρὸς χιτῶν$^\circ$</td>
<td>sclera</td>
</tr>
<tr>
<td>Dura (synonym for scliros)</td>
<td></td>
<td>ὁ σκληρὸς χιτῶν$^\circ$</td>
<td>sclera</td>
</tr>
<tr>
<td>Tela arachnoidea</td>
<td>quia ipsi est simillima</td>
<td>ὁ ἀφαχνοειδῆς χιτῶν$^{\circ,%}$</td>
<td>anterior lens capsule</td>
</tr>
<tr>
<td>Uvea</td>
<td>cuius forma est uue medietas</td>
<td>ὁ ϰαγοειδῆς χιτῶν$^\circ$</td>
<td>iris</td>
</tr>
<tr>
<td>Coniunctiva</td>
<td></td>
<td>ὁ κεφατοειδῆς χιτῶν$^\circ$</td>
<td>cornea</td>
</tr>
<tr>
<td>Coniunctiva</td>
<td>quia in colorum diuersitate ei assimilatur, et incircutionibus</td>
<td>ή ἴρις</td>
<td>conceptualized region near the ciliary body</td>
</tr>
</tbody>
</table>
supplying the ocular parts with respectively natural warmth and nutrition. The clear cornea is lacking blood vessels but is nourished by the *uvea* veins. The *humor vitreus* transforms the blood from the *rete* vessels in a clear fluid to supply the transparent non-vascularized *cristalleidos*.

A lot of attention goes to the vulnerability of the most precious part of the eye: the *cristalleidos*. It is not spherical all-around preventing it to be unstably attached and anteriorly it is covered by the *euagaidos* which prevents its dehydration (and protects the *cornea* against the hard *cristalleidos*). Finally, the *cristalleidos* is protected by the *cornea* from trauma.

Introducing the anatomical names of the ocular components, Constantinus also supplies us with the etymological information wherever it is applicable. In this context the analysis by Baader (1967) is of much interest: he discusses elaborately which of the names are derived from the Greek terms that are already used by Galen. In the table we depict the etymological explanations by Constantinus, add the Greek terms as used by Galen and render the anatomical names into a modern anatomical equivalent.

One sentence about the tunic which has been called *uvea* forms an enigma; what was meant by “Est et uillosa, ut aquam ad oculos descendentem combibat.”? Haly Abbas mentions couching/cataract operation in this context (Majūsī, 1903; Russell, 1994), but the couching is not mentioned by Constantinus in this chapter. Haly Abbas’ text is later also translated from Arabic to Latin by Stephanus Antiochenus (Majūṣī, 1492). Stephanus writes here: “Facti que sunt in ea ab interioribus vil-luli: quibus aqua que ad oculos veit suspendit.” It appears that Constantinus (and Stephanus) describe(s) a physiological phenomenon, which might be hampered in the pathological condition of *cataracta* (Africanus, circa 1080a and circa 1080b; Fischer, 2000; McVaugh, 2001).

We compared our translation with the interpretation of Haly Abbas’ corresponding text by de Koning (Majūṣī, 1903) and by Russell (1994). With respect to the content and the outlay, the description of Constantinus is almost exactly the same as what de Koning (Majūṣī, 1903) and Russell (1994) distilled from the text by Haly Abbas. Constantinus specifically did not add any content or add new insights.

In conclusion, Constantinus bequeathed a compact but comprehensive account of the anatomy of the eye, which can be rendered into a contemporary representation with use of the historical context.

**References**


De oculis by Constantinus Africanus


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