HINDSIGHT
Journal of Optometry History

April, 2009
Volume 40, Number 2

Official Publication of the Optometric Historical Society

Hindsight: Journal of Optometry History publishes material on the history of optometry and related topics. As the official publication of the Optometric Historical Society, Hindsight: Journal of Optometry History supports the purposes and functions of the Optometric Historical Society.

The purposes of the Optometric Historical Society, according to its by-laws, are:

- to encourage the collection and preservation of materials relating to the history of optometry,
- to assist in securing and documenting the recollections of those who participated in the development of optometry,
- to encourage and assist in the care of archives of optometric interest,
- to identify and mark sites, landmarks, monuments, and structures of significance in optometric development, and
- to shed honor and recognition on persons, groups, and agencies making notable contributions toward the goals of the society.

The official publication of the Optometric Historical Society, published quarterly since its beginning, was previously titled:
Newsletter of the Optometric Historical Society, 1970-1991 (volumes 1-22), and
Hindsight: Newsletter of the Optometric Historical Society, 1992-2006 (volumes 23-37).
Hindsight: Journal of Optometry History began in 2007 with volume 38, number 1.

On the cover: The drawing represents OHS for Optometric Historical Society: the O an elementary schematic of an eye, the H three intersecting pairs of spectacles, and the S a representation of a light wave with the Greek letter lambda indicating one wavelength. The drawing artist was Diane Goss.

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Hofstetter HW. Optometry: Professional, Economic, and Legal Aspects. St. Louis: Mosby, 1948:17-35.

Chapter in a multi-author volume:
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A Mesolithic (Middle Stone Age!) Spanish Artificial Eye: *Please Realize This Technology Is circa 7000 Years Old!*

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Abstract

In 2008, the author presented a paper at the Cogan Society which addressed an amazing ancient artificial eye recently found in Iran. That artificial eye is about 5000 years old. A kind reader of some of JME's writings [who lives in Spain] noted this report, and called his attention to yet another artificial eye of a similar sort, but it was 2000 years older! It is dated ca. 7000 years BP [before the present] during the Mesolithic Time Period, i.e., the Middle Stone Age(!), and was unearthed in modern Spain.

This artificial eye was found in situ in the right orbit of the scull of a man who died at 40-45 years of age. The man was tall, and was apparently relatively well-to-do (JME assumes this is based upon items found in the grave). The artificial eye was made of ocher (or ochre). In the artificial eye, an incised cornea (and possibly a pupil) can be identified. This prosthesis may have been inserted backwards into the orbit at the time of burial. This artificial eye was much more primitive in both shape and design than the later one discovered at "The Burnt City" in Eastern Iran.

The man's body (containing the artificial eye) was found at an archaeological site in Spain called Cingle del Mas Nou i Cava Fosca, Ares del Maestro, Castellón Province. This particular body was exhumed at Cingle del Mas Nou by Profa. Dr. Carme Olària Puyoles and her team.

Keywords: *Artificial eye, Mesolithic (Middle stone-age) or Epi-paleolithic time period, ocher/ochre artificial eye, European Cro-Magnon People*

Introduction

In June 2008, at the fine/new "Cosmocaixa" or "Cosmo Caixa" Science Museum in Barcelona(!), the speaker presented a discussion of the remarkable ancient artificial eye recently found in "The Burnt City", in Eastern Iran! That artificial eye is ca. 5000 years old. (Fig 1) The presentation in Barcelona[11,12] was a then updated/ expanded version of JME's 2008 Cogan talk in Charlestown, South Carolina.

A reader of Enoch's Cosmocaixa paper, Dr. Elena Garcia-Guixé, a Spanish physical anthropologist, kindly called JME's attention to a second artificial eye of a similar sort, but one which is 2000 years older! It originated in Spain ca. 7000 years ago during the Mesolithic or Epi-Paleolithic Age, that is, during the Middle Stone Age!

Figure 1. Artificial Eye Found at "The Burnt City", Iran, dated ca. 5000 BP (Before the Present). The "eye" was found in the left orbit in the skull of a woman whose body was recently exhumed. Note inscribed patterns, and the residua of gold coating and painting of this prosthesis. Also, observe holes where supportive ties affixed were located. The "eye" was made from a type of "bitumen". These figures are reproduced courtesy of the C.A.I.S., Iran.

A Mesolithic Artificial Eye Found *in Situ:* I

The artificial eye described in this paper was found in the right orbit of a man who died at 40-45 years of age. He was quite tall and apparently well-to-do. He had quite prominent supra-orbital ridges, a broken right ulna, and a deformed pelvis.[7] This body was exhumed by Profa. Dr. Carme Olària Puyoles and her archaeological colleagues at a dig area known as "Cingle del Mas Nou i Cava Fosca" located in the Ares del Maestre, Castellón Province, Spain. Specifically, this body was located in the region of Cingle del Mas Nou.

The artificial eye was made of ocher (or ochre), which is defined as any of a class of natural earths, mixtures of hydrated oxide of iron with various earthy materials, ranging in color from pale yellow to orange and to red. Ocher was used for decorative wall and rock paintings and for body decorations and tattoos by then residents of the Iberian Peninsula. Also, ocher (ochre) was broadly and probably symbolically used, as an inclusion with the body at early burial sites across Europe. Profa. Dr. Carme Olária Puyoles considers this matter in her paper, "Death as a transcendental rite. Funeral rituals in the Epi-paleolthic/Mesolithic period and their probable influence on the Megalithic World."[8] She also noted that between the Paleolithic and Neolithic time periods, there was a reduction in the use of ocher. During this period there was also a gradual transition from widely based hunter-gatherer societies to agricultural communities.

There are recent interesting reports by Michael Balter (January and February, 2009, in Science,[13,14] indicating that very early-on(!), ocher was inscribed/ engraved purposely by ancient man either as a means of possible artistic expression or as a symbolic gesture.(Figs. 2,3) These "decorated" pieces of ocher were located in South Africa at the Blombus dig. The lineal patterns inscribed on these pieces of ocher are dated about 77,000 years ago,[13,14] and are thought to be the oldest known drawings made by human beings!

Primitive Human Use of Symbolic Decoration on Ocher (Ochre).

Symbolic start. Some scientists argue that this 77,000-year-old engraved ochre shows symbolic capacity.

Fig. 2,3

Figures 2 and 3. Early line drawings on ocher, possibly used symbolically; these may be the earliest known such items(?). They were found in Blombus Cave in South Africa by Michael Balter, et al., Science Jan. 30, 2009;323:569 & Science February 6, 2009;323:709-711. These line patterns were inscribed ca. 77,000 B.P. Reproduced courtesy of the author(s) and Science.

The Now Oldest Artificial Eye(!) Located at "Cingle Del Mas Nou i Cava Fosca":

Figs. 4-6 help the reader to locate the dig area in Spain where the now oldest known artificial eye was found, and to provide him/her with a sense of the region where these individuals lived. Note, Fig. 6 was provided by and is reproduced with permission of Profa. Carme Olaria Puyoles.[7]

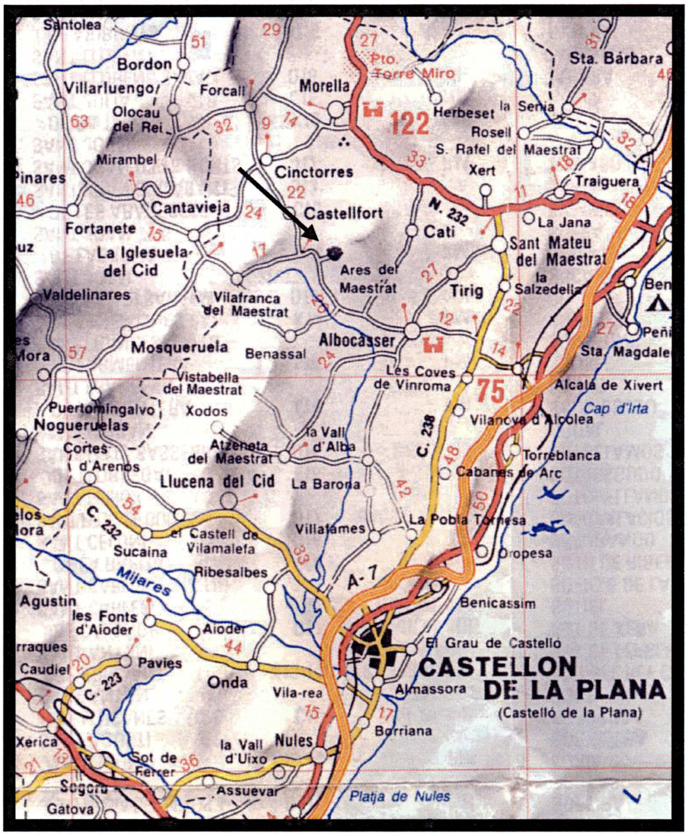

Figure 4. Map of the Castellón area, which is located south of Barcelona. This small segment of a larger map shows the general area of the archaeological dig. The black arrow points to the location of Cingle del Mas Nou i Cava Fosca, Ares del Maestre, Castellón Province, España. This is taken from a map: Editorial Everest, SA, España y Portugal. Scale 1:100,000, 14a Edición.

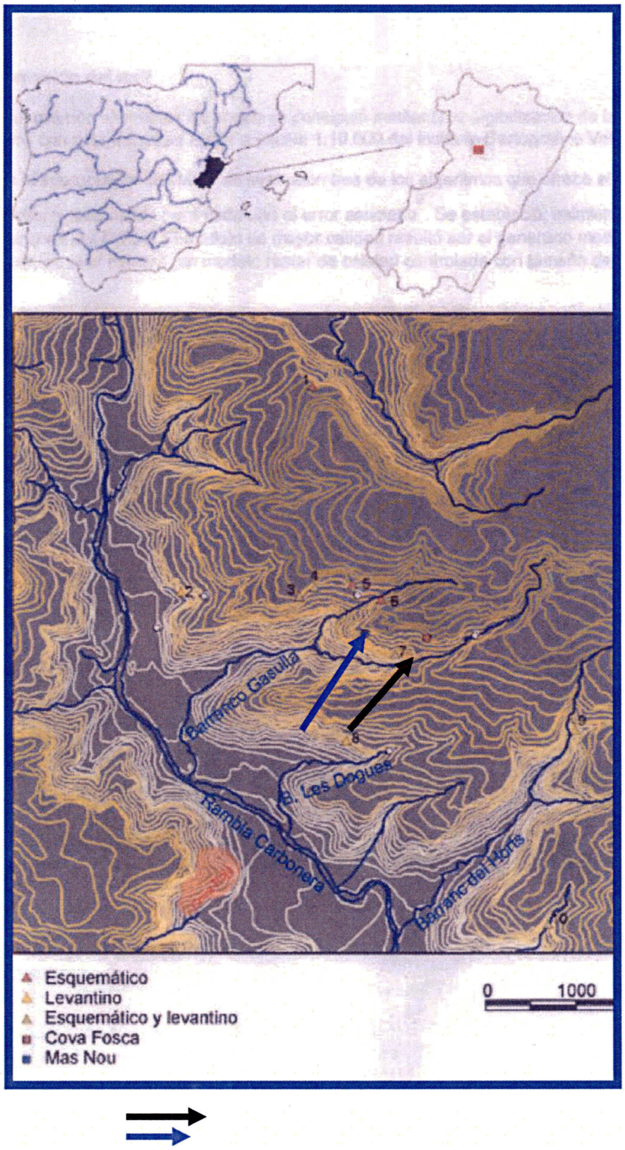

Figure 5. This terrestrial map shows the contours of the land in this mountainous region. The small upper map-insert shows where Castellón Province is located in Spain. The blue arrow locates Mas Nou where the man's body with the artificial eye was exhumed. This illustration derives from: Cartesia Modelos Digitales del Terreno e Investigación Prehistórica Gustau Aguilella Arzo, Servicio de Arqueologica, Diputación de Castellón, España, <gustauaguilella@dipcas.es> 8/6/04; See p.2 of 12pages. http://www.cartesia.org/print.php?sid=146

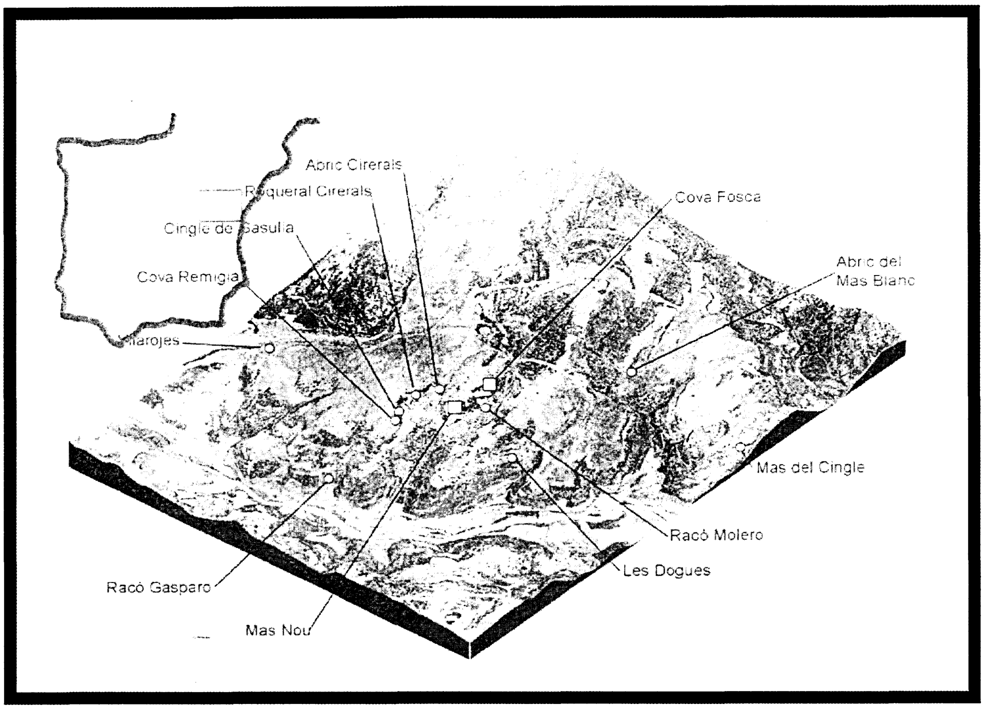

Figure 6. This map helps the viewer appreciate the altitude and contour of the dig sites, i.e., both Mas Nou and Cava Fosca.(Ref. 7) This map is reproduced with permission of the Profa. Puyoles.

The appellation, Cingle Del Mas Nou i Cava (or Cova) Fosca, is translated as follows: The word "Cingle" means 'crag', i.e., a place with a rocky wall where cavities, or hollows, or rocky shelters have developed. A "Mas" or "Masia" is a farm, or country house; "Nou" = new. Note, less than 200 yards away from the dig site there is a country house, now abandoned, but which earlier had been described as "new". A "Cava" = cave in English, and "Fosca" = "oscura" in Spanish, or dark or dim in English. The "Cingle del Mas Nou i Cava Fosca" is a well-known geographical and archeological site located in Northeastern Spain near its Mediterranean coast. Another translation of "Cingle", in addition to crag, is a cliff, "a steep, rugged rock formation arising from a rock mass." This Cingle is located on the side of a mountain called "e Barranco". There are archaeological sites and caves located in this area which have been carefully researched, e.g., by archaeologist Profa. Dr. Carme Olària Puyoles and her associates.

Profa. Carme Olària Puyoles and Prof. José Luis Gomez Lopez point out that these archaeological sites were continuously inhabited by local peoples from 12,000-7000 years BP (before the present).[7,8] "The population...probably had a transitional subsistence economy, which combined agriculture and livestock-based economy with hunting and harvesting/fruit picking." It is noted that some of the modest number of bodies exhumed at this/these site(s) were quite short (of course, excluding the man with the artificial eye). Did some of them exhibit dwarfism? Courtesy Dr. Carme Olària Puyoles.

Designation of Eras; the Time Line:

1. **Paleolithic:** The early/older Stone Age period. During this time period, less complex, or simpler stone implements were employed.
   a. Lower Paleolithic: Circa. 2,000,000–100,000 BCE
   b. Middle Paleolithic: Circa 100,000–30,000 BCE
   c. Upper Paleolithic: Circa 30,000–10,000 BCE

2. **Mesolithic or Epi-Paleolithic:** Featured use of more complex stone tools and/or instruments:
Circa 10,000–6,000/5000 BCE

3. **Neolithic:** This time period is defined, in part, by the introduction of metal tools; and use of copper predated bronze. Please note, time of introduction of metal tools varied with location!
Circa 6,000–5,000 BCE ...
*Reference: The Stone Ages: e.g., Kime (2005),[10] also see Ref 9.

Dates for at least sub-portions of "ancient eras" are assigned differently by various sources (e.g., see tabular materials presented in Wenke[10]). A caution, one must realize that individual groups of ancient peoples made the transition from one era (or sub-era) to another one at somewhat different times. When considering the peoples who lived in the area of modern Spain considered here, we should speak of their still being in the Mesolithic Era, or Middle Stone Age!

Designations of the Age of Discoveries

One can readily become confused by different designations for the ages of objects, and specifications of time.

1. Archaeologists and others try to avoid antagonizing different peoples, particularly those with differing religious beliefs.
2. In the U.S.A. we usually define calendar years as either BC or AD.
3. In the scientific domain, one often encounters use of BCE (Before the Common Era) instead of BC, and CE (the Common Era) in place of AD. Also BP (Before the Present) is used. For example, 2000 years BCE = 2000 years BC = about 4000 years BP.

The Mesolithic Spanish Artificial Eye: II

In Figs. 7-9 parts of the exhumed skeleton, head, and in situ artificial eye are seen. Interestingly, this Spanish artificial eye "may" have been placed in a reversed/backwards orientation into the orbit of this deceased person at the time of burial (please see below). The external or outward-facing portion of the prosthesis (back?) had an incised left-right facing "X" mark (for centration?). Please note, this eye-structure precedes, by quite some period of time, known written language! The Spanish archaeologists believe this X mark might have symbolized an iris (?).

The inward-orbit-facing portion of the artificial eye (Figs. 9,10) had what might be considered an outlined and raised cornea made by hammering-in short incisures into an approximately circular pattern on the block of ocher. There also might have been a flattened pupil located at it's center(?). Was the seating of the eye, as found, accidental or purposeful?

Let us assume the artificial eye was erroneously inserted into the orbit during burial in a-reverse-manner (intentionally or un-intentionally?). If it was intentional, this might have symbolized the death of the man, or an inward- or rear-ward facing alignment, or a looking-backward-in-time, etc.(?)

Figure 7. The body, *in situ,* containing the artificial eye in the right orbit. Note, the site has been partially cleaned up.

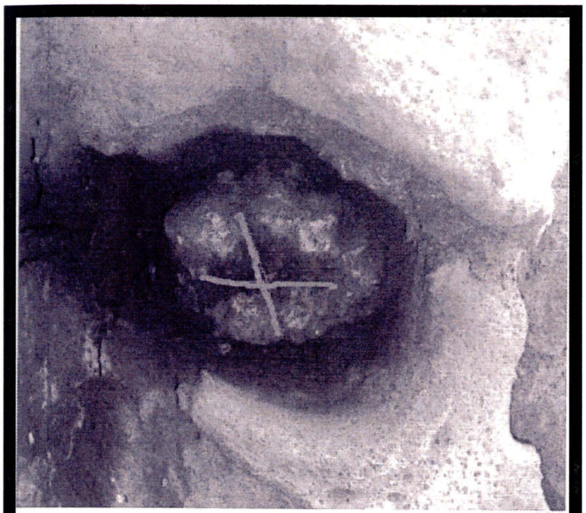

Figura 5. Vista del globo ocular postizo realizado en ocre y mostrando incisiones para simular el iris.

Figure 8. Another view of the artificial eye *in situ*. Note the "X" located on this side of the artificial eye. Reproduced with permission of Prof. Puyoles.

The features on the inner side of this artificial eye more closely approximated the appearance of a front-of-the-eye configuration. Alternatively, this device might not have stayed in-place within the orbit without lid pressure, etc., had it been facing forward. The writer can only surmise the reason this artificial eye structure was placed in this curious orientation within the orbit.

Not surprisingly, this earlier artificial eye was much more primitive in design than the Iranian one discovered 2000 years later at "The Burnt City", in Iran. (Fig. 1)

The Iberian dwellers were Cro-Magnon individuals (*Homo sapiens sapiens*) of European origin (that is, it was unlikely they were of African origin). This point was made to Enoch by Profa. Dr. Carme Olária Puyoles. Included here is an artist's portrayal of the people living in those times in the area of Cingle del Mas Nou i Cava Fosca! (see Fig. 11).

Mesolithic Spanish Artificial Eye III:

As noted, the area containing this dig was inhabited over a lengthy time period. *The bodies exhumed,* including the body of interest here, are dated from about 7010+/- 40 years BP (Before the Present) to 6920+/- 40 years BP. This is equivalent to 5010 +/- years to 4920+/- years Before the Common Era (BCE).[7,8]

Figura 6. La pieza de ocre una vez extraida de la cuenca ocular con indicación de la incisión circular del ojo.

Figures 9, 10. The rear view of the artificial eye! Was the "eye" inserted in reverse orientation? This appears to be the front of the eye, i.e., one discerns the cornea with a possible centered pupil?! That is, the modest chipped out depression in the center of the raised area might have been intended as the eye pupil (note red arrow)? Photo presented in Color and Black and White. Courtesy Profa. Puyoles.

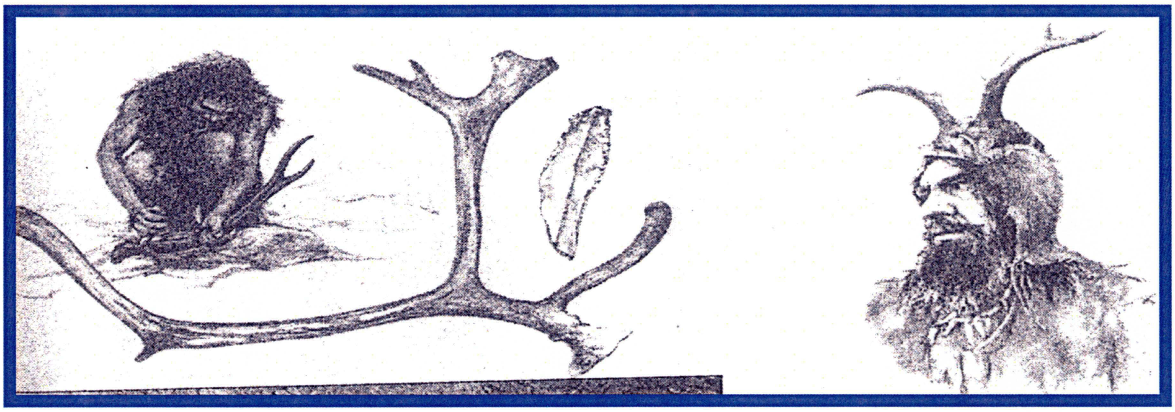

Figure 11. An artist's perception of what a man of the time might wear. Courtesy of Profa. Puyoles.

Skull and Orbit

Observe this man's skull. (Figs. 7,12,13) Note, that the supra-orbital ridges of this man are quite prominent (this is termed [in Spanish] “ceja ósea” = bony eyebrow”)! This is considered normal by the Spanish examiners. It is postulated that these protuberances look like a “torus supraorbitalis”(a marked eyebrow ridge). The comment is made that further anthropological study of these features is indicated. It is not quite clear from the figures whether there is close symmetry between his two supra-orbital ridges(?). Courtesy Dr. Carme Olària Puyoles.

Was There An Injury?

Importantly, *there may have been an injury here.* Apparently the man's right ulna had been broken and it is suggested this may have been associated with an attempt by this man to protect his face/eyes from a blow coming from above (or above left?). Please observe the calvarium (Figs. 7,10,11) where it contacts the nasal bones, and we must not forget the broken right ulna.

There also has been evidence presented for a possible chronic infectious process associated with the para-nasal sinuses, i.e., it is suggested this process might have favored development of osteomyelitis (inflammation of the bone marrow). Further analysis is needed. This is a difficult set of issues to analyze.

Figure 12. Profa. Puyoles provided this fine photograph(!) of the skull of this exhumed male. Please note the heavy supra-orbital ridges, and the possible downward shift of the calvarium in the area of the junction with the nasal bone, etc. What was the cause of cracks in the skull? Etc. Note also, there was no information provided as what might have happened earlier to the individual's right eye.

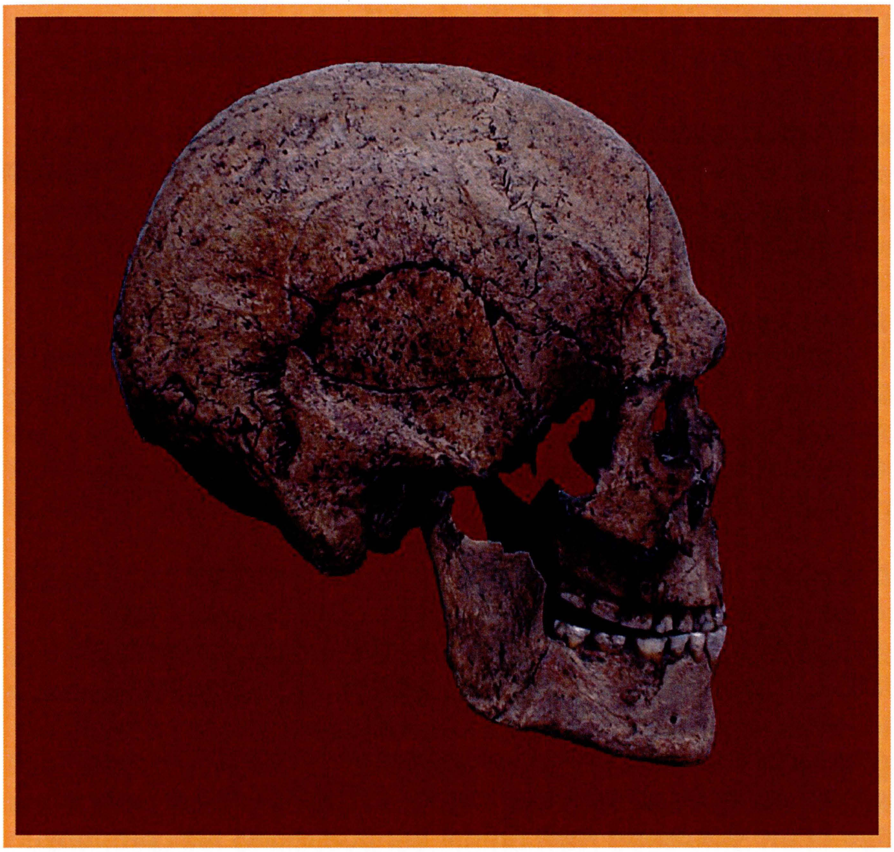

Figure 13. The right side of the skull of this man. Courtesy Profa. Puyoles.

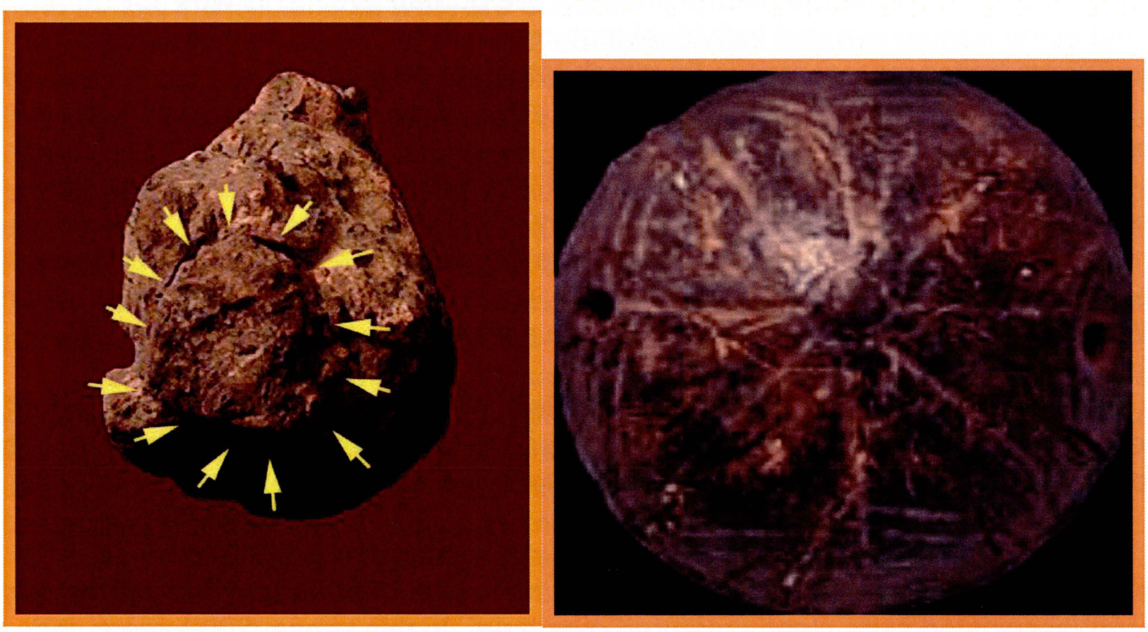

Figure 14. Comparison of the two artificial eyes, left, the Iberian/Spanish artificial eye, ca. 7000 BP; and the Iranian/"Burnt City" artificial eye, ca. 5000 BP. Courtesy Profa. Puyoles; and C.A.I.S.,

Comparison of the Two Early Artificial Eyes, An Ancient Technology!: The Spanish "Eye", ca 7000 BP; and the Iranian "Eye", 5000 BP. (Fig. 14)

1. The "Spanish" eye was constructed from ocher (ochre), the other was made of a resinous/tar-like bitumen (+ animal fat?).(See Refs. 7,8,11,12). Note the Iranian artificial eye was also coated thinly with gold.
2. Orbital fit? The Iranian eye was clearly a better fit, and much better finished.
3. Were 'ties" employed to hold the artificial eye in place? The Iranian eye used ties to hold the eye structure in place; the Spanish one did not.
4. Decorative features: The Iranian eye was decorated in a far superior and more interesting and sophisticated manner. The rays of light radiating from, or entering the eye pupil (Iranian), were among the very earliest ones portrayed!
5. Apparently both artificial eyes were (?) worn under the eyelid; these individuals were both relatively well-to-do, and tall. One must assume artificial eyes were relatively expensive and rare.
6. Both individuals were buried with the artificial eye found *in situ* in their orbit.
7. The gold coating on the Iranian eye would have provided a degree of protection relative to interactions of the prosthesis with the individual wearer's orbital contents. This point was made to JME by Director/Prof T. Freddo, School of Optometry, U Waterloo, Ontario.
8. The question as to whether the Spanish eye was properly oriented in the exhumed male skull limits further comparisons which might be made. If the Spanish eye was placed incorrectly in the eye of the deceased man, and if the prosthesis was properly oriented in life, one could argue the Spanish artificial eye made a more realistic (if modest) attempt to recreate the natural shape of the human eye. This was not attempted in the Iranian eye, but individual features such as scleral capillaries, the iris and pupil, were better represented in the much later Iranian prosthesis.

Conclusions

Not surprisingly, given the dates assigned, the Spanish artificial eye discussed here is much more primitive than the one recently found at "The Burnt City" (located in modern Iran). As noted, the Spanish artificial eye discovered by Profa. Carme Olària Puyoles and co-workers is about 7000 years old, while the Iranian one is ca. 5000 years old. Without doubt, these each were remarkable discoveries!

The two individuals buried with these artificial eyes were apparently both well-off, and were quite tall for their time. The design(s) on the Spanish eye were simple, and it was not as well finished nor as well physically supported as the Iranian one.

So saying, these artificial eye structures were extraordinary for their times! Unless proven otherwise, one needs to assume they were independent developments. So saying, associated skills clearly matured over time. In this sense, 2000 years, the equivalent to the time from the birth of Christ to the present era is a rather long period of time! On the basis of these rare finds, one must predict that in the interim other artificial eyes existed, and there must have been a continuing demand for limited numbers of such products! One must ask, if this technology was communicated, how might this have occurred?

We need also ask, when was the first artificial eye developed, and by whom? Clearly, with the Spanish artificial eye we approach that original development. One wonders if the Spanish eye represented the very first such effort (this cannot be ruled out). Obviously, it must now be considered to be the first known such device.

Separately, JME concludes the Spanish eye was reversed in orientation at interment. As a long time contact-lens-fitter serving mainly patients with complex ocular problems, it is probably valid to state that the Spanish eye (or both such artificial "eyes") were not worn for an extended periods of time with great comfort. JME is amazed to have learned of these early developments of artificial eyes. The desire/incentive of these individuals to wear such appliances must have been very great indeed.

Acknowledgements

The author warmly acknowledges the help of Dr. Elena Garcia-Guixé, a physical anthropologist, located in Spain. She called JME's attention to this ancient and most remarkable discovery! elegagui@gmail.com

He very much appreciates the excellent cooperation of Profa. Dr. Carme Olària Puyoles, and for her advice, for literature sent, and for sending some remarkable figures and other materials from her current publications and files! olaria@his.uji.es This is an outstanding set of discoveries. In no way, does JME mean to preempt her discoveries and those of her able co-workers! He very much hopes his interpretations of their work (and that of the Iranians as well) are correct.

JME is surprised by how limited our knowledge is of the history of the apparently venerable profession served by present-day Ocularists, i.e., those who continue to fill this much needed niche/service-area within ophthalmic science/care. Early in his career, JME spent long hours watching these remarkable miniaturists create startling prosthetic matches for missing eyes due to War injuries. This exposure occurred early during the Korean War when JME was assigned to the Ophthalmology service at Walter Reed Army Hospital in Washington, DC.

Finally, Dr. Esther Moreno-Barriuso was most effective in aiding JME with necessary translations. emb@moreno-barriuso.com

JME expresses his great gratitude for being allowed to reproduce a number of photographs employed in this document. He thanks both C.A.I.S. (Iran), and Prof. Carme Olària Puyoles (Spain), and journals/papers of record from which some illustrations have been reproduced. Both research groups, Iranian and Spanish, need to be congratulated for their outstanding work!

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George Adams Junior and his 1789 book An Essay on Vision

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Abstract

English instrument maker George Adams Junior (1750-1795) published An Essay on Vision in 1789, with a second edition appearing in 1792. The 153 page book (157 pages in the second edition) presented material on structure of the eye and the basic nature of vision and vision conditions, with an emphasis on the proper use and choice of spectacles for the "long sighted" and the "short-sighted." A brief biographical sketch of Adams is given, and the contents of the book are discussed, with presentation of excerpts relating to general optometric principles. The excerpts can serve to illustrate the state of optometric knowledge in the late eighteenth century.

Key words: *George Adams, history of optometry, instrument makers, optometry books*

George Adams Junior (1750-1795) came from a family of English instrument makers. He was apprenticed to his father in 1765. His father died in 1772. After a period of time in which the business was officially run by his mother, George Adams Junior took over the business in 1773. The business included microscopes, telescopes, spectacles, globes, and instruments for astronomy, geometry, surveying, navigation, meteorology, etc.

George Adams Junior, like his father, held various royal appointments. He continued from his father as Mathematical Instrument Maker to the King. In 1787, he became Optician to the Prince of Wales, the future King George IV. A significant part of his business was selling equipment to the British military.

Albert[3] observed that George Adams Junior may be best known for his work in the construction of microscopes. He, as well as his father, made significant contributions to the development of microscopes. They both published books on microscopy, the elder's being a 263 page book first published in 1746 and the younger's being a 724 page book first published in 1787. Adams microscopes and instruments are preserved in many museums and private collections, and pictures of many of them can be seen in Millburn's book on the Adams family.[1]

In the 1780s and 1790s, George Adams Junior published a number of books dealing with scientific topics. These books (with the dates of the first editions in parentheses) included *Essay on Electricity* (1784), *Essays on the Microscope* (1787), *Essay on Vision* (1789), *Astronomical and Geographical Essays* (1789), *Description, Use, and Method of Adjusting Hadley's Quadrant and Sextant* (1789), *A Short*

Dissertation on the Barometer, Thermometer, and other Meteorological Instruments (1790), *Geometrical and Graphical Essays* (1791), and *Lectures on Natural and Experimental Philosophy* (in five volumes, 1794). Some of these books went through several editions. Many of them closed with a catalog of instruments for sale.

The full title of Adams' *Essay on Vision* is *An Essay on Vision, Briefly Explaining the Fabric of the Eye, and the Nature of Vision: Intended for the Service of Those Whose Eyes are Weak or Impaired: Enabling Them to Form an Accurate Idea of the True State of Their Sight, the Means of Preserving it, Together with Proper Rules for Ascertaining When Spectacles are Necessary, and How to Choose Them Without Injuring the Sight.* The first edition was published in 1789, and a second edition appeared in 1792. Adams wrote it for lay persons and opticians ("particularly those who live in the country," page iv) to learn about vision and to be more informed about the proper use and wear of spectacles. The first edition is 153 pages in length, followed by a 14 page catalog of instruments sold by Adams. The second edition is 157 pages.

Introductory material, a description of eye and adnexa, binocular fusion, and the structure of the eye takes the reader through the first 34 pages of the first edition and the first 36 pages of the second edition. In the discussion of the pupil, Adams observed that: "Those who are short-sighted, have the pupils of their eyes, in general, very large; whereas in those whose eyes are perfect, or long-sighted, they are much smaller." (first edition, pages 22-23; second edition, page 24)

After about eleven pages of very basic optics, Adams discusses vision, including image formation by the eye, differences between clarity and distinctness of vision, factors affecting clarity and distinctness of vision, accommodation, and pupillary reflexes. "We see an object *clearly*, when it is sufficiently illuminated, to enable us to form a general idea of its figure, and to distinguish it from other objects: we see it *distinctly*, when the outlines of it are well defined, when we can distinguish the parts of it, and determine their colour and situation. Thus we may be said to see a distant object *clearly*, when we can perceive that it is a tower; but to see it *distinctly*, we approach so near as to be able to determine not only its general outline, but to distinguish the parts of which it is composed." (first edition, page 66; second edition, pages 69-70)

The mechanism of accommodation was unknown at Adams' time, as can be seen by his statement that: "Authors are much divided in their opinions concerning the change that is made in the conformation of the eye, to procure distinct vision at different distances, some thinking it to be a change in the length of the eye, others that it is a change in the figure or position of the crystalline humour, other that it is a change in the cornea." (first edition, page 76; second edition, pages 80-81)

Adams prefaces a discussion of "imperfect sight" by saying that: "There is no branch of science, of which it is more important that a general knowledge should be diffused, than that part which treats of the various imperfections of sight, and the remedies for them." (first edition, page 86; second edition, page 90)

Adams first considers "old or long-sighted eyes." "By the long-sighted, remote objects are seen distinctly, near ones confusedly; and in proportion as this defect increases, the nearer objects become more indistinct, till at length it is found almost impossible to read a common-sized print without assistance." (first edition, pages 88-89; second edition, page 93)

The consequences of presbyopia are noted: "those who were accustomed in their youth to read a common size print, at about twelve or fourteen inches distance from their eyes, are obliged to remove the book to two or three feet before they can see the letters distinctly, and read it with comfort." (first edition, pages 89-90; second edition, page 94)

Adams observed a relation between use of the eyes and refractive conditions: "country-men, sailors, and those that are habituated to look at remote objects, are generally long-sighted, want spectacles soonest, and use the deepest magnifiers; on the other hand, the far greater part of the short-sighted are to be found among students, and those artists who are daily conversant with small and near objects; every man becoming expert in that kind of vision, which is most useful to him in his particular profession and manner of life…" (first edition, pages 91-92; second edition, page 96)

In beginning a discussion of spectacles, the author opined that: "The discovery of optical instruments may be esteemed among the most noble, as well as among the most useful gifts, which the Supreme Artist hath conferred on man." (first edition, pages 94; second edition, page 98)

Concerning the proper choice of spectacles, Adams observed that: "The most general, and perhaps the best rule that can be given, to those who are in want of assistance from glasses, in order so to choose their spectacles, that they may suit the state of their eyes, is to prefer those which shew objects nearest their natural state, neither enlarged not diminished, the glasses being near the eye, and that give a blackness and distinctness to the letters of a book, neither straining the eye, nor causing any unnatural exertion of the pupil." (first edition, page 96; second edition, page 100)

Further he said that: "Though, in the choice of spectacles, every one must finally determine for himself, which are the glasses through which he obtains the most distinct vision; yet some confidence should be placed in the judgment of the artist, of whom they are purchased, and some attention paid to his directions." (first edition, page 96; second edition, pages 100-101)

Adams gave the following rules for the preservation of sight: "1. Never to sit for any length of time in absolute gloom, or exposed to a blaze of light….2. To avoid reading a small print. 3. Not to read in the dusk; nor, if the eyes be disordered, by candle-light….4. The eye should not be permitted to dwell on glaring objects…5. The long-sighted should accustom themselves to read with rather less light, and somewhat nearer to the eye than what they naturally like; while those that are short-sighted, should rather use themselves to read with the book as far off as possible." (first edition, pages 97-99; second edition, pages 101-103)

A few pages later, Adams notes that age is not "an absolute criterion" for deciding whether the use of spectacles for reading is warranted, and he puts forward rules to determine when "sight may be assisted or preserved by the use of spectacles": 1. When we are obliged to remove small objects to a considerable distance from the eye, in order to see them distinctly. 2. If we find it necessary to get more light than formerly; as for instance, to place the candle between the eye and the object. 3. If on looking at, and attentively considering a near object, it becomes confused, and appears to have a kind of mist before it. 4. When the letters of a book run one into the other, and hence appear double and treble. 5. If the eyes are so fatigued by a little exercise, that we are obliged to shut them from time to time, and relieve them by looking at different objects." (first edition, pages 103-104; second edition, pages 107-108)

Another aspect of reading glasses that he addressed was that their power should be based on individual characteristics and reading distance: "magnifying power is not the point that is most to be considered in the choice of spectacles, but their conformity to our sight, their enabling us to see distinctly, and with ease, at the distance we were accustomed to read or work, before the use of spectacles became necessary: or in other words, glasses should so alter the disposition of the rays, at their entrance into the eyes, as will be most suitable to procure distinct vision at a proper distance…" (first edition, page 107; second edition, page 111)

Adams advised against the use of "visual spectacles." Although he did mention Benjamin Martin's (1705-1782) name, it is evident that he was talking about the spectacles also known as Martin's margins." Adams considered the rims of visual spectacles to be "imperfect and detrimental" as a "shade or screen," and thought that they were "inconvenient in use." (first edition, page ; second edition, pages 114-115) He also thought that, in general, that "coloured glasses" should not be recommended.

After a little further discussion of reading glasses, Adams took up the topic of couched eyes. He noted that persons with couched eyes "generally require tow pair of spectacles, one for near, the other for more distant objects. The foci that are used lie between 6 and 1 ½ inches." (first edition, page 122; second edition, page 126)

Adams' next topic is short-sightedness: "In this defect of the eyes, the images of objects at ordinary distance unite before they arrive at the retina, and consequently the images formed thereon are confused and indistinct. This effect is produced either by too great a convexity in the cornea and crystalline, or too great a refractive power in the humours of the eye; or the retina may be placed too far; or it may arise from a concurrence of all these circumstances." (first edition, page 122; second edition, pages 126-127)

Next he says that: "Happily for the short-sighted, the principal inconveniences of their sight may be remedied by the use of concave glasses;…the concave lens produces distinct vision, by causing the rays to diverge more, and unite at the retina, instead of meeting before they reach the bottom of the eye." (first edition, pages 124-125; second edition, page 129) And he observed that the selection of lens power "must depend on the observation of the short-sighted themselves, who, by trying glasses of different degrees of concavity, will soon find out that whose effects are most advantageous..." (first edition, page 125; second edition, page 130)

Adams recognized an association of near work and myopia: "we often find, that watch-makers, engravers, and studious persons, often bring o this defect. By reading or working as great a distance as possible, and often looking at remote objects, the degree of short-sightedness may be much lessened. As children in general read much nearer than grown persons, if they are suffered to indulge this propensity, they become naturally short-sighted." (first edition, page 127; second edition, page 132)

Adams' last topic in the book is strabismus or "squinting." He cited Thomas Reid as presenting that "in perfect human eyes, the centers of the two retinae correspond and harmonize with one another, and that every other point in one retina, corresponds with that point which is similarly situated in the other..." (first edition, pages 135-136; second edition, pages 140-141) He also mentioned an association of strabismus with amblyopia: "the greatest number of that squint have very indistinct vision with one eye..." (first edition, page 140; second edition, pages 145) Next Adams discussed the "eleven subjects of inquiry" that Reid recommended be determined for each individual to establish "the foundation for a rational mode of cure." These included points that we could recognize as difference in acuity between the eyes, change in angle with direction of gaze, and presence of diplopia. Adams closes the narrative with treatment for strabismus, which included aspects such as patching and work to improve fixation.

At the end of the first edition there is "A Catalogue of Mathematical and Philosophical Instruments Made and Sold by George Adams." The headings for the items in the catalog were optical instruments; geographical and astronomical instruments; mathematical instruments, for geometry, drawing, etc.; surveying instruments; military instruments; instruments for navigation; instruments for electricity; apparatus for experiments on magnetism; instruments for experiments on pneumatics; apparatus for an air-pump; meteorological instruments; instruments for illustrating the mechanic powers, the laws of motion, etc.; and instruments for experiments for experiments in hydrostatics and hydraulics. The optical instruments include a number of different types of spectacles, as well as various opera glasses, telescopes, microscopes, prisms, mirrors, and other items.

There is fairly little difference between the first and second editions. The basic outline is the same. In the second edition there are occasional additions of paragraphs, sentences, or footnotes, along with the deletion or revision of a few sentences. *Essay on Vision* appeared in Dutch translations in 1792 and 1800 and a German translation in 1794.

George Adams Junior's younger brother Dudley Adams (1762-1830) was apprenticed to him in 1777. Dudley established his own business in 1788, taking over most of the family's globe making business, but also selling many other instruments. Dudley did not prove to be as good a businessman as his father and brother and he went bankrupt in 1817.

In about 1794, George Adams Junior's health started failing. He died on August 14, 1795, a few weeks after he turned 45 years old. His widow Hannah continued the business for about a year after his death until the business's stock was sold at auction in 1796. W. and S. Jones published updated versions of some of George Adams Junior's books from 1797 to 1813, but *Essay on Vision* was not among those works.

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Medieval Optometric Traditions

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Optometry is relatively young as an organized profession, with many developments taking place in the twentieth century. Therefore, it can be surprising that some of problems that optometry deals with, were subjects of consideration for Medieval natural philosophers (scientists) such as Ibn al-Haitham (in Europe known as Alhazen), Bacon, Grosseteste, Peckham or Witelo. Information on this topic was mainly gained from the works on translation of Witelo's scientific work.[1-3] This was also shown in comparison studies related to some aspects of anatomy and physiology of the eye in the works of Alhazen and Witelo.[4] The previously mentioned Medieval natural philosophers were in favor of an intromission theory of seeing, the basis of which began in antiquity. The theory assumed that the image of an observed object enters the eye through some elementary "forms" released from the observed object together with light. These forms were assumed to be part of each object. The competitive theory was an idea (known today as extramission) which stated that vision happens as a result of releasing specific subtle "emanates" from the eye. When they leave the eye, they reflect from the observed object and reenter the eye causing the act of seeing. The proof used by people in favor of this theory was the greenish tint seen at night in some animals' eyes. It was thought that these animals can see well at night because the "emanates" sent out from their eyes were very strong.

It is necessary to underscore that the founder of the scientific bases of the intromission theory was mostly Alhazen. However, without a doubt, Witelo contributed to the popularization of this theory in Medieval Europe.

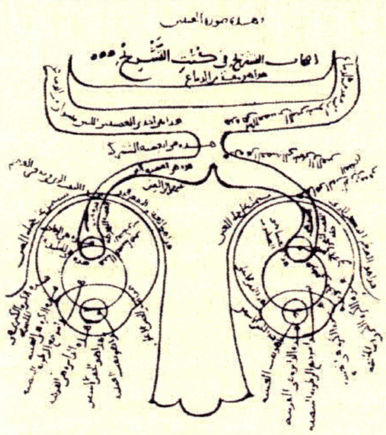
Witelo (1237–1300), son of Turyngs and Poles (*filium Thuringorum et Polonorum,* as he described himself), was born in Poland. After his studies in Italy and Paris, he started, among other projects, to do scientific work. In about 1272 the scientist Wilhelm of Moerbeke, who was connected to the papal curia in Viterbo, proposed that Witelo write a work that would include the whole knowledge in the optics area. Witelo took up this task and this is why he got interested in all the elaborations on this topic available to him. He also had a Latin translation of the work *Kitab al–Manazir* (Arabian, *Optics*) written by Alhazen. This scientist came from Basra and lived from about 963 to 1040. The oldest presently known Latin translation of this work comes from 1269 and a translator gave it the title *De aspectibus* (About Sight).[5]

Witelo, in his epochal work titled *Perspectiva*, indeed included the whole knowledge on optics available during this time. This gigantic work had 10 volumes and was a basic manual in this area for universities practically until the time of Kepler, that is until the seventeenth century. The first (I) volume included mathematical background needed to make mathematical proofs of the statements included in the following volumes. The second book (II) is the introduction to the discussion of optics. In the third volume (III) the author describes how the eye is constructed, and discusses the mechanisms of image formation in the eye and some psychological-physiological aspects connected to vision. The fourth volume (IV) is devoted to the description of vision when an object is being seen directly, and to the reasons for vision problems. The phenomena of light reflections and seeing when using mirrors is described in volumes V-IX. The tenth book (X) discuses the phenomena of light refraction, seeing objects in refracted light, and some of topics on optics of the atmosphere.

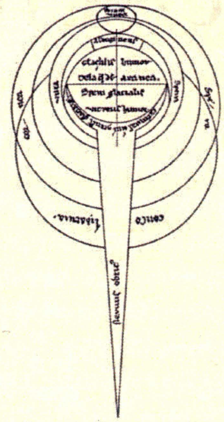
The work of Witelo was first printed in Nuremberg in 1535 and edited by Tanstetter – Apian (a reprint took place in 1551). The next edition was published in Bazylea in 1572 edited by F. Risner. In this edition Risner placed Alhazen's text in front of Witelo's work. He also introduced many modifications and changes in Witelo's text.[6] This editorial interference by Risner resulted in the rising of some critical opinions about Witelo that claimed he used a lot of the work of the Arabian author and that his own input in the essence of his work was very small. Research conducted in the twentieth century on this critical edition of Witelo's work allowed explanation and rejection of many of these criticisms. It was also confirmed that some of the expressions and fragments of Witelo's text are borrowed from Alhazen. However, it was decided that Witelo's work shows the better orientation in the subject, clearly a more correct methodology and the rule of proving formulated theorems mainly based on geometry. (Figs. 1, 2, and 3)

Because most of Witelo's work is now translated into Polish, his ideas will be presented, although obviously Ibn al–Haitham (Alhazen) also worked in this area.

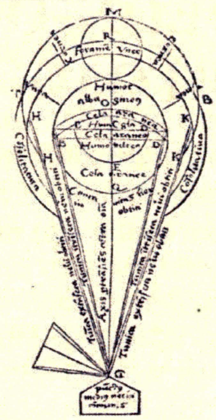
Particularly interesting, for ophthalmologists and optometrists, will be Witelo's ideas concerning: the structure of the eye, mechanisms of image formation in the eye, and conditions required for good vision including binocular vision; these problems are considered in the III and IV volume of *Perspectiva*.



Ryc. 1. Schemat układu wzrokowego w *Kitab al-Manazir* Ibn al-Haithama.



Ryc. 2. Schemat oka w *De aspectibus* Alhazena.



Ryc. 3. Schemat oka w *Perspektywie* Witelona.

Left to right: Figure 1. The schematic of the visual system from *Kitab al–Manazir* Ibn al-Haitham; Figure 2. The schematic of the eye from *De aspectibus,* Ibn al-Haitham; Figure 3. The schematic of the eye from *Perspectiva,* Witelo.

Witelo described the structure of the eye according to medical books of his time. That i's why in statement 4 in book III he wrote that the eye consists of three fluids and four coats, that is: the "crystalline or ice fluid" (i.e., the lens), the "hyaline fluid", the "albumen humour", the "horn membrane" , the "bonding membrane" etc. At the same time, these elements are spherical structures (for example, the eye ball), or they are spherical parts of other elements of the eye. Witelo also put a big emphasis on precise description of the position of geometrical centers of the aforementioned spherical elements in the eye. The eye ball in the posterior part is supposed to connect with the "visual, that is hollowed (concaved) nerve" (*nervus opticus vel concavus*), whose coats are supposed to blend with the eye membranes. Inside this nerve were small canals that were used to nourish the nerve. *(The small canals mentioned by Witelo are certainly branches of arteria at vena centralis retinae.)* The nerve was hollow inside in order to allow the movement of the "visual spirit" (*spiritus visibilis*). Through the hole in the bone, the visual nerve was entering the inside of the skull where, in the front part of the brain, it was meeting with the identical nerve from the other eye and they were switching places. The right visual nerve became the left and the left one became the right. The place of the crossing Witelo named the common nerve. In this place, where the image of an object arrived thanks to the "visual spirit", the ability to see was localized. This ability was responsible for receiving visual sensations (*virtus visiva sentiens*) and for discrimination (*dijudicans*).

It was mentioned before that Witelo paid attention to sphericity of "fluids" and "membranes" of the eye. Underlining the geometric shape of the particular fluids and membranes of the eye led Witelo to change the nomenclature and to start describing these structures using such terms as: “crystal sphere”, “grape-like sphere”, “ice sphere” and “horn sphere”. This tendency becomes clear when Witelo, in the end of the description of the eye, presents a mathematical figure that demonstrates the eye. Witelo’s thoroughly considered goal and purpose was to create a model of the eye that would make the understanding of the next theory, the theory of image formation in the eye, easier to understand for readers. *(It is worthwhile to note that the picture of the sectional view of the eye known as mathematical figure or mathematical picture as well as the description of the picture are totally original work of Witelo.)* This theory, as was already mentioned, assumed that together with light the “forms” of the seen objects enter the eye. According to these ideas, on the front surface of the cornea the exact copy of the object was created, thanks to the expansion of this form (from the observed object to the eye). *(So called first Purkinje image.)* In addition, this concept assumed that the “horn sphere” and the “crystal sphere” had the same middle, thus the surfaces of these “spheres” were parallel. Therefore, according to this idea, also on the front surface of the lens the exact copy of the observed object was created. *(So called second Purkinje image.)* This is why it was assumed that vision is only possible when the forms that came from the observed object and reached the eye were coming along the lines that were perpendicular to the cornea and the lens. Thus, the forms that reached the eye created a cone (called the vision cone), with the base located on the surface of the observed object and the apex in the geometrical center of the eye. According to this theory, after passing through the lens, but before getting to the geometrical center of the eye, the direct image of the observed object was received by the “visual spirit” (*spiritus visibilis*), which carried this copy through the vision nerve to the “common nerve” (the crossing of vision nerves). The additional reason for such explanation of the way of transmitting direct image was the ascertainment that in the opposite situation, after the rays pass the geometrical center of the eye, an inverted image would be created which was contradictory to everyday observations. *(Analyzing these ideas it is necessary to say that in Medieval times the optical features of lenses were not known. It was thought that that the rays perpendicular to the cornea and sclera meet in one point behind the lens. However; for example, the parallel ray, will be refracted but will not meet in one point.)the rays that fall on the cornea at different angles*–Therefore, according to the theory mentioned earlier, the lens was the element of the eye that received visual sensations, and for this reason was considered to be the most important and most protected part of the eye.

It is worth underscoring that the paradigm concerning receipt by the eye of the direct (erect) image of the observed object existed until the eighteenth century! Only the work of Johannes Kepler, *Ad Vitellionem Paralipomena...*, published in 1604, had the description of the lens as an element of the optical system of the eye and a cause for the inverted image falling on the retina. It should be noticed that although the great Kepler realized that his explanation ended the existence of the theory of -intromission to the crystalline lens, the decision to title his work *Ad Vitellionem Paralipomena...* (*paralipomena* means deficiencies in Greek) was made intentionally, surely as the last tribute to Witelo the great Medieval scientist.

Let's take a look at the other problems that can be included in medical, optometric, and psychological aspects, which are described in the work of Witelo. It is possible to include in this area the parts of the work that try to explain why, in spite of having two eyes, we see one object - thus these are issues described nowadays as monocular perception and fusion (the phenomena of stereoscopic vision was not noticed). When Witelo analyzed the issues of single vision, he stated that this process is a result from the fact that both eyes are the same, identically located in relation to each other and they always perform the same movements. The stimulus to move is sent to both eye balls from the common nerve point (crossing of vision nerves). The visual spirit (*spiritus visibilis*) carries the direct image of the observed object to the same point. This occurs because at this point, the ability to see, responsible for both receiving and discriminating the visual sensations (*virtus visiva sentiens et dijudicans*), is located. In the same point of the common nerve the merging of the two identical forms of the observed image takes place. The analysis of the proof of this statement leads to the conclusion that the formation of one image is made possible by the superimposition of geometrically identical figures. In addition let's notice that the function responsible for movements of the eyeball was also thought to be carried by the vision nerve.

Witelo stated that a number of conditions have to be fulfilled in order for the act of vision to take place. They are as follows: the presence of light, a specific distance between the observed object and the eye, the localization of the object in front of the eye, the size of the object, the appropriate transparency of the air, the appropriate observation time and, visual acuity. *(These are issues concerning the threshold of the resolution of the eye – discussion and conclusions are correct although there is a lack of quantitative information.)* Each of these conditions is extensively described and commented on.

Witelo's comprehensive explanations concern the conditions described by him as "indispositions". They concern such characteristic of objects as: distance, size, localization, form (i.e. shape) and sphericity (i.e. three dimensional shape), distance from others, uniformity and number, movement and rest, roughness and smoothness, transparency and density, shadow and darkness, beauty and ugliness, similarity and variety. In addition, each of the indisposition conditions is described and commented on, although sometimes in a very complicated way. Let us just add that in this group an interesting discussion on perspective can be found. Interesting also are Witelo's deliberations concerning the errors that are made by the discrimination ability (*virtus visiva sentiens et dijudicans*) when any of the conditions from the above group are out of the norm. In addition, the author proves that the ability to discriminate may, in some conditions, undergo illusions (that is, visual illusions caused by the bad judgment of distance, size etc.).

The phenomenon of physiological diplopia is described fascinatingly. What is interesting, in addition to the theoretical discussion on this subject, Witelo proposes making a special instrument that can be used to demonstrate this phenomenon.

This short review of medical matters that might be found in Witelo's works allows concluding that the medical and optometric communities' pride in Witelo's achievements and his importance for the scientific knowledge is justified. Thus, the introduction in 1990 of a special commemorative medal made out of bronze is not a surprising but an interesting form of honoring Witelo. *(This action was initiated by prof. dr. Bolesław Kędzia, founder and head of the Department of Optometry at the University of Medical Science in Poznań. The author of the medal is sculptor, Ewa Olszewska-Borys.)* (Figs. 4 and 5)

Ryc. 4 i 5. Medal Witeloński – awers i rewers.

Figures 4 and 5. Witelo's medal – front and back.

Naming one of the moon's craters Vittellon in the 1990s of the 20th century may be a sign of international tribute to Witelo. *(The diameter of the crater is 42 km. The position of the crater is: 30° 24′ S and 37°5′ W; see: The hatfield photographic lunar atlas, Jeremy Cook, ed., London 1999, boards 9, 11, 12)*

Looking from today's perspective at the views presented here, it should be stated that the theory of intromission to the crystalline lens extraordinarily intelligently and cleverly explains the visual process and the mechanism of image formation in the eye, mainly based on the observation of the first Purkinje image. However, the theory had to come to pass, since it was based on false assumptions. Yet, this was the level of academic knowledge during these times – the best scientists did not know the facts that today are taught in elementary schools. It seems that when evaluating the level of knowledge from ages ago it is still true what Bernard of Chartres (XII century) said: *"We are midgets that stand on giants' shoulders. If we see further and reach further than they do, it is not because our sight is sharper or our posture taller, but because they brought us higher and uphold us on their gigantic height."*

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Selected Online Sources of Images Relevant to the History of Optometry

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This article provides descriptions of a sampling of websites that contain images relevant to the history of optometry.

International Library, Archives, and Museum of Optometry

The International Library, Archives, and Museum of Optometry (ILAMO) has a "virtual museum" that can be found at www.aoa.org/x7388.xml. There are eleven categories of pictures of items: Eyewear Cases and Containers; Contact Lenses; Decorative Items, Art, Photos; Eyeglasses and Spectacles; Four Lens Spectacles; Instruments, Equipment, Tools, and Training; Lorgnettes; Martin's Margins; Miscellanea; Pince-nez, Folding, and Quizzers; and Recreational and safety Eyewear. One can click on any of these categories and observe photos of items in the ILAMO collection. There are anywhere from 5 to 27 items displayed in the separate categories. Individual photographs have brief descriptive captions.

Among the cases is a leather case from McAllister Opticians, 1226 Chestnut St., Philadelphia. The Contact Lenses grouping consists mostly of photos of equipment and contact lenses. There are two groupings under Eyeglasses and Spectacles. One is antique spectacles, with 20 photos, some of which are from the McAllisters, and the other is 20th century spectacles, with six photos. Items in the Instruments, Equipment, Tools, and Training category include an Arneson Korector, optometers, refractors, a lens bar, pupillometer, reflecting retinoscopes, schematic eye, Stereo orthoptor, Syntonizer, Worth Black amblyoscope, B&L Ferree-Rand projector, and Clason projector. Among the Miscellanea are a number of early American Optometric Association meeting badge medals.

National Library of Medicine Images from the History of Medicine

Images from the History of Medicine (www.nlm.nih.gov/hmd/ihm/) contains almost 70,000 images from the prints and photographs collection of the History of Medicine Division of the United States National Library of Medicine. The emphasis is, of course, on medicine, disease, and surgery. There is a search function on this website. A search on the word optometry yielded zero results. A search on the word optician came up with seven records, including portraits of Jesse Ramsden, Benjamin Martin, and one of the Dollonds. Searches on eyeglasses and optics resulted in 40 and

28 records, respectively, mostly prints depicting eyeglasses, or in the case of optics, mostly prints depicting telescopes and optical instruments.

The College of Optometrists On-line Exhibitions

The College of Optometrists is the organization which performs professional, scientific, and examining functions for optometry in the United Kingdom. It has an online exhibition based on the collection of the British Optical Association Museum in London.

This online exhibit can found online at www.college-optometrists.org/index.aspx/pcms/site.college.What_We_Do.museyeum.online_exhibitions.onlineexhibs_home/. Categories of items are: Art Gallery, Colour Vision Gallery, Eye Gallery, Observatory (history of astronomical optics), Optical Instruments Gallery, Print Room, Students Past, Artificial Eyes Gallery, Contact Lenses Gallery, Microscopy Gallery, Optical Entertainment Gallery, Post Room (stamp collection), and Spectacles Gallery.

Clicking on one of those categories leads one to a list of topics. For instance, in the Optical Instruments Gallery, the topics are: examination chairs, retinoscopes, perimeters, slit lamps, duochrome tests, focimeters, ophthalmoscopes, keratometers, and tonometers. For each topic, there is both text describing the history of each topic and a number of images. For example, the discussion of retinoscopes include a description of retinoscopy, the history and development of retinoscopy, other terms used for retinoscopy, early simple retinoscopes, dynamic retinoscopy, spot retinoscopes, and streak retinoscopes. The text on retinoscopy is accompanied by eleven images. The discussion of ophthalmoscopes is the most extensively of any topic and is complemented by 41 images.

There are many interesting items to be found by perusing this website. For example, under the topic invention of spectacles in the Spectacles Gallery, one sees a picture of the church where Giordano da Rivalto delivered his 1305 sermon in which he stated that “It is not yet twenty years since there was found the art of making spectacles.”

The Science Museum (London) History of Medicine website

The Science Museum in London was founded in 1857. It has a great deal of online material including a History of Medicine website which can be found at www.sciencemuseum.org.uk/broughttolife.aspx. By using the search function, one can find some eye related items, such as eye models and eye cups. Searching on the word lenses yields some images of intraocular lenses and microscopes. Not much can be found by searching on words such as optometry, eyeglasses, and spectacles. However, an interesting find resulted from searching on the word optician: trade cards of late 17th century through 19th century English opticians James Mann, William Dowling, John Yarwell, Thomas Ribright, and James Ayscough.

Wellcome Collection Images

Images from the collection in the Wellcome Library in London can be found at http://images.wellcome.ac.uk. The website includes a search function. A search for optometry resulted in only two images, a portrait of F.C. Donders and the title page of his *Die Anomalien der Refraction und Accommodation des Auges*. A search for spectacles yielded 100 results, most of which were pictures of spectacles and prints depicting spectacles. By searching on the word ophthalmology, 134 items were found. These images included pictures of glass eyes, eye models, pages from various manuscripts and printed texts, pages from Chinese ophthalmology texts, various prints and drawings depicting eye diseases, surgery and instruments, and portraits of Ferdinand von Arlt and Thomas Wharton Jones.

Antique Spectacles

No discussion of online images of optometrically related materials would be complete without mention of www.antiquespectacles.com. This website is managed by retired ophthalmologist David A. Fleishman. The tops of its pages proclaim it to have "over 4,950 images". It is self-described as "the online museum and encyclopedia of vision aids," an apt description because of the extensive information it contains. Among the goals that it lists are "to accumulate in one place the wealth of knowledge regarding Antique Vision Aids" and "to share images of the finest and most interesting historical items in both private and public collections from around the world." The extent of the information on this website can be appreciated by going to the Table of Contents page found under the Introduction and News tab.

To give examples of some of the images available, under the Collections tab, one can find "virtual museums" of spectacles, cases, materials, and other items. Under the Interesting Topics tab, there are images of spectacles of well known people, along with documentation of sources and descriptions. One can also find 55 images of antique optical trade cards. In addition to the images at this website, more images can be located by using its numerous links to art institutes, publishers, organizations, libraries, and museums.

Book Review: Phoroptors: Early American Instruments of Refraction and Those who Used Them

Phoroptors: Early American Instruments of Refraction and Those who Used Them. Gary L. Campbell. Wheaton, IL: the author, 2008. 99 pages. Paperback, $10.

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In the foreword to this book (p. 11), the author explained that as a collector of phoropters, he was disappointed to learn that there was no single source that he could use to find information about most historical phoropters. As a consequence, he decided to produce this monograph. In the title and throughout the book, the author uses the spelling phoroptor, an early spelling of the word.

The front matter of the book includes a glossary of terms for persons not familiar with the terminology used in the book (pages 15-18). Chapters 1 through 3 (pages 21-30) provide a historical overview of the optical business and state of refraction just before phoropters were developed.

Chapters 4 through 6 (pages 33-59) discuss precursor instruments – trial lenses, trial frames, optometers, and phorometers. Chapters 7 through 11 (pages 61-89) are devoted specifically to phoropters. After a brief introduction to phoropters in chapter 7, chapters 8 through 10 are organized to illustrate the evolution of particular lines of instruments made in the United States. Chapter 8 starts with Henry DeZeng's phoropter patented in 1909 and proceeds through the Phoro-Optometer to the No. 574, No.584, No. 588, No. 589, No. 593, and the AO Model 590 to the AO Rx Master.

Chapter 9 notes that patents received by Nathan Shigon in 1910 and 1915 were transferred to the Woolf Instrument Corporation which subsequently produced the Ski-Optometer Models 215 and 205. The patents were later transferred to the General Optical Company and the Shuron Optical Company which produced the Genothalmic Refractor. Chapter 10 looks at the Bausch & Lomb Greens Refractor and the Greens II Refractor. The Greens Refractor was developed from the patent of Clyde Hunsicker by A.S., L.D., and M.I. Green. Chapter 11 briefly mentions some phoropters made outside the United States.

In an epilogue on page 91, the author notes that "Phoroptors have advanced significantly since the time DeZeng, Woolf, General Optical, and the Greens first designed them. Improvements have been substantial and the competition has been hardy. Eventually Woolf, Shuron, and Bausch & Lomb stopped making phoroptors. Only the line of DeZeng/American Optical prevailed and it has now achieved a century of producing phoroptors in America."

The monograph contains 31 figures, most of which are photographs or diagrams of phoropters. There are also pictures or diagrams of optometers, phorometers, and other instruments. A five-page listing of references can be found on pages 93 to 97. The book is produced in a 22 cm high by 14 cm wide format.

I found this book to be enjoyable, easy, and quick to read. I learned quite a bit about the history of phoropters. The author is a 1977 graduate of the Indiana University School of Optometry and practices in Wheaton, Illinois. He can be contacted at GaryLCampbell@gmail.com to obtain a copy of the book.

Book Review: The Microscope and the Eye: A History of Reflections, 1740-1870

The Microscope and the Eye: A History of Reflections, 1740-1870. Jutta Schickore. Chicago: University of Chicago Press, 2007. ix + 317 pages. ISBN-10: 0-226-73784-5. ISBN-13: 978-0-226-73784-3. Hardcover, $40.

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This book examines a number of issues surrounding the use of the microscope in the eighteenth and nineteenth centuries. It is not a chronology of the development of the microscope. Rather, the author elaborates on matters such as the discourses among microscopists concerning the correctness of the observations being made; studies of how visual function affected the perception of objects viewed with the microscope; use of microscopes in validation of surveying, meteorology, and astronomy instruments; advance of the use of microscopes from parlor amusement to scientific tool; use of microscopy to study neural and retinal tissue; realization that different chemicals used to handle tissues affected the observations with the microscope; and views on the value of microscopy. The inclusion of the words microscope and eye in the title reflects the fact that the author emphasizes that the eye was one of the objects studied with the microscope during the time in question, that "The eye and the microscope together have been described as an optical system…", and that "the enhancement of the eye's powers through the microscope has been indispensable for the study of subvisible realm…" (page 1)

The author notes that the book addresses three main questions: "What were the main procedural problems that the microscopists addressed? Did they assume that these problems could be solved, and if so, how? What conclusions did the practitioners [of microscopy] draw regarding the epistemic merits of the microscope, microscopy, vision, and the validity of specific observations and results?" (page 10) Emphasis is on Great Britain and the German lands.

Popular eighteenth century books on microscopy included books by Henry Baker, Benjamin Martin, and George Adams Senior. Martin and Adams were instrument makers. Baker was a gentleman of science who wrote on a number of different topics. These books were somewhat modeled after Hooke's 1665 book on microscopy. They dealt with a variety of matters such as procedural instruction, optics of the microscope, and descriptions of various objects seen with the microscope, and the promotion of microscopy as a means of improvement of the observer as "a tool for gathering factual knowledge as well as for gaining self-knowledge, a means of elevating the soul by presenting it with the marvels of the divine creation." (page 21)

Concerns about "optical deceptions" in microscopy are related to the study of optical illusions and sensory perception in the early 1800s. Studies by Thomas Young, David Brewster, Michael Faraday, and Peter Mark Roget of perceptual function as it relates to microscopy are discussed. Test objects were adopted to test the quality of observations with microscopes and the level of distortion produced with different microscopes. Test objects included scales, feathers, or other parts of various animals and insects.

The book examines the work of Johannes Müller and the development of microscopy in German universities. Prior to that time, microscopy was largely a social avocation of gentleman scientists in each other's homes. Among Müller's students were Henle, Schwann, Virchow, Haeckel, Helmholtz, and duBois-Reymond. Detailed discussions of methods of microscopy started to appear in publications in the 1820s.

Separate chapters are devoted to the study of nervous tissue and the retina with microscopy. Debates about the fine structure of these tissues and the possible functions of their parts are examined along with their implications for the understanding of vision and for the improvement of microscopy. Familiar names from nineteenth vision science found in these chapters include Brücke and Volkmann.

This book roams over a broad range of topics surrounding the uses and methodology of microscopy and how microscopy was viewed and practiced by the microscopists of the time. Along the way the reader can gain some glimpses of historical perspectives on the interrelations of microscope and eye. The author is Assistant Professor of the History and Philosophy of Science at Indiana University.

Optometric Historical Society Membership Application

Membership in the Optometric Historical Society (OHS) is open to anyone interested in the history of optometry, spectacles, vision science, or related topics. Membership includes a subscription to *Hindsight: Journal of Optometry History*.

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