The green cataract seen in the 16th to 18th centuries was reinterpreted in the 19th century (on the basis of pathological examinations) to be a greenish color of the light returning through the pupil in an eye with absolute glaucoma and not due to a greenish discoloration of a cataract. Were the older observers in error? It seems unlikely. This article presents photographs of true green cataracts—ie, opaque lenses of greenish color—from my own practice; a published photograph of a green cataract; and histopathological documentation of the cause, iron (blood pigment).

Bartisch, writing in German (in 1583),1 and Heister in Latin (in 1739)2 both characterized cataracts by their colors. They described white, gray, black, blue, yellow, and green cataracts (“grüne Star/Viridis cataracta” [Bartisch] and “subviridis” [Heister]). Bartisch wrote sections on each type and prescribed specific management regimens, purgatives, and collyria for each. Surgery for green cataract was prescribed (and indeed in any eye without light perception): experience had shown that the couching of a green cataract would not restore vision.

In 1705, Brisseau on the basis of dissections correctly ascribed cataract to an opacification of the lens rather than to a membrane in front of it.3 In 1709, he also reported the dissection by Maréchal of the eye of a patient with a “green cataract,” who found not opacity of the lens but a discoloration of the vitreous. Brisseau proposed that the term cataract should be reserved for opacities of the lens and that glaucoma be used for those cases of greenish changes in the vitreous behind a lens (often with a clear lens).3

Beer was reported to have done several dissections in 1809 that confirmed Brisseau's findings. He found that most of the opacification and discoloration of the vitreous lay near the retina.3

These isolated reports were confirmed and augmented in 1830 when Mackenzie dissected more glaucomatous eyes and published his findings in the Glasgow Medical Journal (which he had founded) and in his widely read A Practical Treatise on Diseases of the Eye. The treatise went through 5 English editions (one in the United States) and translations into German and Italian. He found the lenses in these eyes to be transparent but with a yellowish hue, not the “deep sea-green” color seen in the living eye. He explained this discrepancy to be due to filtration of the returning light and coined the term diplochromatism of the lens. In his 1855 American edition,5 with mature consideration, he wrote

A green cataract is always attended by glaucoma. . . . On dilating the pupil by belladonna, the green appearance presented in simple glaucoma seems to retire to a greater depth. . . . The lens [is] of an amber or yellowish brown color. . . .

He also wrote:

The distinctive characteristic of glaucoma is a green or greenish color of the pupil. The second stage of glaucoma is the only one in which removal of the lens can be defended. . . . [the] cataracte lenticulaire verte operable of M. Sichel. The pale muddy green opacity [lies] behind the pupil, more deeply seated than the opacity in ordinary cataract. . . . [In operable cases] vision is not extinguished. . . . the eyeball is not hard and stony to the feeling. . . .

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The point was argued and Sichel himself stated in 1837 (translating the French): “The colors of the opacity of the lens vary, . . . white . . . or green . . . .” His 1841 paper is quoted by Rintelen as quoting Saint-Yves in 1722 (translating from the French again):

Glaucoma is a type of alteration of the crystalline lens, following a paralysis of the optic nerve. . . . Because of this the crystalline loses its transparency and takes on the color of the sea.

Mackenzie won the debate and as happens even in the precise language of science, the very term changed its meaning. Even today, the phrase grüne Star in German means glaucoma.

It is now universally agreed that there are no green cataracts. Interestingly, the greenish pupil indicative of glaucoma is no longer seen either. Were the old observers deceived?

The story is an intriguing one. I report my own observations and opinions with photographs of green cataracts.

METHODS AND MATERIALS
I have seen several patients in the past 55 years who clearly fit the literal diagnosis of green cataract. Because of a growing interest in the subject, in later years I made an effort to record the diagnosis and to photograph these cases. The 90,000 old records in my office were handwritten and impractical to search. A search of the 17,000 computerized records of patients seen in the last 13 years of practice yielded 2 cases. A search of the files of photographs yielded 6 more. All photographs were taken with the same camera, using electronic flash.

RESULTS
The Table summarizes the findings in the 8 cases I could find and the case in the American Journal of Ophthalmology. All of the cases I have observed followed vascular occlusion, severe trauma, or end-stage retinitis proliferans with an intraocular hemorrhage or a retinal detachment behind the cataract. Pathologically, patients with chronic retinal detachment and pain have hemorrhage. All had absolute glaucoma with rubeosis iridis and no light perception. Hence, none could have had vision restored by removal of the cataract and their conditions were inoperable. The greenish color reminded me of the greenish discoloration that is sometimes seen in areas of skin around a

<table>
<thead>
<tr>
<th>Case</th>
<th>Race/Sex/Age, y</th>
<th>Basis</th>
<th>Vitr Hem</th>
<th>Hyphema</th>
<th>Rubeosis</th>
<th>Glaucoma</th>
<th>RD</th>
<th>VA</th>
<th>Enuc</th>
<th>Age at Death, y</th>
</tr>
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<tr>
<td>1</td>
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<td>Vasc occl</td>
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<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>NA</td>
<td>NLP</td>
<td>NA</td>
<td>79</td>
</tr>
<tr>
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<td>Vasc occl</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>NA</td>
<td>NLP</td>
<td>NA</td>
<td>84</td>
</tr>
<tr>
<td>3*</td>
<td>W/M/51</td>
<td>Vasc occl</td>
<td>NA</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>NLP</td>
<td>NA</td>
<td>71</td>
</tr>
<tr>
<td>4+†</td>
<td>W/M/39</td>
<td>Trauma</td>
<td>Prob</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>NLP</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>W/M/63</td>
<td>Trauma</td>
<td>Prob</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>NLP</td>
<td>NA</td>
<td>71</td>
</tr>
<tr>
<td>6†</td>
<td>W/F/23</td>
<td>Juven diab</td>
<td>NA</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Vasc occl</td>
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<td>Y</td>
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<tr>
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<td>NA</td>
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<td>Y</td>
<td>Y</td>
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<tr>
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<td>Y</td>
<td>NA</td>
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</table>

Abbreviations: AJO, American Journal of Ophthalmology case; Enuc, enucleation; Juven diab, juvenile diabetes; LP, light perception; NA, not available; NLP, no light perception; Prob, probably; RD, retinal detachment; VA, visual acuity; Vasc occl, vascular occlusion; Vitr Hem, vitreous hemorrhage; Y, yes (present).

*The patients in cases 3 and 4 had severe ocular ischemia syndrome and stroke.
†The patients in cases 4, 6, and 8 went on to phthisis.
bruise that is resorbing, from the breakdown products of blood pigments, but the cause of the green color of the cataracts needed elucidation.

Case 1

A white woman was first seen in 1969 at age 54 years, stating that she had suffered hemorrhages in both eyes, more marked in the left. On advice, she had discontinued using birth control pills. When I saw her, visual acuity with best correction was 20/15 OD and 20/30 eccentrically OS. The vessels temporal to the left macula were markedly tortuous, but there was no macular pigment disturbance. The patient was seen occasionally for a few years.

In 1990, 21 years later at age 75 years, she saw another ophthalmologist in the state where she was then living because of total loss of vision in her left eye. Workup demonstrated a total block of the left carotid artery, and she was told that nothing could be done for her eye. She returned to my practice for another opinion. The left eye had no light perception. There was rubeosis of the iris and a greenish mature cataract. A B-scan showed a vitreous hemorrhage. Intraocular pressure was 25 mm Hg. She returned again in 1993: there were depigmentation of the iris, rubeosis of the chamber angle out onto the cornea, and a slightly greenish-yellow mature cataract. The pupil was fixed at 5.5 mm, and the pressure was 24 mm Hg. I did not see her again; she died the next year.

Case 2

A white man was first seen in 1965 at the age of 68 years complaining of blurred vision in the right eye for 6 weeks. The left eye was normal with acuity correctable to 20/20−. Acuity OD was 20/200, pressure was 17 mm Hg, and there was no cataract. There was a branch retinal vein occlusion with hemorrhages and exudates emanating from the disc superiorly and extending into the upper half of the left fundus. He went on to rubeosis, a mature cataract, hemorrhagic glaucoma, and no light perception. The photograph in Figure 3A was taken in 1974 and shows a mature green cataract, rubeosis, and chronic hyphema. Further observation of the cataract was prevented by blood staining and subsequent opacity of the cornea. He died in 1981. Figure 3B of the left eye shows the heterochromia.

Case 3

In 1972, this white man had had a left stroke. A year later, when I first saw him at age 49 years, he had developed a left ocular ischemic syndrome with rubeosis, uveitis, glaucoma, total retinal detachment, and a green cataract. He was 51 years old when a photograph herein of his left eye (Figure 4) was taken. Later the rubeosis disappeared as did the green color of the cataract. Phthisis ensued. In 1980, I removed the cataract in his right eye, which did well with the aid of repeated cryopexies, maintaining 20/25 visual acu-
Case 4
A white man was 39 years old when first seen in 1972. His left eye had been struck by a baseball 20 years earlier, with detachment of the retina. It was never operated on. He had no light perception, fine rubeosis, and an intraocular pressure of 50 mm Hg. There was a shrunken, hypermature greenish cataract (Figure 5). He was followed up for 21 years with bouts of iritis. The rubeosis disappeared, but the eye became phthisical and the cornea developed a nummular opacity centrally. The right eye remained normal.

Case 5
A 63-year-old white man presented in 1977 with rubeosis, glaucoma, retinal detachment on A scan, green cataract, and no light perception in both eyes. Two years later, she had mature cataracts. The cataract in the right eye had a slight but definite greenish color when Figure 7 was taken. I followed up with her for another 2 years; she developed phthisis in both eyes. She was lost to follow-up 1 year later when she planned to get married.

Case 6
A 74-year-old man was first seen in my office in 1982 wanting a second opinion about removal of the cataract in his right eye. He had been treated for glaucoma in both eyes since 1968 and had had laser treatment for retinal vascular problems in both eyes. He had had coronary artery surgery in 1980 and had suffered a stroke during the operation. Four months before I saw him, a vessel in the left fundus had broken, with profound loss of vision.

When I saw him, the vision was improvable to 20/40−; the left eye had no light perception. The right eye had minimal cataract with a clear view of the fundus; the acuity was accounted for by macular changes. The left eye had corneal haze, a pressure of 34 mm Hg, fine rubeosis iridis, a fixed pupil, and dense cortical and nuclear cataract with a green cast (Figure 8). No hyphema was noted on the first visit, but a variable amount of hyphema was seen on subsequent visits. Intraocular pressure OS varied between 46 and 54 mm Hg on follow-up. The right eye had normal intraocular pressures on the Timoptic (Merck & Co Inc, Whitehouse Station, NJ) and Propine (Allergan, Irvine, Calif) the previous ophthalmologist had ordered. The visual field of the right eye showed a left hemianopsia, consistent with the history of stroke. Because of increasing pain in the left eye, on request an enucleation was performed.

Case 7
A 74-year-old man was first seen in my office in 1982 wanting a second opinion about removal of the cataract in his right eye. He had been treated for glaucoma in both eyes since 1968 and had had laser treatment for retinal vascular problems in both eyes. He had had coronary artery surgery in 1980 and had suffered a stroke during the operation. Four months before I saw him, a vessel in the left fundus had broken, with profound loss of vision.

When I saw him, the vision was improvable to 20/40−; the left eye had no light perception. The right eye had minimal cataract with a clear view of the fundus; the acuity was accounted for by macular changes. The left eye had corneal haze, a pressure of 34 mm Hg, fine rubeosis iridis, a fixed pupil, and dense cortical and nuclear cataract with a green cast (Figure 8). No hyphema was noted on the first visit, but a variable amount of hyphema was seen on subsequent visits. Intraocular pressure OS varied between 46 and 54 mm Hg on follow-up. The right eye had normal intraocular pressures on the Timoptic (Merck & Co Inc, Whitehouse Station, NJ) and Propine (Allergan, Irvine, Calif) the previous ophthalmologist had ordered. The visual field of the right eye showed a left hemianopsia, consistent with the history of stroke. Because of increasing pain in the left eye, on request an enucleation was performed.
performed in 1985. The patient died 2 months later.

Histopathological examination of this enucleated eye showed a loss of the retinal ganglion cells and complete glaucomatous optic atrophy (Figure 9A) with rubeosis, peripheral anterior synchecia, and hyphema (Figure 9B and C). Iron stain revealed a heavy deposit of iron in the lens epithelial cells (Figure 9D), accounting for the green discoloration of the cataract.

Case 8

A 59-year-old white man was seen in consultation in 1995 and found to have a retinal detachment with a vitreous hemorrhage, counting-fingers visual acuity, and early cataract in his right eye. The detachment was replaced, but he soon developed rubeosis, heterochromia, a greenish mature cataract (Figure 10), and bare light perception vision with early phthisis. He and his wife were anxious to have the cataract removed, but I advised against it. A white cataract with a brunescent nucleus is included as a color control (Figure 11).

COMMENT

By the 18th century, it was known from the work of Brisseau3 and others that the crystalline lens sat just behind the iris and that a cataract was opacity of the lens itself and not a membrane in front of it. Characterization of cataract, as it had been for centuries, was made by gross examination through an undilated pupil and included density and color. Without Helmholtz’s ophthalmoscope (1850)9 and Henker’s slit-lamp (1916), subtle distinctions hardly existed, and attention was given to gross characteristics such as color. Atropine was not used much in ophthalmic practice until 1801.11 A cataract in the 18th century was an opacity that was visible to the unaided eye just behind the undilated pupil. Cataracts that could be couched or extracted successfully were “mature”: a completely milky opacity.

If there were green cataracts, what shade or hue of green? Mackenzie5 described the pupil in the living eye in these cases as sea green and later as muddy green, but he was not referring to cataract at all but to cases of glaucoma in which he thought the lens acted as a filter, transmitting the yellow and green rays while absorbing the blue and red. The cases I have seen are not the green of a red-green stoplight or grass, but instead a subtle greenish cast to a white or brownish cataract.

Note that prior to 1850, the diagnosis of glaucoma was imprecise by today’s standards. Ophthalmoscopy, visual field testing, and quantitative measurement of intraocular pressure all awaited the later work of Helmholtz, von Graefe, and others.

The observation of a greenish cast to the pupil became quite common once mydriatics were used. In the 1892 edition of his textbook, Ernst Fuchs states: “This reflex, however, is a characteristic by no means restricted to glaucoma. It is always found when the pupil is dilated, and at the same time the media are not completely transparent.”12 The shades of green found in drawings of the 18th and 19th centuries varied. With the invention of the ophthalmoscope, a much more accu-
rate description and differential diagnosis erased first the dependence on and then the observation of a greenish cast in the pupil. References to green cataract disappeared. Now we no longer see green pupils either, in glaucoma or in any other entity.

Within limits, does the color of the examining light make any difference? It certainly does if one is using photographic film. Thus, daylight film must be used for exposure by daylight or electronic flash, and film balanced for tungsten light must be used for electric lights. Fluorescent lights yield a greenish cast to photographs. The human eye is quite different. A white shirt appears white to us in daylight, tungsten light, fluorescent light, or even candlelight. And the color of the pupil would be compared with the apparent color of the sclera (also in color photographs). The speculation that the greenish cast was due to the color temperature of the illumination by which the observations were made does not stand scrutiny. Some of the older observations were made in daylight or with a beam of daylight admitted through a shuttered window. Forty years ago, Snyder described an experiment in which trained ophthalmologists observed the pupil of an eye with absolute glaucoma and nuclear sclerosis. None of them saw any greenish color.

The distinction arose initially in the observations of surgeons who, on the basis of experience, strongly

Figure 8. When the patient (case 7) was 76 years old, the left eye had a green cataract, rubeosis, hyphema, and corneal edema secondary to uncontrolled glaucoma.

Figure 9. Histological examination of case 7 showed loss of ganglion cells and marked glaucomatous cupping of the optic disc (A) with rubeosis, hyphema and peripheral anterior synechia (B and C), and a heavy deposit of material in the lens epithelium (D) that took up iron stain, hence the green color of the cataract.
advised against surgery on green cataracts because surgery would fail to restore vision. The cataract surgeon of the 15th to 18th centuries was performing couching. The extracapsular surgery introduced by Daviel in 1752 was limited to mature cataracts with a white pupil. The proscription against operating on green cataract was applied to both couching and extraction. The definition was not just of clinical import, but surgical.

Heavy metals are toxic: lead, mercury, iron, copper, manganese, cadmium, arsenic, nickel, aluminum, silver, and beryllium. They form complexes with organic compounds by binding to oxygen, nitrogen, and sulfur to inactivate enzymes and alter protein structure. Lead has recently been proposed to be a risk factor for cataract, which was white in the illustration. Mercury (cinnabar) is used to produce a tattoo of red color. Although mercury can cause “innocuous” reddish brown mercury-containing pigment deposits under the lens capsule, these persist for many years but are said not to progress to cataract. There is now 1 case report of a Japanese newborn with cataract who had elevated blood levels of mercury. His mother had used soap containing mercury during the pregnancy. I could not find a report of mercury associated with an increased incidence of cataract in Japanese adults, although chronic mercury poisoning is a public health problem in Japan. Perhaps that possibility would be worth investigating. Beryllium produces pulmonary granulomas and fibrosis and conjunctival irritation but no mention of cataract; it would be interesting to examine these patients with a slitlamp. In the absence of contrary data, I assume that heavy metals other than iron do not produce cataract of a greenish hue. The rapidly maturing toxic cataract seen in some younger alcoholic adults is white.

What we do not understand in the writings of others is often presumed error. There then follows a great deal of speculation as to “what the author really meant.” In the case of green cataract, it is my thesis that the experts of former years meant exactly what they said: that they observed, as I still do, mature cataracts of greenish hue, the removal of which would not restore vision. We do not know what the incidence of these cataracts was 300 years ago. Heister says green cataracts were infrequent; they are very unusual today. It is interesting that current observers do not pay attention to the green hue of these lenses in their preoccupation with the vascular occlusive disease, rubecis iridis, absolute glaucoma, and amaurosis. Perhaps believing that green cataracts do not exist contributes to not seeing them.

CONCLUSIONS

Green cataract is a distinct entity, correctly described by our forbears and still observable today. It is due to the presence of blood pigments that have leached into a mature cataract from the breakdown of intraocular hemorrhage, concentrated in the lens epithelial cells under the anterior capsule. It is usually accompanied by rubecis iridis and an absolute glaucoma. The old observation that surgery on these cataracts will not restore vision is also correct.

Portions of this material were published as part of a Festschrift in

Figure 10. A 59-year-old white man (case 8) who developed rubeosis and a mature greenish cataract after surgery for a retinal detachment with a vitreous hemorrhage.

Figure 11. A white cataract with a brunescent nucleus as a color control.
This article was presented at the 2004 meeting of the Cogan Ophthalmic History Society. Heitz commented on the confusion in the old texts between cataract and blindness as well as glaucoma and drew my attention to the paper he had presented to the society. He also supplied me with a source, with an excellent summary by him, for ancient French publications that had not been available to me.

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REFERENCES


Calendar of Events: A New Web Feature

On the new Calendar of Events site, available at http://pubs.ama-assn.org/cgi/calendarcontent and linked off the home page of the Archives of Ophthalmology, individuals can now submit meetings to be listed. Just go to http://pubs.ama-assn.org/cgi/cal-submit/ (also linked off the Calendar of Events home page). The meetings are reviewed internally for suitability prior to posting. This feature also includes a search function that allows searching by journal as well as by date and/or location. Meetings that have already taken place are removed automatically.