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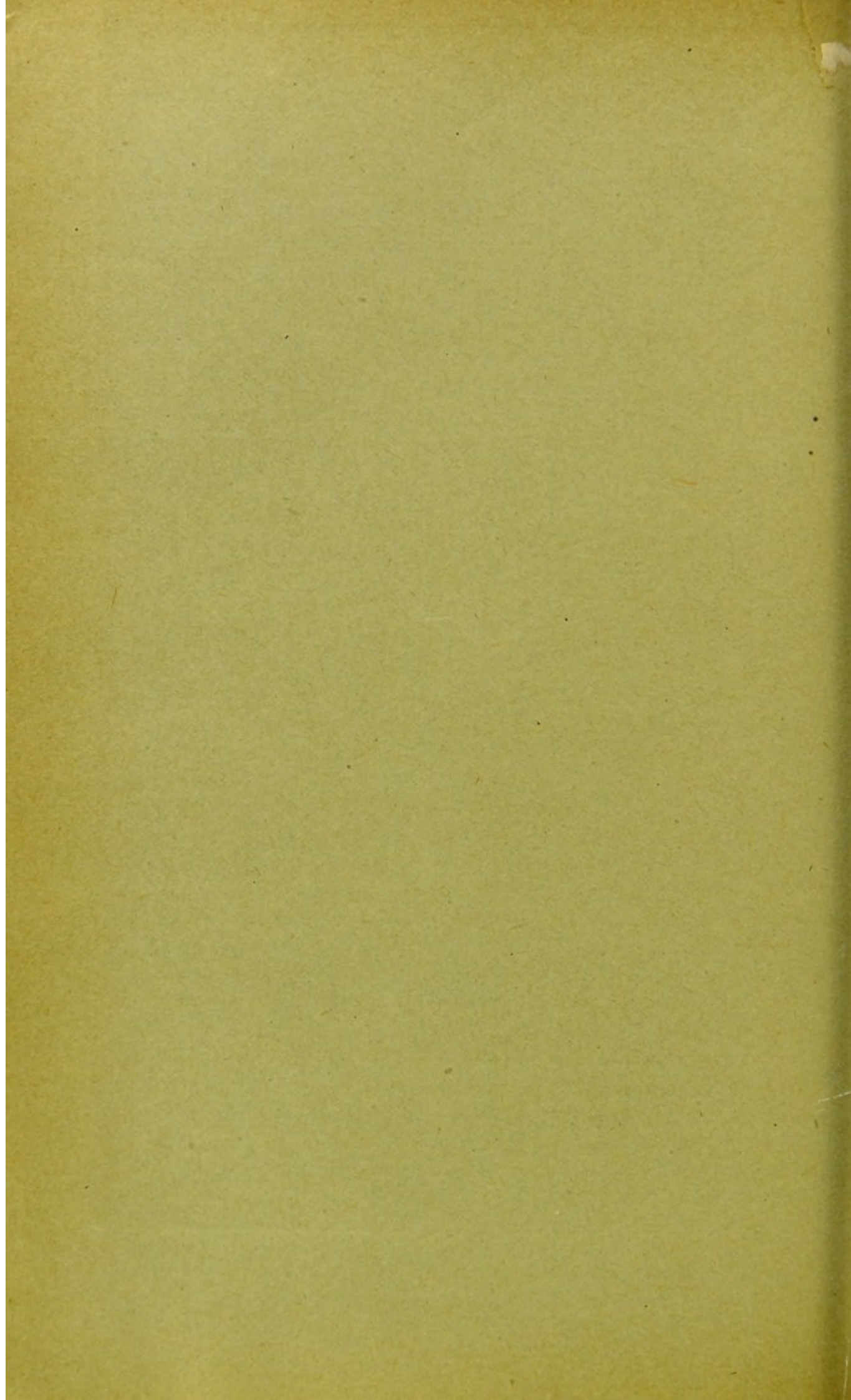
CONCERNING SIDEROSIS BULBI

BY

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CONCERNING SIDEROSIS BULBI.*

BY CHARLES J. KIPP, M. D., NEWARK.

The fact that eyes harboring fragments of iron do sometimes, after a varying length of time show discoloration of the iris, a brownish staining of the cornea, yellowish brown dots arranged in the form of a wreath under the capsule of the lens, brownish staining of the lens and cataract, has been known for a long time. v. Graefe (1) seems to have been the first to call attention to the yellowish brown spots in or under the anterior capsule of the lens in an eye, which according to the history of the case, had been struck by a fragment of a gun cap. The eye was enucleated and on examination a splinter of metal was found in its interior. Since then Leber (2), Samelsohn (3), Landmann (4), Vosius (5), E. v. Hippel (6), Eisenberg (7), Natanson (15), Barkan (16), and others have reported cases in which these rust spots were present, and in which fragments of iron were found in the eye.

The appropriate term Siderosis bulbi seems to have been first used by Bunge (8) in a paper giving his views as to the manner in which iron was disseminated in the eye.

Leber holds the view that the iron is dissolved by the carbonic

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acid of the tissue, the solution in this form of bicarbonate of iron is diffused through the tissue, and precipitated by the oxygen of the arteries in an insoluble form.

The most complete anatomical examination of cases of Siderosis bulbi has been made by E. v. Hippel; Bunge, and Bednarski (9) have also examined a number of eyes with siderosis of xenogenic origin.

My own interest in the subject was aroused by cases which I saw long before the sideroscope was invented and the Roentgen ray was made available for the location of foreign bodies in the eye. Since then I have been constantly on the lookout for such cases and it has been my fortune to see a good many of them.

I have seen a number of cases on which the cornea was stained brownish for some distance around a fragment of iron which had been lodged in it for weeks, but I have never seen staining of this membrane from iron located in the lens or deeper in the eye. Bunge has reported two cases of siderosis cornea. The fragment of iron was situated in the nasal ora serrata, Hirschberg (10) saw 2 1-2 years after a fragment of iron had entered the eye, a deposit of yellow dots on the posterior surface of the cornea. Praun (11) has reported a case in which a large splinter of iron had remained for a year in the center of the cornea causing a ring of rustbrown color 2 mm. in diameter which was surrounded by a somewhat lighter ring of 5 mm. in diameter.

The change in the color of the iris mentioned by other observers I have seen only in cases in which the yellowish brown dots arranged in the form of a wreath under the anterior capsules of the lens, were present at the same time. I have seen both a yellowish brown and a greenish yellow discoloration, but the first most frequently. The eyes showing this discoloration of the iris had in all my cases harbored the fragment of iron more than six months. I may say right here that in all of the cases on which these remarks are founded the fragment of iron was either extracted by means of the magnet or the iron was found in the enucleated eyeball. The discoloration of the iris due to xegoneous siderosis has been seen to disappear again and the original color restored after the removal of the iron (Hirschberg (12)), and even in cases in which the iron remained in the eye (Vossius (15)). In my own cases the discoloration remained in all cases after the extraction of the iron as long as they were under observation. It is well-known that a similar discolora-

tion of the iris follows extensive hemorrhage in the vitreous and some times in the anterior chamber and so far as I have been able to discover there is no difference whatever in the discoloration caused by either. Hirschberg thinks that the discoloration due to iron in the eye is permanent, while that caused by hemorrhage may disappear.

The change which I regard as of greatest practical importance, is the appearance of the yellowish brown spots under the capsule to which already repeated reference has been made. Anyone who has seen them will always recognize them thereafter. These spots are of a round form, less than 1-2 a mm. in diameter are of a yellowish brown color, and appear at regular intervals of about a mm. or two, in a circle, in or under the capsule of the lens, about midway between the anterior pole and equator of the lens. In addition to these spots there often are also spots on the anterior capsule, also of a yellowish brown color, but situated much nearer to the anterior pole—the remains of broken posterior synechiæ. The spots behind the capsule, are only seen after nearly ad maximum dilatation of the pupil. I have seen these spots repeated in eyes in which the lens was still transparent and in which the capsule had not been ruptured. In all the cases in which they were present the fragment of iron was found back of the lens. In former years, before we had the sideroscope I have repeatedly cut open the eye and extracted the fragments of iron by means of the small electro-magnet, on no other evidence of the presence of iron in the eye, than the spots here described. Even now I should not hesitate to proceed to operate, if both the Roentgen ray picture and the sideroscope failed to reveal the presence of iron in the eye, and the spots here described together with the discoloration of the iris were present.

The lenses in which these spots are seen are in most cases opaque as in the following case:

Case 1. F. D., 30 years of age was seen by me for the first time February 2, 1906. He came to have a cataract removed from left eye. I learned from him that two years ago he was struck on the left eye by a piece of iron; he did not think that the iron penetrated the eye as he had but little pain at the time, and his vision remained good for some time after the injury. He did not consult a surgeon about the injury as he considered it trifling. About six months after the injury his left eye became suddenly much inflamed, it was very red and somewhat painful and a few days later he noticed that the eye was

practically blind. The inflammation gradually passed away, but the vision has not improved. The examination showed the right eye to be perfectly normal in every respect. With a -0.5D. glass the vision was 6/5. The *left eye* was free from injection; the cornea was perfectly clear, no scar was visible in it or in the sclera; the anterior chamber was very shallow, the iris was discolored brownish (the iris of the other eye was blue). The pupil was of medium size and active; the lens was opaque and on its anterior capsule in its pupillary area were three dark brownish spots of irregular form. The pupil dilated readily ad maximum after the instillation of a one per cent. solution of sulphate of atropin. At the margin of the dilated pupil was now seen a wreath of yellowish brown round spots each about 0.5 in diameter. They were arranged at regular intervals of about 1.5 mm. and formed a complete ring. They were apparently situated in or under the capsule. The eye had perception of light only. From the appearance of the eye, I felt confident that it harbored a fragment of iron and advised the patient to go to the hospital where I would try to remove the fragment with the electro-magnet. This attempt was made on March 27, 1906, after the sideroscope had confirmed my suspicion of the presence of iron in the eye. It failed however to indicate the part of the eye in which the fragment was located. The eye was placed before the pole of the large or giant electro-magnet and kept there till the magnet got so hot that it was thought best to cut off the current for fear of destroying the apparatus. The magnet produced neither pain in the eye nor any change whatever in the appearance of the eye. Several other attempts lasting as long as the first one, were made on the next day but all with the same result. Although the eye was free from all symptoms of irritation, the patient fearing that the other eye would become sympathetically affected, I consented to enucleate the eye and did this under local anæsthesia on the following day. The wound healed in a few days and he was discharged on the sixth day after the operation.

Immediately after the enucleation I opened the eye and found the following condition. The iris was almost in contact with the cornea. The lens was much swollen and opaque and pushed the iris forward. The vitreous chamber was filled with a watery fluid. Of the vitreous body only a small quantity remained, it was condensed and extended from the ciliary process in the form of a strand to the retina between the equator and the

posterior pole in the temporal half; at this point was found a large foreign body, partly black, partly of color of iron rust and covered by a thick whitish membrane. On looking more closely at the beginning of the condensed remains of the vitreous body it was found to be adherent to the orbiculus ciliaris on the temporal side, where a long slit or opening in this structure could be distinctly seen. It was evidently at this point where the foreign body had entered and that the strand of vitreous represented the track of the iron. The foreign body was 7 to 8 mm. in length, about 4 mm. in width and 2 to 3 mm. in thickness. The major part was lying off the retina, but its inner end had penetrated the retina, the choroid and the sclera. The end of it was very sharp pointed and could be seen and felt on the outside of the sclera. The retina was evidently thickened throughout and of decidedly brownish color, the retinal vessels were unusually distinct and of an almost black hue. The papilla was flat but also brownish in color. Over the entire retina were strewn innumerable very minute elevations also of a dark color, they looked like very fine sand. I do not think that the retina was detached in any part when the globe was opened, but shortly after it had been placed in a solution of 3 per cent. formalin, I noticed several folds in it near the foreign body. I removed a part of the retina and placed it in a solution of ferro cyanide of potassium (2 per cent) and afterwards in weak hydrochloric acid. This treatment changed its color from brownish to a beautiful blue. Under a low power, the surface of the retina was found to be covered with dark blue minute elevations which were especially abundant on the sides of the vessels which also were of a blue color. The eye was then put in a 3 per cent solution of formalin. I may here mention that to convince myself that the foreign body was iron, I held the bottle containing the globe with the foreign body in it, at some distance from the pole of the large Haab electro-magnet and that before one side of the bottle came in contact with the magnet the eye, which was at the other side of the bottle measuring about 3 inches across, began to move toward the pole of the magnet and in a few seconds had reached the other side of the bottle. Later I held the globe itself within the cornea in front against the pole of the magnet for many minutes without producing the slightest movement in the foreign body. I submitted the globe for further micro-chemical examination to Dr. Dixon, whose report is as follows:

My Dear Dr. Kipp:

As you know, the eye was exceedingly brown—a shade not attributable to the presence of ordinary pigment, nor yet *ordinary* siderosis, hence I felt that the iron reaction should be very marked; but ordinarily applied it was not.

I send you four slides. The two stained after Van Gieson show the corneal epithelium intact; Bowman's membrane poorly marked; circumcorneal injection; a few wandering cells in the cornea propria; Descemet's membrane intact, and Schlemm's canal open.

The iris is rather densely pigmented, vessel walls somewhat thick, but otherwise normal.

The lens is in a condition of Morgagnian cataract well advanced, with pigment deposits under the anterior capsule.

The ciliary processes and body in good condition, but the choroid atrophied.

The retina is somewhat degenerated and the inner layers beginning with the external reticular layer loaded with pigment principally granular in character, particularly in the vicinity of the vessels, but a few chromatophores are to be seen.

The nerve and sclera appear to be normal, except that the latter presents collections of pigment in a few of the lymph spaces.

The other two sections are stained after Perl's method for iron reaction—Berlin blue. You will notice that one is very blue, and the other is a yellowish green. The first owes its color to prolonged action of the reagent, the other to the usual length of time. In the first specimen the iron appears to have been dissolved out and then reabsorbed, thus diffusely staining the entire section. The other was not allowed to remain in the reagent sufficiently long to set free so much Berlin blue, and hence is of a yellowish green color.

In these Berlin blue specimens you will find particles of iron somewhat diffusely located, no particular set of cells appearing to be implicated in the dissemination of the iron; for instance, the particles will be found in the lens substance and about the capsule, in the irisstroma, the cornea propria, in the retina, and the nerve, but not to the extent that would be anticipated from the brown discoloration of the different parts of the globe.

This dusky brown color appears to be due more to the deposit of haemosiderin than true siderosis. You will observe that some of the new formed retinal pigment reacts as iron, and some does not, which corresponds with the change which would be expected

to take place in deposits of haemosiderin—that is, after a time it is likely to fail to respond to tests for iron—further that it is principally granular, is in and about the blood vessels, is of a color entirely different from the neighboring autochthonous pigment, and is of the same character as the pigment under the anterior capsule of the lens.

I would further call attention to the fact that the greater part of the Berlin blue will be found on the surface of the specimens, showing that it has been washed out in considerable quantities and evidently came from the adventitious retinal pigment.

Very respectfully,

GEO. H. DIXON.

June 18th, 1906.

As I have already stated, I have seen the wreath of yellowish brown spots also in a few cases before the lens became cataractous, as the following cases show.

Case No. II. J. C., 27 years of age, consulted me for first time January 10. He stated that about a year ago his left eye was struck by a piece of steel, and that under treatment the eye had healed and had given him no trouble since. He came now because he had a severe pain over this eye. I found that the left eye was free from evidences of inflammation. The cornea was clear; the anterior chamber of normal dimensions; the aqueous was clear. The iris was discolored yellowish brown, (the other iris was brown;) the media perfectly clear. The optic papilla was very red. No disease of retina or choroid. No scar was visible outside or inside the eye. I have no notes of the vision of this eye at this time and I did not dilate the pupil. Under quinin the pain passed away in a few days.

The other eye was perfectly normal.

The patient was not seen again until August 10, six months after his first visit. He told me that since his visit to me, he had had many attacks of inflammation in the left eye for which he had been treated by well known ophthalmologists in another city. One of them had told him that he had a foreign body in his eye, while others equally experienced had advised him against enucleation, which the others had proposed. The eye was now blind. There was severe iritis, many posterior synechiae which were mostly broken up by instillation of atropin. In or under the anterior capsule was a wreath of yellowish brown small dots, placed at regular intervals on a line with the dilated pupil. The

lens was clear. The vitreous opaque. No reflex could be obtained. On the strength of the rust spots in the capsule, the discoloration of the iris and the condition of the vitreous together with the history of the case, I diagnosed the presence of a fragment of iron in the vitreous chamber or the membranes of the eye and asked the patient to let me try to extract it with the small electro magnet. His consent having been given, I made an incision through the coats of the eye, between the insertion of the tendons of the external rectus and inferior rectus muscles, and then introduced the tip of the magnet about 5 mm. in the vitreous chamber. I felt the well known click at once, and on withdrawing the magnet found the fragment of iron hanging to it. The fragment measured about 3 mm. in length and was very slender. The operation was not followed by any marked reaction. Later on he had an atropin conjunctivitis which subsided under sulphate of zinc solution. The eye was free from inflammation for about six months after the operation, then he had another attack of irido choroiditis. Since then I have not seen him.

Case No. III. J. B. D., 49 years of age, states that two days before he was struck on the right eye by a piece of metal. I found a linear wound about 2 mm. in length in the sclera, close to upper margin of cornea. There was not much injection of ocular conjunctiva; the cornea was clear; the anterior chamber of normal dimensions, the aqueous clear; the iris of normal appearance; pupil active, lens clear; the vitreous was very cloudy; the optic papilla seemed normal; in the upper part of the fundus was seen a white spot a little less than a disc's diameter in size and surrounded by an extensive extravasation of blood, apparently in retina. His vision was reduced to 6/10. As the eye gave him no pain he refused to enter hospital and was not seen again for eight months. At this second visit he told me that the injured eye had given him no pain and that vision had been good up to a month ago, when his sight failed rapidly. Last night he had much pain in the eye. The eye was now much injected around the cornea, which was clear. The iris was discolored brownish yellow (the iris of the other eye was brown); pupil was now dilated by atropin. In or under anterior capsule of lens was a wreath, a small round yellowish brown spot, at regular intervals about midway between center and periphery. The lens was clear. The vitreous was full of large floating opacities. The white spot in upper part of fundus was now surrounded by

a broad ring of pigment. No foreign body could be found. S. 5/24. Two days later I made an incision through sclera, choroid and retina between insertions of tendons of external rectus and inferior rectus muscles about 10 mm. back of corneal margin, and through this opening introduced the tip of a hand electro-magnet several times to various depths, but without bringing out a foreign body. The wound healed in a few days. S. 5/24 after the operation. A month after this operation the eye was free from injection and was painless. S. 5/24. Shortly after this last visit the eye became again painful and much inflamed, and vision failed rapidly. Seven weeks after the attempt at extraction with magnet, and ten months after the receipt of the injury, the eye was totally blind, and as the pain was very great I enucleated the eye. An examination of the eye made immediately after the enucleation showed the presence of a fragment of iron about 4 mm. in length and 1 m. thick, covered by a thin membrane on lower part of ciliary body.

I have seen spots of almost the same color as those due to the presence of iron, also arranged in a circle at the same place but situated on the capsule, in a case of interocular hemorrhage followed by severe irido cyclitis with haemorrhage in the anterior chamber.

Case No. IV. The case is that of a man 40 years of age who is otherwise in good health, denies having had syphilis, is of good habits and so far as I can find out is free from disease of any other organ. He came to me with the symptoms of a severe sero-plastic iritis of one eye. He told me that he had consulted an oculist for failing vision of this eye a month before and that the oculist had told him that no local application was required and had prescribed potassium iodide in 10 grain doses. A week later this eye began to pain him and he was induced to place himself under the treatment of a "magnetic" physician. As no improvement followed this treatment he came to me. I found the pupils bound down by many posterior synechiae, and the aqueous very turbid. Under leeches to the temple, instillation of sulphate of atropin and cocain solution, the posterior synechiae were broken up completely. The vitreous humor was found to be so opaque that the fundus could not be seen. A few days later, a clot of blood was seen in the lower part of the anterior chamber, and a few vessels entered the cornea from below. The clot was absorbed in a few days, but an opacity of the size of a pea has developed in the cornea adjoining lower margin; in this area of

opacity are several small dots of denser opacity. Used dionin solution (10 per cent.) once daily in addition to atropin. The globe is now white, but many fine precipitates are now seen on Descemet's membrane, especially in lower half. During the following two weeks, the deposit on Descemet's membrane became more dense and was seen in all but the uppermost quarter of the cornea. The pupil is widely dilated and he is entirely free from pain. Two and a half months after his first visit to me he had a relapse of the acute symptoms with another somewhat larger hemorrhage in the anterior chamber. He recovered from this attack in the course of two weeks. There is now in the lower part of the cornea, a dense opacity of a somewhat pyramidal shape, base downwards evidently on Descemet's membrane there are also a few discreet spots all over other parts of Descemet's membrane. The aqueous is perfectly clear. There is now a wreath of yellowish brown spots, at regular intervals, on the anterior capsule. They are of the size and color seen in eyes containing iron, but are somewhat irregular in outline, not perfectly round. They are connected by a thin thread like opacity. Their situation is on a plane corresponding to the edge of a pupil of medium size. The pupil is now so widely dilated that a ring of not more than 2 mm. in width of the iris is visible. There are other spots of a darker color near the center, the remains of the posterior synechias. The vitreous is still so opaque that no details of fundus can be made out.

The patient is a merchant, has never, so far as he knows, been anywhere where particles of iron were flying about, and it is seen that this eye has never sustained an accidental injury. I think we may safely assume that a haemorrhage in the vitreous body is accountable for its dense opacity.

From this case it is apparent that only on very close examination a differential diagnosis can be made.

These spots under the capsule were found only in connection with cataracts in all the recorded cases. Hirschberg says however, that he has seen them in lenses, the capsules of which had not been broken, and E. v. Hippel (14), who in previous papers stated that he had never seen them in other than cataractous lenses, in his last statement on this subject admits that they are also found in clear lenses. He says moreover, that he has never seen them except in eyes containing fragments of iron.

Among other symptoms of siderosis bulbi, Hirschberg (10) mentions the ochre color of adhesions between the iris and lens

capsule. I have also noticed the same, but have never attached much value to this particular color of posterior synechiae.

Spontaneous mydriasis in cases of siderosis bulbi was observed in four cases out of fourteen seen by Vossius (13), and his examination of the literature of this subject has revealed a few similar cases observed by Mayweg, Wingenroth and Hirschberg. He attributes the mydriasis to irritation of the fibres of the sympathetic nerve which supply the dilator of the iris. Following this mydriasis after a year he has observed a miosis which would not yield to the application of atropin. Atrophy of the musculature of the iris, is regarded as the cause of this condition. The mydriasis as well as the miosis must be a comparatively rare condition, as I do not remember to have seen it in any of my cases.

Spontaneous subluxation of the lens has also been observed by Vossius (13). Spontaneous resorption of the lens has been observed by both E. v. Hippel and Vossius. This I think is not a very rare event. I have seen this cataract disappear entirely leaving only the capsule, in a number of cases especially in young persons.

Torpor of the retina, concentric contraction of the visual field and defective color perception have been frequently observed in cases of siderosis bulbi by the writers already referred to.

E. v. Hippel (6), who has investigated the subject of siderosis exhaustively, by examining human eyes which contained fragments of iron and has studied the effect of iron placed in the anterior chamber and in the vitreous body of rabbits, and studied the effects of injections of blood in the anterior chamber and in the vitreous of rabbits, gives the following as the result of his investigations:

I. The iron reaction with ferro cyanide of potassium and hydrochloric acid succeeds without exception even in preparations which have been kept in Müller's fluid for years, if the action of the reagent is continuous for a sufficiently long period (12 — 24 hours).

A subsequent diffusion of the Berlin blue does not take place either in fresh preparations which are examined in acidulated water, nor in sections which with the avoidance of distilled water, are enclosed in Canada balsam in the usual manner. All the pigment which gives the iron reaction may be decolorized by exposing it to the action of hydrochloric acid for 24 hours.

II. The Berlin blue reactions give exactly the same results

as Quinkes' method with sulphur ammonium, but it is immeasurably more effective, inasmuch as it brings out very distinctly faint colorations in preparations which normally contain pigment.

III. There exists a true siderosis bulbi which may originate in a two-fold manner, firstly direct from the foreign body (xenogenous siderosis) and secondly from the blood (haematogenous siderosis). Siderosis consists of the deposit of oxide of iron combined with the organic substance in certain cell groups.

IV. The haematogenous siderosis is entirely independent of haematogenous pigment; on the other hand "Haemosideria" is a haematogenous pigment to which split-off iron is adherent. The color of the same is not dependent on iron.

V. The siderosis appears predominantly in specific cell groups more particularly in the epithelium of the ciliary processes, the pars ciliaris retinae, the retina and the epithelium of the lens capsule. The siderosis of these parts may be a xenogenous or a haematogenous. The possibility of a genuine siderosis cornea can not be absolutely denied; its occurrence has not, however, been positively proved. It is probable that the brownish discoloration is due to the deposit of haemosiderin.

VI. The "xenogenous siderosis" is produced in such a way that the iron is dissolved by the carbonic acid of the tissues, the solution is diffused and becomes fixed by entering into an insoluble combination with a substance in the protoplasm and becomes gradually oxidized in cell groups which have a specific affinity for the iron. The accumulation of these cells makes micro-chemical authentication possible (distant effect or indirect siderosis). The great concentration of the solution in the immediate neighborhood of the foreign body, is the cause of the great deposition of the iron in the form of an oxide at this place. In the haematogenous siderosis the iron becomes free in the dissolved state and is then subject to the same conditions as that derived from the foreign body.

VII. Neither the greenish nor the greenish brown nor the rust colored discoloration of the iris and the cornea enable us to say positively that a piece of iron is in the bulb, as the same discoloration may be produced by the coloring matter of the blood.

VIII. The characteristic wreath of brown spots beneath the capsule of the lens, in the presence of a foreign body in the

eye, is the result of the deposition of iron in circumscribed collections of proliferating epithelial cells of the capsule.

IX. The introduction of a fragment of iron in the vitreous body is followed by a high degree of degeneration of the retina (Leber). The large peculiar granular cells which are seen in this condition, are derived largely from the pigment epithelium of the retina. The cells of the same have the faculty to proliferate upon certain irritations, to change their form and to actively wander.

X. Exactly the same alteration which the retina of the rabbit undergoes, may appear in the undetached retina of man.

XI. After injection of blood in the vitreous, detachment of the retina may occur (Pröbsting); in addition there appears in the retina degenerative changes which have great similarity to the degeneration in its first stage, produced by the introduction of a fragment of iron in the eye.

XII. Injection of blood in the vitreous following the evacuation of the anterior chamber may cause rupture of the lens capsule; a satisfactory explanation for this phenomenon is still wanting.

Bednarski (9), who has had the opportunity of examining eyes containing fragments of iron, could demonstrate the iron reaction of Perl, chiefly in the proliferating cells; the epithelial cells of the iris and ciliary body did not turn blue, and the epithelium of the retina showed only a partial reaction. His examination does not confirm the assertion of E. v. Hippel that the epithelial cells of the ciliary processes, the pars ciliaris retina and the retina as a whole, have a specific affinity for iron.

The question why the rust spots under the lens capsule are almost uniformly found in the same region and of the same form, has as yet not been satisfactorily answered.

Samelsohn's (3) view that the spots represent pores in the capsule through which the fluid containing the insoluble particles of iron passes out of the capsule and on which the iron is deposited, cannot be correct as no one has as yet seen such pores.

Another question which remains to be answered is, why do not all eyes containing fragments of iron give outward evidence of its presence. I have seen a number of eyes which had harbored a fragment of iron for more than six months, and I have very recently examined one in which according to the patient's statements, the fragment of iron had entered the globe twenty-

five years before I enucleated it and found the iron imbedded in a coating and resting on the retina, which showed none of the signs of siderosis. The thickness of the coating on the iron can have nothing to do with it as is shown by Case I. In this case a very thick layer covered the iron while in the eye in which the iron had been lodged for twenty-five years, the coating was so thin that the iron showed through it. The dimensions of the fragment were about the same.

The length of time intervening between the entrance of the foreign body and the first appearance of outward signs of siderosis seems to vary considerably. In all of my cases the iron had entered at least six months before I saw the patient. Natanson (15) has observed signs of siderosis as early as two months after the foreign body had entered the eye.

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