

Supplementary material

The Early History of Glaucoma: The Glaucomous Eye (800 BC to 1050 AD)

Christopher T. Leffler, MD, MPH
Stephen G. Schwartz, MD, MBA
Tamer Hadi, MD, PhD
Ali Salman
Vivek Vasuki, MD

Bold type represents information not found in the printed text. This supplement also contains the specific page relevant to each book reference.

Glaucomous, and other ancient colors.

In 1858, William Gladstone, the former British prime minister, published his analysis of the use of color terms in Homer's writing (Berlin 1991, p 134). In the Iliad, Homer repeatedly described the goddess Athena as γλαυκῶπις (**Iliad 1.206**), and once described the sea as γλαυκή (**Iliad 16.34**, Maxwell-Stuart 1981, vol. 1, **p. 90**)

The term χλωρός (kloros), representing the green of vegetation (Clarke 2003, p. 274; Cleland 2004, pp. 131-9; Irwin 1974, pp. 31-78), and from which the English words chlorophyll and chlorine are derived, described young leaves, honey, and sand.(Berlin p 70-71) One interpretation is that *kloros* referred not only to green, but also to its spectral neighbor yellow, as there was less distinction between green and yellow during this period (Bradley 2009, p. 14; Cleland 2004, pp. 131-9; Irwin 1974, pp. 31-78), or indicated other properties typical of vegetation, such as moistness, or freshness (Cleland 2004, pp. 131-9; Clarke p. 146; Edgeworth 1992 p. 251-3; Irwin 1974, pp. 31-78). The cognate of cyan, κυανοχαίτης, typically used as a dark color, or blue, was used to describe the beard of Poseidon (Iliad 13.563, 14.390) (Clarke 2003, p. 148; Irwin 1974, pp. 79-110). Interpretations have included that the brightness was the salient characteristic, with *kloros* representing pallor, and *kuanos* representing darkness (Irwin 1974, pp. 31-110). Gladstone was particularly struck by the paucity of color terms relative to the abundance of descriptions of darkness and lightness, and actually concluded "...that the organ of color and its impressions were but partially developed among the Greeks of the heroic age". (Berlin 1991, pp. 134-5)

Missionaries, colonial officials, and other travellers were given color chips and a questionnaire to learn the color names used by 61 indigenous peoples from every inhabited continent (Berlin 1991, **pp. 139-140**). Magnus concluded in 1880: "Linguistic expressions for long wave colors are always much more sharply defined than those for short wave colors...The most usual mixing is that of green with blue...it often occurs that the colors of shorter wavelength are united with the linguistic concept of dark or indefinite. Blue and violet (and even green) are designated black or grey." (Berlin 1991, **p. 145**)

Modern scholars have concluded that “there appears to be a fixed sequence of evolutionary stages through which a language must pass as its basic color vocabulary increases.”(Berlin 1991, p. 14) In general, terms for white, black, and red precede the introduction of terms for (and distinction of) green, yellow, and blue.(Berlin 1991, p. 4) According to some scholars of English, blue was used more expansively and encroached upon its spectral neighbors violet and green until the eighteenth century (Cleland 2004, p. 41) .

For instance, Biblical Hebrew contains many color terms, such as *tekhelet*, translated as blue, *argaman* translated as purple, and *tolaat shani*, translated as scarlet (Cleland 2004, p. 40). In fact, the King James translation of the Bible contains all the basic color terms of Berlin and Kay except pink and orange (Berlin 1991, p. 3), based on our review of every Biblical mention of the eye. Therefore, this translation reflects the final stage (VII) of color language evolution, according to the system of Berlin and Kay (1991, p. 21).

**“Woe to the idle shepherd that leaveth the flock!...his right eye shall be utterly darkened.” (Zechariah 11:17),
“The light of the body is the eye.” (Matthew 6:22),
“in the twinkling of an eye” (Corinthians 15:52)**

In 1822, the reviewer of a novel which described a dwarf as having “large, green, goggle eyes” noted “...we endeavoured, for some moments, to conceive what like a green eye might be; and we had almost decided that the author had given this colour to the Dwarf’s eyes, merely to distinguish them from the eyes of all other mortals.”(Hibbert 1822, p. 307)

This concept seems to apply to the classical period. The Greeks had terms for the green of plants--e.g. *kloros*,(Clarke 2003, p. 274) as discussed above. In addition, *prasinos*, the color of the leek, was used by the philosopher Aristotle (Maxwell-Stuart 1981, vol. 1, p. 165), and is the modern Greek term for green.

They strongly associated old age and disease with dryness, and youth and vitality with moisture (Irwin 1974, pp. 33-42). *Kloros*, the color of lush vegetation, represented moisture and therefore youth (Irwin 1974, pp. 31-78).

Similarly, in Latin, the terms *virido* (Clarke p. 144-6) or *viridis* (Clarke p. 146-51; Edgeworth 1992 pp. 165-172) for the green of vegetation do not seem to have been applied as descriptions of eye color. **The playwright Plautus did refer to *oculis herbeis* (grassy eyes) (Hibbert p. 307; Bradley 2009, p. 125), but this was a single use offered for comedic effect. This term was thought to refer to the character’s sickly condition, and the color of his theater mask (Bradley 2009, p. 125).**

But *vitreus*, as a color term, is typically interpreted to be a greenish hue (Clarke p. 151; Edgeworth 1992, p. 168). The reason is that ancient or Roman glass was typically

green, due to contamination by iron.(Maxwell-Stuart 1981, vol 1, p. 81) Sometimes, the glass was blue-green (Clarke p. 151), blue, amber, or other colors, depending on contaminants and additives. Moreover, the glaucous hues could have overlapped with the glassy hues. **Antiphilus of Byzantium** (c. 1st century AD) described a glass bottle as γλακῆς (Maxwell-Stuart 1981, vol 1, p. 80). Apsyrτος of Bithynia (fl. 3rd century A.D) wrote: “When γλαύκωμα occurs, lancing is useless because [the disease] is incurable. It is a result of a so-called glazing of the eye (ύάλωμα, [glassy disease]) rather like a λευκη pebble.” (Apud Hippiatrica Berolinensia 11.1, Maxwell-Stuart 1981, vol. 1, p. 26).

Whether the term originated before Homer with the sea or with eye color is a matter of conjecture (Maxwell-Stuart, 1981, vol. 1, p. 145).

We also can surmise that glaukos eyes were light colored by their repeated association with visitors from a Northern climate, with blond (*xanthos*) or reddish hair, and with a pale complexion (Maxwell-Stuart 1981, vol. 1, pp. 108,110,115,116, 134).

We see its use to describe woad dye, lapis lazuli, and topaz (Maxwell-Stuart, vol. 1, pp. 150-5). **Plato’s statement that “Κυανοῦ [cyan] mixed with λευκῶ [white] is λγαυκόν”** (Timaeus 68c, Maxwell-Stuart, 1981, vol. 1, p. 70) **would seem to support the notion that *glaukos* represented light blue. On the other hand, *kyaneos* was used in verse to represent the hues of darker eyes,**(Irwin 1974, pp. 79-110) **and might have encompassed a broader spectral range than simply blue** (Bradley 2009, p. 37; Irwin 1974, pp. 79-110).

Usually, the term applied to the olive leaf or branch, but also to the Greater Celandine, or perhaps the Horned Poppy (*Glaucium flavum*), the laurel, the elder, and grapes (Maxwell-Stuart 1981, vol. 1, pp. 150-5).

Some have suggested that *glaukos* in the period of Homer suggested merely brightness (Cleland 2004, p. 58, 85), such as “glaring” (Clarke p. 50), with an implication regarding hue coming closer to the Common Era (Clarke p. 50; Cleland 2004, p. 85). However, our analysis of the color uses shows no shift in usage with the Common Era, once one separates prose from verse (Table 2, in Supplement).

***Glaukos* was originally derived from the term ka-ra-u-ko in the script Linear B** (Cleland 2004, p. 64).

Table 2. Number of authors using γλαυκός (glaukos), or related terms, by type of object described, and by era.

	Prose, Before Common Era.	Prose, Common Era.	Verse, Before Common Era.	Verse, Common Era.
Color of Eyes.	14 (74%)	33 (80%)	17 (50%)	6 (32%)
Color of Diseased Eyes.	5 (26%)	7 (17%)	0 (0%)	0 (0%)
The sea (including several authors who described sea gods).	1 (5%)	5 (12%)	12 (35%)	8 (42%)
Plants	0 (0%)	5 (12%)	9 (26%)	5 (26%)
Animals	6 (32%)	2 (5%)	5 (15%)	4 (21%)
The moon.	0 (0%)	1 (2%)	2 (6%)	3 (16%)
Gems.	2 (11%)	0 (0%)	0 (0%)	3 (16%)
Sky (air, dawn)	1 (5%)	2 (5%)	2 (6%)	0 (0%)
Total number of authors.	19 (100%)	41 (100%)	34 (100%)	19 (100%)

The glaucous eye in the Hippocratic era.

Hippocrates wrote that “Pupils which have become γλαυκούμεναι or ἀργυροειδέες [silvery] or κυάνεαι are useless.” (Prorrheticon 2.20-Littré 9.48; Maxwell-Stuart, 1981, vol. 1, p. 57; Magnus 1998, part 1, p. 95). Hippocrates referred to glaucosis as a disease of the elderly: “To olde men doth happen...moistnesse and humidities of the bellie, eyes, and nostrills, dimnesse of the sight, Glaucoma [γλαύκωσις], and dulnesse of hearing.” (Aphorisms III.31.6, Magnus 1998, part 1, p. 95; Hippocrates 1610, p. 51-2).

The philosopher Aristotle (383-322 B.C.) categorized eye colors: “The eyes of human beings show great variety of colour; some are γλαυκοί, some χαροποί [amber], some μελανόφθαλμοι [dark], others αἰγωποί [goat-eyed, yellow].” (De Generatione Animalium 5.1 (779a.35) (Maxwell-Stuart 1981, vol. 1, p. 27; Aristotle 1808, p. 421; Aristotle 1943, pp. 492-495) The eye color was determined by the amount of water in the eye, in the same way that a shallow body of water appears bright, while a deep sea appears dark: “Clear (εὐδιόπτρον) sea-water appears γλαυκόν, that which is less clear, murky (ὑδατωδές), and that through which one cannot see clearly because of its depth, μέλαν and κυανοειδές.” (DGA 5.1, 779b.31; Maxwell-Stuart 1981, vol. 1, p. 28) As mentioned above, Aristotle observed that, “The eyes of all infants are γλαυκότερα immediately after they are born.” (DGA 5.1, 779a.26, Maxwell-Stuart 1981, vol. 1, p. 27) The reason is that the small eye could hold little water: “In children, it is because of the small volume of fluid [that the eyes] appear γλαυκά at first.” (DGA 5.1, 780b.2-3; Maxwell-Stuart 1981, vol., 1, p. 27-8) A pathologic change in color to glaukos in the elderly was also accounted for by a shortage of moisture in the eye: “γλαύκωμα tends to attack those with γλακοῖς eyes...γλαύκωμα is a kind of dryness of the eyes.” (DGA 5.1.780a.15-18, Maxwell-Stuart 1981, vol., 1, p. 28; Magnus 1998, part 1 p. 95)

The glaucous eye in the period of couching.

Celsus offered the interesting theory that eye color derived from the glass-like vitreous: “contained in that hollow is what, from its resemblance to glass [*vitri*], the Greeks call hyaloides; it is humour, neither fluid nor thick, but as it were curdled, and upon its colour is dependent the colour of the pupil, whether black [*niger*] or steel-blue [*caesius*].” (*De Medicina* VII.7.13; Celsus 1938, pp. 346-7)

Caesius, describing a light-colored eye, usually in people (Clarke 2003, p. 49) was often the term used to translate *glaukos* (Maxwell-Stuart 1981, vol. 1, p. 207; Clarke 2003, p. 49; Bradley 2009, p. 231), and in fact, was used to describe Minerva, (Lewis 1915, p. 102; Riddle 1870, p. 76) the Roman counterpart to Athena. *Caesius* eyes have been described in translation as blue, (Evans 1969 p. 36-7, 40; Bradley 2009, pp. 142-3) gray, and occasionally green (Evans 1969 p. 36-7, 40).

Celsus described factors which predicted the outcome of couching (*De Medicina* 7.7.14; Celsus 1938, pp. 348-9):

“...a humour forms underneath the two tunics...and this as it gradually hardens [indurescens] is an obstacle to the visual power within. And there are several species of this lesion; some curable, some which do not admit of treatment. For there is hope if the cataract [suffusio] is small,...if it has also the colour of sea water [marinae aquae] or of glistening steel [ferri nitentis], and if at the side there persists some sensation to a flash of light. If large, if the black part of the eye has lost its natural configuration and is changed to another form, if the colour of the suffusion is sky blue [caeruleus] or golden [auri]... then it is scarcely ever to be remedied. Generally too the case is worse when the cataract has arisen...from severe pains in the head...And in the cataract itself, there is a certain development. Therefore we must wait until it is no longer fluid, but appears to have coalesced to some sort of hardness [duritie].”

Caeruleus was similar to *glaukos* in spectral range: *caeruleus* was generally a blue or gray hue (Lewis 1915, p. 102; Riddle 1870, p. 76; Bradley 2009, p. 10-11), and was used to describe eyes (Lewis 1915, p. 102; Riddle 1870, p. 76) or the sea (Lewis 1915, p. 102; Riddle 1870, p. 76; Clarke 2003, p. 47-49, p. 157; Edgeworth 1992 p. 107-112), but could also be used to describe green objects (Lewis 1915, p. 102; Riddle 1870, p. 76; Clarke 2003, p. 47-48; Bradley 2009, p. 231), such as plants (Oxford English Dictionary 2014; Clarke 2003, p. 49). In comparison with *glaukos*, *caeruleus* might generally be interpreted as a darker hue due to its association with deeper water (Lewis 1915, p. 102; Riddle 1870, p. 76; Clarke 2003, p. 47-48; Bradley 2009, pp. 10-11). On the other hand, *caeruleus* was used to describe the lighter eyes of the Germans (Evans 1969 p. 48; Bradley 2009, p. 11, 142) (as we have seen with *glaukos*). Like *glaukos* eyes in Greece, the lighter eyes of Northern Europeans with *caeruleus* eyes might have negative connotations in Rome, as barbaric or uncivilized (Bradley 2009, p. 11).

Demosthenes Philalethes (fl. early 1st century AD) wrote an influential work *Ophthalmicus*, portions of which survived through subsequent authors, such as Aetius of Amida (Apud Aetium: Libri Medicinales 7.52). (Aetius 2000, p. 84-5; Aetii Amideni 1950, p. 308) In Demosthenes' work, some glaucoma is attributed to pathology of the crystalline humor:

“There are said to be two kinds of γλαύκωσις. Γλαύκωσις in the strict sense of the word is a change toward γλαυκόν because of dryness and coagulation [πῆξις] of the crystalline fluid. The other kind of γλαυκώσεως comes from an antecedent cataract (ὑποχύματος), when the fluid in the area of the pupil is damaged and become extremely dry. It is this type which is incurable.” (Maxwell-Stuart 1981, vol. 1, p. 46-7)

Next, we see in the writings of Rufus of Ephesus (80-150 A.D.) that glaucoma has become firmly associated with the crystalline lens (Fragmenta 116): “...γλαυκώματα are changes in the crystalline fluid altering under the influence of moisture to γλαυκόν...All γλαυκώματα are incurable.” (Maxwell-Stuart 1981, vol. 1, p. 74) Glaucous was also one of the standard eye colors, which was due to the iris (Nomina Corporis,

25): “In accordance with the colour of the iris [Ιριν], one says that [the eye] is μέλανα [black], πυρρὸν [flame-colored, russet], γλαυκόν or χαροπὸν [amber].”(Maxwell-Stuart 1981, vol. 1, p. 74) Rufus’ description of the iris as a rainbow (Ιριν) is the root of the modern term.(Rufus 1879, p. 136; Autenrieth 1889, p. 160)

Galen wrote in *Ars Medica* (section 9, K1.330; Hirschberg 1982, vol. 1, pp 313-314):

“As far as the color [χρῶαν] of the eye is concerned we have to differentiate the following: The eye will appear blue [γλαυκὸς] either because of the size and the brightness of the crystalline lens or because the lens is located more anteriorly; similarly it can be due to not enough or not pure enough watery fluid in the pupil. If all these conditions are fulfilled the eye will appear in a saturated blue [γλαυκότητος]. If some of the conditions are present but others not then the eye will demonstrate variations of blue [γλαυκότητι]. A black [Μέλας] eye has either a small crystalline lens or the lens is deeply located or has incomplete brightness; it can also be due to an ample amount of aqueous fluid or because the fluid is not pure.”

Hirschberg furnishes the above translation, and states (1982, vol. 1, section 230, p. 313-314) that Oribasius’ (volume III, p. 198) discusses cataracts, and that this passage is “literally taken from Galen “Medical Art”, c. 9 (volume I, page 329).” Both the original text of Oribasius and a French translation are readily available (Oribasius 1858, p. 198-200). We note that the French translation of γλαυκὸς was “gris” (gray), while Hirschberg translated it as blue. This difference in interpretation demonstrates the ambiguity and uncertainty which has surrounded the term γλαυκὸς. Maxwell-Stuart attributes this quote to Galen in *Ars Medica* (section 9 = K1.330; Maxwell-Stuart 1981, vol. 1, p. 51).

In the same passage, Galen wrote that the crystalline humor contributes to the dryness of the eye if the crystalline is too hard (σκληρότερον) or exceeds the amount of thin liquid (aqueous) (Oribasius 1858, p. 200).

Elsewhere, Galen noted that the glaucous hue could be a pathologic change:

“Damage to the eyes occurs when too much fluid is drawn off during couching for cataracts, and the symptom called by doctors γλαύκωσις is a dryness and disproportionate coagulation [πῆξις] of crystalline fluid.”(Maxwell-Stuart 1981, vol. 1, p. 51; De usu partium corporis humani 10.6=K3.786; Galen 1907, p.74).

Medieval works in Arabic.

1) Yuhanna ibn Masawaih (777-857 AD), known to later Latin writers as Mesue (Prufer 1996, pp. 217-68).

2) Hunain Ibn Is-Haq (809-877 AD), originally of Southern Mesopotamia (Hunain 1928, pp. xvii-xix, x), and known later as Johannitus, was the student of Māsawaih, but

eventually eclipsed him in influence. **Hunain translated 95 of Galen's books into Syriac, and 39 of them into Arabic (Hunain 1928, p. xxiii).**

3) Ali ibn Isa el-Kahhal (ca. 940-1010 AD) (Ibn Isa 1936, p. xxviii), a dedicated oculist, known later as Jesu Hali (Hirschberg 1985, vol. 2, pp. 53-58), who cited Hunain (Ibn Isa 1936 p. 179; Ibn Isa 1964, p. 259).

4) Abul Hasan Ahmad ibn Muhammad Tabari (c. 916-986 AD), a physician who treated eye diseases, and covered ophthalmology in his work *Al-Mu'alajat al-Buqratiya* (the Hippocratic Treatments) (Ghaffari 2014; Hirschberg 1985, vol. 2, pp. 116-123). Tabari mentioned "migraine of the eye" (*Shaqiqat Al-Ayn*), (Hirschberg 1985, vol. 2, p. 118) which according to later Arabic works involved eye pain, a pressure sensation, opacification of the ocular fluids, and a dilated pupil (Hirschberg 1985, vol. 2, p. 188).

These authors, beginning with Mesue and Hunain, translated γλαυκός as *zarqaa*, in both pathologic cases (Prufer 1996, Chapter 40, p. 239; Hunain 1928, English p. 70, Arabic p. 141; Ibn Sina 1902, pp 95-98; Ibn Isa 1936, p 11; Ibn Isa 1964, p. 12; Hirschberg 1985, vol. 2, p.121, r.e. Tabari), and when used to represent light-colored irides (Hunain 1928, English p. 67, Arabic p. 139; Ibn Isa 1936, pp. 8-9, 175-176; Ibn Sina 1902, Bk 3 Fen 3 Tract 2 Ch 34, p. 175). Moreover, as light-colored irides were less common than dark for both Greeks and Arabs, relative to foreign populations, both terms acquired negative moral connotations (Maxwell-Stuart 1981, vol. 1, pp. 108, 110,115, 116, 134; Cleland 2004, p. 86; al-Jamal 1960; Omar 2010). Indeed, *zarqaa* was used to describe the eyes of nonbelievers in the Quran (Surah Ta-ha 20:102; al-Jamal 1960; Omar 2010), which predated the works of Mesue and Hunain. **One modern translation of this passage is:**

"The Day when the Trumpet will be blown (the second blowing): that Day, We shall gather the Mujrimun (criminals, polytheists, sinners, disbelievers in the Oneness of Allah, etc.) Zurqa: (blue or blind eyed with black faces)." (No author listed, Noble Quran 2014)

Other translations relate to eye color, without mentioning blindness:

"The Day the Horn will be blown. And We will gather the criminals, that Day, blue-eyed." (No author listed, quran.com 2014)

One eighteenth-century interpreter of this passage wrote:

"...and they were described in this way because *al-zarqah* was the vilest of colors of the eye and the most hateful to the Arabs because "ar-Room" [modern Rome, but classically the Greeks/Byzantium] were their worst enemies and they were "zurq". This is why, when enemies are described, they are called:

'Black of liver [i.e. burning with hostility], Blond of beard, Azraq of eye' (al-Jamal, 1960, vol. 3, p. 110)

Like *glaukos*, *zarqaa* probably corresponded with a range of hues, as these Arabic authors sorted eye color into just 3 categories: *zarqaa*, grey (*shahlaa*), and black (*sawdaa*) (Hunain 1928, English p. 67, Arabic p. 139; Ibn Isa 1936, p. 8-9; Ibn Isa 1964, p. 10-11; Ibn Sina Bk 3 Fan 3 Tract 2 Ch 34, 1902, p. 95; Ibn Sina 1982, p. 175). *Zarqaa* has been used to describe eyes which are blue or gray (Omar 2010), and occasionally even green (Lane 1968, p. 1227-1228).

They described the color of the sky simply as “the color of the sky” (*luwn al-samaa*) (Hunain 1928, English pp. 4, 9-10, 69-70, Arabic pp. 75, 79, 141; Ibn Isa 1936, p. 177; Ibn Isa 1964, p. 256).

The Arabic authors agreed the *zarqaa* hue could occur with anterior pathology displaced by couching (Hunain 1928, English pp 69-70, Arabic p. 141; Ibn Isa 1936, p 177; Ibn Isa 1964, p. 256; Ibn Sina, Bk 3, Fen 3. Tract 4. Chap 18., Ibn Sina 1608 pp. 564-565; Ibn Sina 1902, p. 155). **Hunain did not attribute the *zarqaa* hue to anterior prominence of the lens, and, like Demosthenes, mentioned simply drying of the lens (Hunain 1928, English pp. 69-70, Arabic p. 141).** Ibn Isa noted a blue eye (*zurqa*) from forward dislocation (which did not impair the sight), or from drying, thickening, and coagulation of the humor (which did affect vision, and was difficult to cure) (Ibn Isa 1936, p. 197-8). Tabari and Ibn Sina (Avicenna) stated that the *zarqaa* hue could occur in an acquired (pathologic) manner and could occur due to anterior prominence of the lens (Hirschberg 1985, vol. 2, p. 121; Ibn Sina Bk 3, Fen 3, Tract 2, Chap 34, 1608, pp. 551-552; Ibn Sina 1902 p. 95; Ibn Sina 1982, p. 189)

Specifically, cataracts were described as green (*akhdar*) (Hunain 1928, English p. 69-70, Arabic p. 141; Ibn Sina Bk 3, Fen 3. Tract 4. Chap 18.; Ibn Sina 1608, pp. 564-565; Ibn Sina 1902, p. 155; Ibn Isa 1936, p 177; Ibn Isa 1964, p. 256). Avicenna recorded that green (*akhdar*), yellow, gypsum, and black cataracts did not improve with couching (Ibn Sina 1982, p. 212). **This pathology was completely distinct from the change to *zarqaa* affecting the crystalline humor.**

Solidification of intraocular fluids and palpation of the eye.

This process of hardening of the hypochyma was described by the Greeks as πῆξις (*pezis*) (Magnus 1998, Part 1, p 185). In its first sense, *pexis* refers to “a fixing, fastening, joining, cementing” (Groves 1842, p. 466), and is the root of the suffix -pexy, as in retinal cryopexy (Oxford English Dictionary 2014). Here *pexis* is used in its second sense as “coagulation, curdling, congelation, hardening.” (Groves 1842, p. 466)

Ibn Isa (Jesu Hali) made explicit that determination of cataract maturity required palpation of the eye: “Press his eyelid with your thumb...then open the eye and note the position of the cataract. In case it is not sufficiently matured or consolidated there will

seem to be variations in its apparent breath and shape.” (Ibn Isa 1936 p. 179; Ibn Isa 1964, p. 260)

Although not previously emphasized by historians, Ibn Sina (Avicenna) came to the opposite conclusion: the cataracts which were immobile due to hardening were *less* suitable for surgery (Ibn Sina Bk 3, Fen 3. Tract 4. Chap 18.; Ibn Sina 1608, pp. 564-565; Ibn Sina 1902, p. 155-8; Ibn Sina 1982, p. 212).

Table 3. Prognosis and primary interpretation of color terms for the pupil among representative writers through 1050 A.D.

	<u>Crystalline humor disorders.</u>	<u>Unfavorable Cataracts (Suffusion, Hypochyma)</u>	<u>Cataracts (Suffusion, Hypochyma) not categorized as unfavorable.</u>
Cornelius Celsus (c. 25 BC-c. 50 AD) (<i>De Medicina</i> 7.7.14; Celsus 1938, pp. 348-9)		“suffusioni color caeruleus” (dark blue), “auri” (golden).	“marinae aquae” (sea-colored), “ferri nitentis” (glistening steel)
Demosthenes (flourished 1 st century AD) (Apud Aetium: <i>Libri Medicinales</i> 7.52) (Aetius 2000, p. 84-5; Aetii Amideni 1950, p. 308; Shastid 1913, p. 8669)	γλαυκον (glaukon, blue-gray).	απογλαυκουται, “water-blue”	θαλασζίξει (sea-colored). αεριζει (“atmospheric-blue”). υελίξει (glass-colored, green or amber), κυανωτερον (“dark blue”), εκλευκα “white”.
Hunain Ibn Is-Haq (Johannitus, 809-877 AD), Hunain (1928).	zarqaa (blue)		Not classified by favorability: (“ma yashbah luwn al-hawaa”, like the air), (“ma yashbah luwn al-zujaaaj”, the colour of glass), (“abyadh”, white), (“luwn al-samaa”, the colour of the sky), (akhdar, green), (“ma yalee al-zurqah”, almost blue), (“aswad”, black), (“asfar”, dust-coloured, grey), (“aghbar”, variegated) (“ablaq jassani”, gypsumlike). Favorable: zarqaa (usually translated as blue). (p. 69-70, 141 of Hunain 1928).

<p>Ibn Isa (Jesu Hali) (Ibn Isa 1936 p. 179; Ibn Isa 1964)</p>	<p>zarqaa (blue).</p>	<p>“aerial color” if paresis of optic nerve (English p. 179-80, Arabic p. 260) (shabeehan bil hawaa). Immature cataracts: gypsum (jassiy), hail-stone (baradi).</p>	<p>“aerial color” if no paresis of optic nerve. page 180-- Ripened cataracts (English p. 180, Arabic p. 261): steel (al-hadeed), lead color (al-asrab). Not classified by favorability (English p. 177, Arabic p. 256): “colors of the sky” (maa yashbah luwn al-samaa), green (akhdhar), yellow (asfar), red (ahmar), golden (dhahabiy), blue (azraq), black (aswad).</p>
<p>Abu Ali al-Husain Ibn Sina (Avicenna, c. 980-1037 AD). (glaucoma: Bk 3, Fen 3, Tract 2, Chap 34; 1608, pp. 551-552; 1902 p. 95; 1982, p. 189) (cataracts: Bk 3, Fen 3. Tract 4. Chap 18.; 1608, pp. 564-565; 1902, p. 155; 1982, p. 212)</p>	<p>zarqaa (blue) (1902, pp. 95-99)</p>	<p>(“al-jabsy al-jassy”, gypsum plasterboard), (“al-akhdhar”, green), (“al-kadar”, muddy/cloudy), (“al-shadeed al-sawaad”, severe black), and (“al-asfar”, yellow), (1982, p. 212).</p>	<p>(“al-luwn al-hawaaee”, the color of the air), (“al-abyadh al-loloe”, pearl white), (“Al-lathee ila al-zurqa qaleelan”, towards a little blueness), (“ila al-ghabra al-firuzagiyyah”, towards variegated turquoise). (1982, p. 212)</p>

References (alphabetized by author).

Aetii Amideni, Olivieri A (ed.). Libri Medicinales V-VIII. Berlin, 1950, p. 308. Available from: http://cmg.bbaw.de/epubl/online/cmg_08_02.html (Accessed September 5, 2014)

Aetius of Amida, Hirschberg J, Waugh RL (translators). The Ophthalmology of Aetius of Amida. Belgium, Wayenborgh, 2000, pp. 84-5

(al-Jamal) Sulaymān ibn ‘Umar Jamal, Abū al-Baqā’ ‘Abd Allāh ibn al-Ḥusayn ‘Akbarī. Title: al-Futūḥāt al-Ilāhīyah bi-tawḍīḥ tafsīr al-jalālayn lil- daqā’iq al-khafīyah. Wa-bi-al-hāmish kitābān: Tafsīr al-jalālayn lil- Suyūṭī wa-al-Maḥallī wa-implā’ mā-manna bihi al-Raḥmān min wujūh al- i’rāb wa-al-qirā’āt fī jamī’ al-Qur’ān lil-‘Akbarī. Publisher: Miṣr: Maṭba‘at al-Bābī al-Ḥalabī, vol 3, Cairo, 1960?, p. 110. Available from: https://archive.org/details/hashiya_jamal_amira_01 (Accessed September 5, 2014)

Aristotle, Taylor T (translator). On the Generation of Animals. The Treatises of Aristotle. London. Robert Wilks. 1808. p. 423.

Available at: <http://books.google.com/books?id=dOU-AAAAYAAJ&pg=PA423&lpg=PA423&dq=aristotle+generation+of+animals+glaucoma&source=bl&ots=uvqTfHSRbG&sig=4WOUVuu7bGKcg674ImSL65jCL7sQ&hl=en&sa=X&ei=FEp5U5LMAvDMsQS894GgCQ&ved=0CEsQ6AEwBA#v=onepage&q=glaucoma&f=false>

Aristotle, Peck AL (ed.). Generation of Animals. Cambridge. Harvard University Press. 1943. pp. 492-5. Available from:

<https://archive.org/stream/generationofanim00arisuoft#page/n3/mode/2up>

Autenrieth G, Keep R. A Homeric Dictionary for Use in Schools and Colleges. New York, Harper, 1889, p. 160

Barton K. Secondary Glaucoma. In: DJ Spalton, RA Hitchings, PA Hunter (ed). Atlas of Clinical Ophthalmology, 3rd ed. Philadelphia, Elsevier Mosby, 2005, p. 225

Baxter JM, Alexander P, Maharajan VS. Bilateral, acute angle-closure glaucoma associated with Guillain-Barre syndrome variant. BMJ Case Rep. 2010 Jul 21;2010. Available from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3027938/> (Accessed September 5, 2014).

Berlin B, Kay P. Basic Color Terms: Their Universality and Evolution. Berkeley, University of California Press, 1991, pp. 4-145

Bradley M. Colour and Meaning in Ancient Rome. New York, Cambridge University Press, 2009, pp. 7-231

Celsus C, Spencer WG (translator). De Medicina. Vol. 3. London, William Heinemann Ltd, 1938, pp. 346-350. Available from:

<https://archive.org/stream/demedicina03celsuoft#page/348/mode/2up>

(Accessed September 5, 2014)

Clarke J. Imagery of Colour & Shining in Catullus, Propertius, & Horace. New York, Peter Lang, 2003, pp. 47-274

Cleland L, Stears K (eds). Colour in the Ancient Mediterranean World. BAR International Series. Oxford, Hadrian Books, 2004, pp. 40-139

Day AC, Baio G, Gazzard G, Bunce C, Azuara-Blanco A, Munoz B, Friedman DS, Foster PJ. The prevalence of primary angle closure glaucoma in European derived populations: a systematic review. Br J Ophthalmol. 2012;96(9):1162-7

Drews RC. Green cataract. Arch Ophthalmol. 2006;124(4):579-586

Edgeworth RJ. The Colors of the Aeneid. New York, Peter Lang, 1992, pp. 107-162

Evans EC. Physiognomics in the Ancient World. Transactions of the American Philosophical Society. Philadelphia, American Philosophical Society. 1969;59(part 5):36-48

Galen. De usu partium libri XVII. Vol. 2. Lipsiae, In aedibus B. G. Teubneri, 1907-09, p. 74. Available from:

<http://babel.hathitrust.org/cgi/pt?id=coo.31924064990140;view=1up;seq=86>

(Accessed September 5, 2014)

Ghaffari F, Naseri M, Asghari M, Naseri V. Abul- Hasan al-Tabari: A Review of his Views and Works. Arch Iran Med 2014;17(4):299-301

Groves J. A Greek and English Dictionary: Comprising All the Words in the Writings of the Most Popular Greek Authors ; with the Difficult Inflections in Them and in the Septuagint and New Testament. Boston, J.H. Wilkins & R.B. Carter, 1842, p. 466.

Available at: <http://books.google.com/books?id=fesNAAAAIAAJ&pg=RA1-PA14&dq=%CF%80%E1%BF%86%CE%BE%CE%B9%CF%82+intitle:dictionary&hl=en&sa=X&ei=Eoh4U8X3JpC2sASShYCICg&ved=0CEIQ6AEwAA#v=onepage&q=fastening&f=false> (Accessed September 5, 2014).

Hibbert S. A description of the Shetland Islands. The Scots Magazine. Edinburgh. March 1822;89:307

Hippocrates. The whole aphorismes of great Hippocrates. London, H. L. for Richard Redmer, 1610, pp. 51-2

Hirschberg J, Blodi FC. The History of Ophthalmology. Vol. 1. Antiquity. Bonn, J. P. Wayenborgh Verlag, 1982, pp. 313-314

Hirschberg J, Blodi FC (translator). The History of Ophthalmology. Vol 2. The Middle Ages; The Sixteenth and Seventeenth Centuries. Bonn, J. P. Wayenborgh Verlag, 1985, pp. 53-188

Hunain Ibn Is-Haq (Johannitus), Meyerhof M (translator). The Book of the Ten Treatises on the Eye Ascribed to Hunain Ibn Is-Haq (809-877 A.D.). Cairo, Government Press, 1928, pp. xvii-141

Ibn Al-Haytham (Alhazen), Sabra AI (translator). The Optics of Ibn Al-Haytham. Books I-III. On Direct Vision. II. Introduction, Commentary, Glossaries, Concordance, Indices. London, Warburg Institute, Univ. of London. 1989, p. 41

ibn Isa el-Kahhal A (Jesu Hali), Wood CA (translator). Memorandum Book of a Tenth-Century Oculist. Chicago, Northwestern University, 1936, pp. xxviii-179

ibn Isa al-Kahhal (Jesu Hali). Tadhkiratu'l Kahhalin. Mohiuddin al-Sharafi (ed.) Hyderabad, Osmania Univ., 1964, pp. 10-260

Ibn Sina AA (Avicenna), Gerardus Cremonensis. Avicennae Arabum medicorum principis, Canon medicinæ. Venice, Fabium Paulinum, 1608, pp. 551-565. Available from: http://books.google.com/books?id=qA4VK-w7WDoC&pg=PA551&lpg=PA551&dq=%22viriditate+oculi%22&source=bl&ots=8bmyuHM_9G&sig=fJTiGj29u-GKIFYTtd6CfrLan0&hl=en&sa=X&ei=tXt7U_CRCsWBqgbAuYHoCw&ved=0CCsQ6AEwAA#v=onepage&q=%22viriditate%22&f=false (Accessed September 5, 2014)

Ibn Sina AA (Avicenna), Hirschberg J, Lippert J (translators). Die Augenheilkunde des Ibn Sina. Leipzig, Verlag von Veit, 1902, pp. 95-175. Available from: <https://archive.org/details/dieaugenheilkund00avic> (Accessed September 5, 2014)

Ibn Sina (Avicenna). al-Qānūn fī al-ṭibb. New Delhi, Institute of History of Medicine and Medical Research, 1982, pp. 175-212

Irwin E. Colour Terms in Greek Poetry. Toronto, Hakkert, 1974, pp. 31-78

Lane EW. An Arabic-English Lexicon. Part 1. Beirut, Librairie du Liban, 1968, pp. 1227-1228. Available at: <http://www.tyndalearchive.com/tabs/lane/> (Accessed September 5, 2014)

Leffler CT, Schwartz SG, Stackhouse R, Byrd Davenport B, Spetzler K. Evolution and impact of eye and vision terms in written English. JAMA Ophthalmol 2013;131(12):1625-31

Lewis CT. An Elementary Latin Dictionary. New York, American Book Company, 1915, p. 102

Magnus H, Waugh RL (translator). Ophthalmology of the Ancients. Part 1. Oostende, J. P. Wayenborgh, 1998, pp. 95-185

Maxwell-Stuart PG. Studies in Greek colour terminology. Vol 1. Glaukos. Leiden, Brill Archive, 1981, pp. 26-165

Maxwell-Stuart PG. Studies in Greek colour terminology. Vol 2. Charopos. Leiden. Brill Archive, 1981

No author listed. The Holy Bible, King James version: containing the Old and New Testaments. New York, American Bible Society, 1999. Available from: www.bartleby.com/108/ (Accessed September 5, 2014)

No author listed. The Quran. Surah Ta-Ha. 20:102. Dar-us-Salam Publications. Available from: www.noblequran.com/translation/ Last Accessed September 14, 2014.

No author listed. The Quran. Surat TaHa. 20:102. Available from: <http://quran.com/search?q=blue> Last Accessed September 14, 2014.

Nongpiur ME, Ku JY, Aung T. Angle closure glaucoma: a mechanistic review. Curr Opin Ophthalmol. 2011;22(2):96-101

Omar AM. Dictionary of the Holy Qur'ân. Hockessin, Delaware, Noor Foundation International, 2010, p. 231. Available from: <http://islamusa.org/dictionary.pdf> (Accessed September 5, 2014)

Oribasius. Oeuvres d'Oribase. translated by Bussemaker and Daremberg. 6 vols. Paris, 1858, vol. 3, p. 198-200. Available at: <http://gallica.bnf.fr/ark:/12148/bpt6k28927t/f230.image> (Accessed September 5, 2014)

Oxford English Dictionary Online. September 2014. Oxford University Press. Available from <http://www.oed.com/> (Accessed September 5, 2014)

Patel K, Patel S. Angle-closure glaucoma. Disease-a-Month. 2014;60(6):254-262

Pierre Filho Pde T, Carvalho Filho JP, Pierre ET. Bilateral acute angle closure glaucoma in a patient with dengue fever: case report. Arq Bras Oftalmol. 2008;71(2):265-8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0004-27492008000200025 (Accessed September 5, 2014).

Prüfer C, Meyerhof M. Die Augenheilkunde des Jûḥannā b. Mâsawaih (777-857 n. Chr.), in Sezgin F (ed). Yuhanna Ibn Masawayh (d. 243/857). Texts and Studies, Frankfurt, Goethe Univ., 1996, pp. 217-68

Riddle JE. A Complete English-Latin and Latin-English Dictionary. London, Longmans, Green, and Co, 1870, p. 76. Available from:
http://books.google.com/books?id=l_UsAAAAYAAJ&pg=RA1-PA76&dq=caeruleus+intitle:dictionary+intitle:latin&hl=en&sa=X&ei=pouwU_XHCuTIsATSzIKYAw&ved=0CEkQ6AEwAw#v=onepage&q=caeruleus%20intitle%3Adictionary%20intitle%3Alatin&f=false (Accessed September 5, 2014)

Rufus d'Éphèse. Oeuvres de Rufus d'Éphèse. Paris, Imprimerie nationale, 1879, p. 136. Available from:
<http://www2.biusante.parisdescartes.fr/livanc/index.las?cote=36058&p=194&do=page> (Accessed September 5, 2014)

See J. Phacoemulsification in Angle Closure Glaucoma. Journal of Current Glaucoma Practice. 2009; 3(1):28-35. Available from:
<http://www.jaypeejournal.com/eJournals/ShowText.aspx?ID=249&Type=FREE&TYP=TOP&IN=eJournals/images/JPLOGO.gif&IID=28&isPDF=NO> (Accessed September 5, 2014).

Shastid TH. History of Ophthalmology. American Dictionary and Encyclopedia of Ophthalmology. Chicago, Cleveland Press, 1913, p. 8669

Simplicius of Cilicia, Gaskin R (translator). Simplicius: On Aristotle's "Categories 9-15". Ithaca, Cornell University Press, 2000, p. 143

Snyder C. Mr. Mackenzie Investigates Green Cataracts. Arch Ophthalmol. 1965;74(1):133-136

Wilensky JT, Campbell DG. Primary Angle-Closure Glaucoma. In: Albert DM, Jakobiec FA. Principles and Practice of Ophthalmology, 2nd ed. Philadelphia, WB Saunders Company, 2000, p. 2691