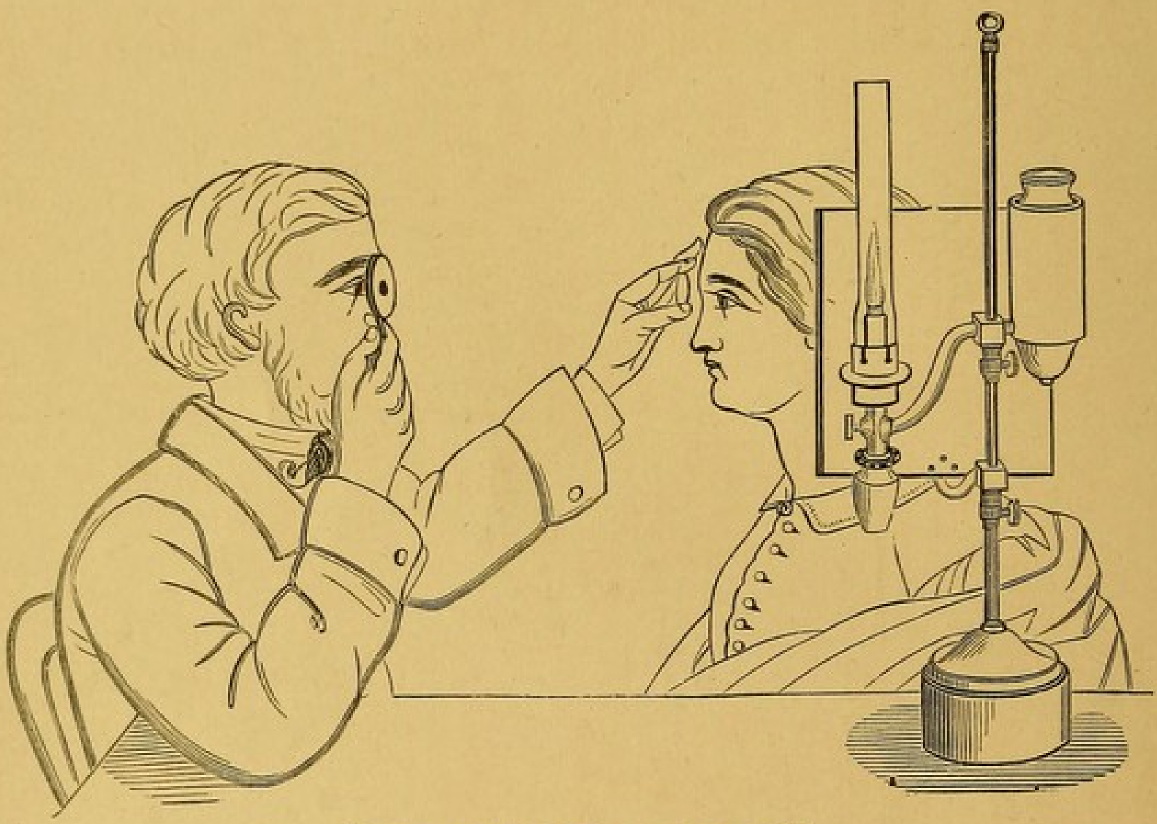

OPHTHALMOSCOPIC EXAMINATION.

THE DIAGNOSIS AND TREATMENT OF THE DISEASES OF THE EYE.

BY

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BOSTON:
HOUGHTON, MIFFLIN AND COMPANY.
The Riverside Press, Cambridge.
1882.

The Riverside Press, Cambridge:
Electrotyped and Printed by H. O. Houghton & Co.

PREFACE.

SEVERAL editions of a smaller work on Diseases of the Eye having been received with steadily increasing favor, the author ventures to offer to the Profession another contribution to its literature, which he hopes may be acceptable and useful.

In carefully preparing this new treatise, in which he has sought to embody that which his own observation and the recorded experience of others has proved to be of most value, the author has kept always in view his original purpose, and has endeavored to make his book a Practical Guide, serviceable to the general practitioner and to students. His aim has been to describe clearly and accurately, but at the same time as simply and concisely as possible, the nature and the cause of diseased processes in the various parts of the eye; to define the normal conditions, and to show the most important variations, of its optical functions of refraction and accommodation; to explain the ophthalmoscope, and the modern methods of exploration, which have so greatly increased our knowledge of the changes occurring in the internal structures of the eyeball; and to indicate modes of treatment promising the best results.

Too elaborately scientific descriptions and statements of theories have been for the most part avoided; as tending to encumber the work rather than to aid those whom it has been the author's earnest wish to assist.

To Dr. Charles H. Williams the author is indebted for valuable suggestions and assistance in carrying the book through the press.

15 Arlington Street, Boston, *November* 1, 1881.

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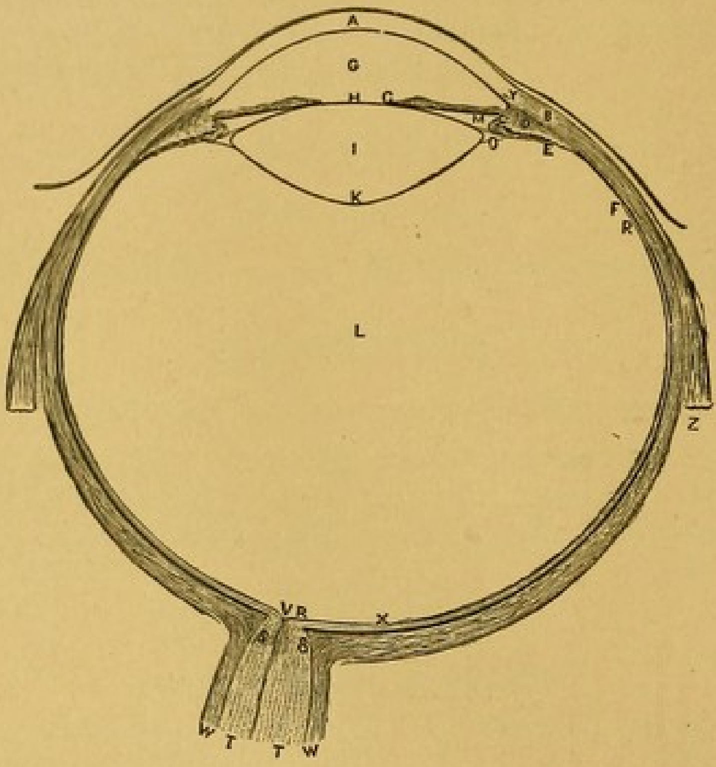


(*After Arlt.*)

A. Cornea.
B. Sclera.
C. Iris.
D. Ciliary Muscle.
E. Ciliary Processes.
F. Ora Serrata.
G. Anterior Chamber.
H. Pupil.
I. Crystalline Lens.
K. Posterior Capsule.
L. Vitreous.
M. Posterior Chamber.
O. Petit's Canal.
R. R. Retina.
S. S. Lamina Cribrosa.
T. T. Optic Nerve.
V. Canal of Retinal Vessels.
W. Sheath of Optic Nerve.
X. Region of Macula Lutea.
Y. Schlemm's Canal.
Z. Rectus Muscle.

DISEASES OF THE EYE.

CHAPTER I.

METHOD OF EXAMINING THE EYE.

As a general rule, the eye should first be inspected by the physician, that he may obtain such information as is afforded by his own senses, before making inquiries of his patient. If, as is often the case, the actual disease or the cause of the principal symptoms is thus detected, perhaps at a single glance, the adviser may at once gain the confidence of his patient by showing him, in the first question he asks or the first remark he makes, that he has already discovered his ailment. Even the general bearing of the patient who is nearly blind often indicates whether the loss of vision is due to cataract or amaurosis.

The patient to be examined should be placed facing a window with a good illumination ; a northern aspect being preferred. Such light is less annoying than direct sunlight to sensitive eyes, and, causing less contraction of the pupil, is more favorable for inspection. To have the light fall obliquely upon one or the other eye, the head of the patient may be turned a little. The physician, placed in front of his patient, first observes his general aspect, and the state of the external parts of the eyes and their appendages. In many cases he will at once detect the morbid condition, or some of the leading symptoms. Strabismus, or defects of the mobility of the eye, tumors or inflammation of the lids, diseases of the lachrymal passages, alterations in the form or of the healthy external appearance of the eyeball, opacities, foreign bodies, or ulcers of the cornea, intolerance of light, copious flow of tears, mucus, or pus, the situation and character of any injection, may be at once seen ; and the presence or absence of these conditions serves as a guide to the further examination of the case. Varieties of forms of injection can readily be distinguished after a little practice; that arising from the presence of a foreign body differing from that caused by inflammatory processes in either the external or internal parts.

If nothing very obvious appears to enlighten the observer, a more minute inspection may be made. The edges and outside of the lids should be carefully looked over, to discover irregularities of form or position, thickening or incrustations of their margins, ingrowing eyelashes, or closure or displacement of the minute orifices by which the tears enter the lachrymal canals. Then, the fingers of one hand being steadied upon the forehead, the upper lid should be gently raised with the thumb, placed upon the centre and nearly to the border of the lid to give it a gliding motion without pressure on the eyeball, so as to allow of a careful scrutiny as to whether traces of any former or actual disease can be found on the cornea, or the anterior portion of the globe, or in the anterior chamber or the iris. Foreign bodies in the cornea, faint opacities of long standing or depending on existing inflammation, ulceration, or changes of curvature of this structure, as well as the varied forms of vascularity attending inflammation of the external membranes or of the deeper parts of the eye, and the stains or cicatrices of the conjunctiva caused by excessive use of caustics, by wounds, or burns, or phlyctenular elevations on its surface, are thus discovered. Where these appearances are only slight, a lens of large field and of about six inches focus may be used to give to them a clearer definition. Oblique illumination, presently to be described, is also of great service in the inspection of all the transparent parts of the eye.

The lower lid may then be depressed in like manner; the hand resting upon the cheek, while the thumb or one finger draws down the lid. These movements of the lids may be alternated; or, where it is desirable to inspect the front of the globe as a whole, traction may be made at once, by using both hands, on the upper and lower lids.

It is sometimes impossible to open the lids with the fingers, where œdematous or phlegmonous thickening has taken place, or where there is great photophobia; or the endeavor to do so might cause much pain or dangerous pressure upon the eye. It is then necessary to employ one or perhaps two elevators to separate the lids, so as to gain a view of the eyeball.

Alternately raising and closing the upper lid, so as to admit and exclude the light suddenly, the opposite eye being kept shut with the thumb of the other hand, allows us to judge as to the sensitiveness of the pupil of one eye to the stimulus of light, and its power of free dilatation and contraction. Any abnormalities of size or mobility of the pupil, or opacities or deposits in its field, should be carefully noted. The separate examination of each eye is necessary to determine the mobility of the pupil, because, if the light falls upon one eye, reflex contraction of the pupil will be excited in the other, even though this eye may not itself be sensible to the influence of light. For the more accurate estimation of the extent of any existing adhesions of the margin of the pupil, or of opacities in its field or in the lens behind it, a magnifying lens or oblique illumination is to be employed. It should be remembered that the pupil appears black in early life, but after middle age the lens acquires a slight amber tint, which might be mistaken for commencing cataract. The color of the iris, its vascularity or congestion, and the position it occupies, as being either normal, or drawn back, or pressed forward, or tremulous, or more or less adherent to the cornea or the crystalline, as also any deficiencies or lacerations in its structure, should be objects of attention.

The degree of tension of the globe, as indicating morbid increase of the intra-ocular pressure, or its diminution from atrophy, can be estimated by placing the two forefingers a little apart from each other upon the closed lid, a little above the centre of the globe, and making moderate pressure upon it downwards, with each finger alternately, as if to detect fluctuation. The other eye is then to be comparatively tested in the same manner. Or one finger of each hand may be placed upon the eyes at the same time, and pressure made simultaneously, so as to estimate the comparative tension. If the surgeon is in doubt as to there being an increase or lessening of the normal fullness, he may compare the tension of the eyes of the patient with that of his own eyes, or those of a by-stander, it being always remembered, however, that T may vary within normal limits. Tonometers have been devised to be placed upon sclera for determining the intra-ocular pressure; but the *tactus eruditus*, the touch of the practiced finger, is best able to estimate the amount of elastic resistance of the eyeball, and is a surer guide than any instrument in determining the degree of plus or minus tension.

Bowman marks the degrees of tension by the following signs: —

T n, tension normal.

T 1, slight but positive increase of tension.

T 2, considerable tension, but the finger can indent the sclera.

T 3, extreme tension, in which the finger cannot depress the sclera.

—T 1, slight lessening of tension.

—T 2, considerable reduction of tension.

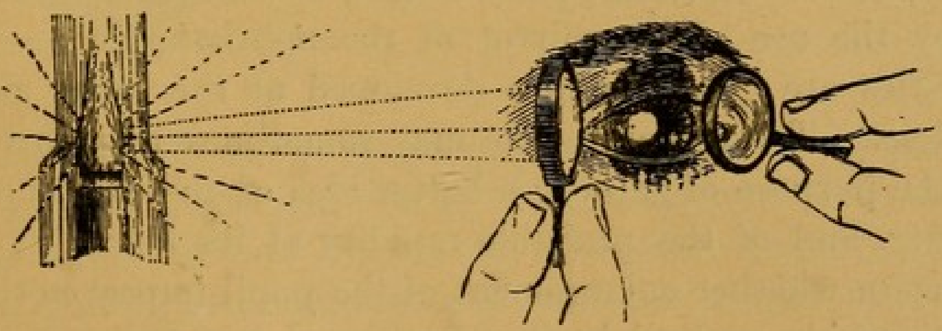
—T 3, very marked softening.

Either of these degrees of + or — tension may be followed by an interrogation point (?), to indicate that the observer is not quite sure as to the existence of that degree at the time of examination.

This objective inspection, which has required so long a description, occupies in fact but a few moments of time. If it reveals to us the probable pathological condition, and indicates whether we have to do with some structural lesion or with a mere optical defect of refraction or accommodation, we may go on with other explorations, or may first question the patient or his friends as to the history of the case and the subjective symptoms he may have experienced.

If an inspection has discovered opacities, irregularities, or deposits in the cornea, anterior chamber, iris, pupil, crystalline lens, or vitreous, it is often desirable to examine these more minutely, by oblique illumination. For this purpose the room is to be darkened, and the patient placed near a gas jet or other bright flame, so that the light may fall from the temporal side upon the eye to be examined. If some delicate point is to be noted, it is well to interpose a screen between the observer and the flame, so that, his own eye being shaded, his pupil may be more expanded, and allow a greater number of rays to pass through it to the retina. Then, holding a convex lens of about two inches focus between his thumb and finger, he concentrates the light by its means upon the parts of the eye he wishes to explore, the eye being turned in various directions, and the lens held nearer or farther from it. He is enabled by this bright illu-

FIG. 1. Oblique illumination.



mination to detect commencing cataract, to discover foreign bodies in the cornea which were not previously visible, or to form a better judgment as to the nature or degree of various abnormal conditions of the cornea, the field of the pupil, or the parts behind it, which thus become more clearly manifest. A magnifying lens of large field and about six inches focus, held before the observer's eye, gives still greater distinctness to the appearances looked at.

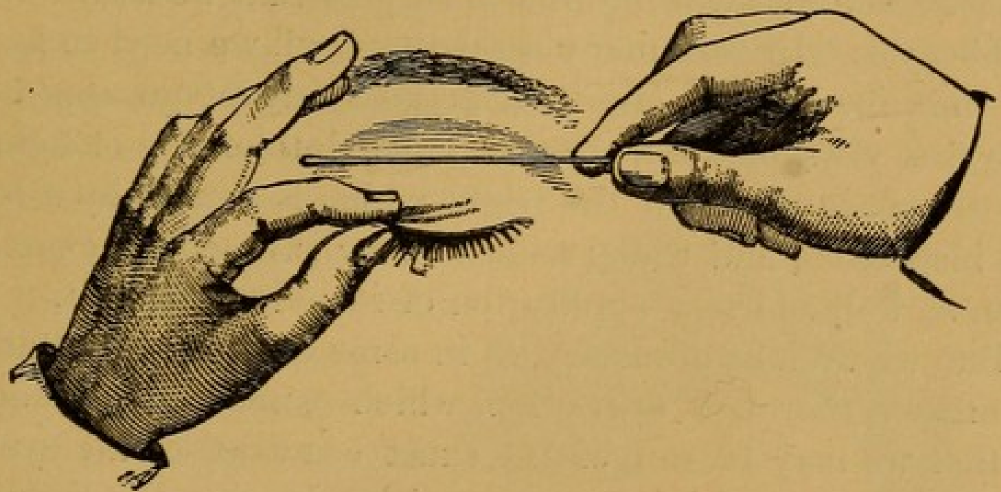
In estimating the extent to which adhesions of the margin of the pupil have taken place, it is frequently best to use sulphate of atropia as an auxiliary to the oblique illumination. As the pupil dilates under its influence the adhesions become clearly defined; and we may also determine at the same time whether and to what extent these adhesions may probably be stretched or detached through the continued use of this means. A solution of two grains to the ounce of water is generally sufficient for this purpose, a few drops being put into the eye from a spoon, a drop tube, or a camel's-hair brush. This causes no pain, and its effect in dilating the pupil should be evident in fifteen or twenty minutes. If the adhesions are extensive, or the iris seems to be much congested and likely to yield but sluggishly to the action of the mydriatic, a solution of four grains to the ounce may be used. The fresh juice or the extract of belladonna or of stramonium are also efficient means of dilatation, where atropia cannot be obtained.

This dilatation of the pupil by atropia is rarely needed for the detection of cataract, as this may almost always be discovered in the form of whitish spots or lines, or of a central haziness, even in its incipient stages, by oblique illumination or by the use of the mirror of the ophthalmoscope. The opacities are generally first developed at the lower part of the lens. The use of atropia may sometimes be resorted to for the purpose of gaining a better idea of the extent of the opacity, and of the probable rapidity of its increase; or to ascertain whether enlargement of the pupil improves the patient's vision, and might therefore be of use, temporarily, as a palliative; or, especially, to enable us to investigate with the ophthalmoscope the conditions of the fundus of the eye while some portions of the lens still remain sufficiently transparent to allow the deeper-seated parts to be seen, and thus to form an opinion as to the existence of any complications which might perhaps affect the advisability of an operation for the removal of cataract.

Some changes in the deeper parts of the globe, such as opacities of the vitreous, separation of the retina, and intra-ocular growths, may often be observed with a certain advantage by lateral illumination, as one of the methods of inspection, even though seen still better with the ophthalmoscope.

If we discover inflammatory changes of the conjunctiva of the globe, it is generally advisable to evert the upper lid and ascertain the condition of its lining. This little procedure is one of the most frequent of the manipulations about the eye, and to do it quickly and painlessly is an accomplishment which should be carefully acquired. It is not uncommon to have a person complain that some one had "nearly pulled the eyelid off in trying to turn it over." The patient should

FIG. 2.



be told to look down, which greatly facilitates the manœuvre, and the physician, taking the eyelashes and the border of the upper lid between the thumb and forefinger of the left hand, draws these outwards and upwards, at the same time pressing with a pencil, a probe, or some similar small object against the centre of the lid, at the upper edge of the tarsal cartilage, in a direction downwards and backwards, so as to cause the lid to evert, and expose its inner surface. In this method no pressure is made on the eyeball, as is often done where a thumb or finger is used as a fulcrum against the upper edge of the cartilage.

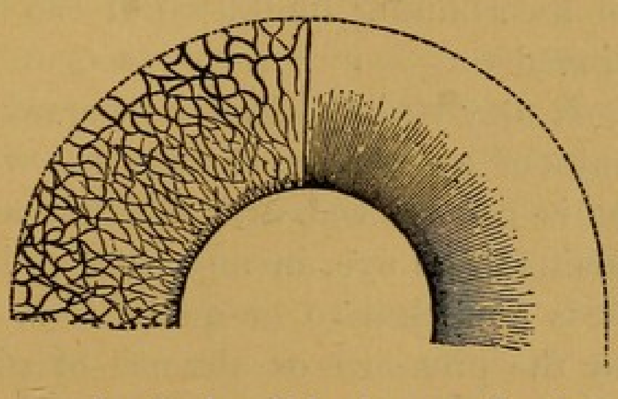
Eversion of the lid is also required where the presence of a foreign body beneath it is suspected, and this is generally found lodged near the centre of the tarsal cartilage. In these and other cases the upper palpebral fold may also be explored by drawing the lid gently forward without eversion, so as to look under it, the patient's head being thrown back and his eye turned as far downwards as possible.

The examination of the eyes of children requires much tact. Unless the morbid condition is obvious, we should first learn all we can from the parents or friends, so that our subsequent investigation may be as brief and as little troublesome to the child as possible. With a little patience we may often get a sufficient view of the eye to satisfy us that no threatening danger to the cornea exists, without a resort to force, by attracting the child's attention to toys or other objects, and not allowing him to suspect that we wish to look at his eyes. In very many cases this is all we need to know, for the time at least, and it is a great advantage, especially at a first visit, or when there is much intolerance of light, if we can spare the child the fright which is caused by a forcible inspection, and which makes every subsequent examination, as well as every application of remedies, difficult.

But where it is necessary, as in some cases of consultation, to make a thorough inspection, which cannot be postponed, so that we may be sure of the exact condition of the eye; if we cannot succeed by stratagem, either because the child has been previously terrified, or because his intolerance of light or the swollen condition of the lids makes it quite impossible for him to open the eyes, we must take care that the eye shall not be injured by the struggles of the child during the use of the gentle force required for the examination. He should be held on the lap of a friend or nurse, who sits on a chair in front of, but placed at a right angle to, that of the surgeon, and who is to hold the child's hands while the head is lowered between the surgeon's knees and firmly grasped by them. The latter is thus enabled to steady the child's head, while having the free use of both his hands. The feet of the child should not be held: they may kick the air *ad libitum.* The lids may now be opened, by a traction movement with the two thumbs, without pressure on the globe; but if the dread of light causes the cornea to be turned strongly upwards, or if there is reason to fear that the strong contractions of the orbicularis muscle might cause rupture of a largely ulcerated cornea, or where there is much swelling of the lids, it may be necessary to employ one or two elevators instead of the thumbs, to draw the lids apart without pressure on the eyeball. A good view of the eye is thus gained with more safety, and generally more quickly and painlessly, than where attempts are made to dispense with the use of the elevator.

Primâ facie evidence as to the seat and character of the existing disease may often be gained by simple inspection. If the vessels upon the front of the globe are of scarlet color, tortuous, movable, anastomosing in all directions; if the conjunctiva of the lid is hyperæmic, or velvety; and if at the same time we notice an increased mucous secretion, the conjunctiva is probably the principal seat of disease. If the injection is mostly circum-corneal, and of a purplish or lake tint, the vessels radiating outwards, while the rest of the surface of the globe and of the lids is nearly free from abnormal congestion, and if the secretion is only an augmented serous flow, the external mucous membrane is not primarily involved, but it is the cornea or the internal parts which require closer scrutiny. Our judgment in these respects may often also be assisted by inquiry as to the nature of the pain experienced, it being generally a smarting or itching when the outer surfaces, an aching when the deeper parts, are involved. The distinctive symptoms in these three phenomena — the injection, the secretion, and the pain — should be kept in mind as being of prime importance.

FIG. 3.



Perhaps the closest investigation discloses to our own eyes no apparent pathological condition of the eyes of the patient. We have then to discover whether he has some structural alteration of deeper-lying parts, or some functional defect. According to our judgment as to the probable conditions, we proceed at once to ophthalmoscopic exploration, or we first have recourse to other tests, which it is sometimes desirable to make use of before employing the ophthalmoscope to inspect the deeper-seated parts of the eye. Some of these means are resorted to for the determination of the extent or limitations of the visual field; of sensibility or insensibility to certain colors; of the existence of insufficiency of the internal recti muscles, or of any paralytic or other defects of mobility of the eyes; of binocular vision; of normal or defective refraction; and of normal or irregular accommodation. To avoid repetition, the methods of investigating some of these questions will be described in connection with the conditions to which they especially apply. The methods of ascertaining limitation of the field will be presently mentioned.

It may be important, as regards the prognosis of the results of operations, to ascertain whether the field of vision is or is not limited, and whether any perception of light remains in an eye, in any part of its field, and if so whether it is quantitative or qualitative. This may be determined by the presence or absence of phosphenes, which are crescentic flashes seen at the opposite side of the globe from that upon which sudden pressure is made with the finger; and by suddenly throwing light upon the eye in a darkened room. Even a feeble light should be discerned if quantitative perception exists. Qualitative perception implies an ability to see the outlines of bright objects.

As a guide to prognosis and treatment, it is desirable to estimate the duration of any structural changes or abnormal conditions we may discover. Some changes, as, for instance, pannus of the cornea, resulting from long-continued friction of trachomatous lids, can be removed by patient treatment, but admit of no speedy relief; while, on the other hand, the increased tension, pain, and blindness observed in attacks of acute glaucoma require an immediate resort to operative measures as the sole hope of recovery, any very prolonged duration of the morbid conditions being fatal to vision.

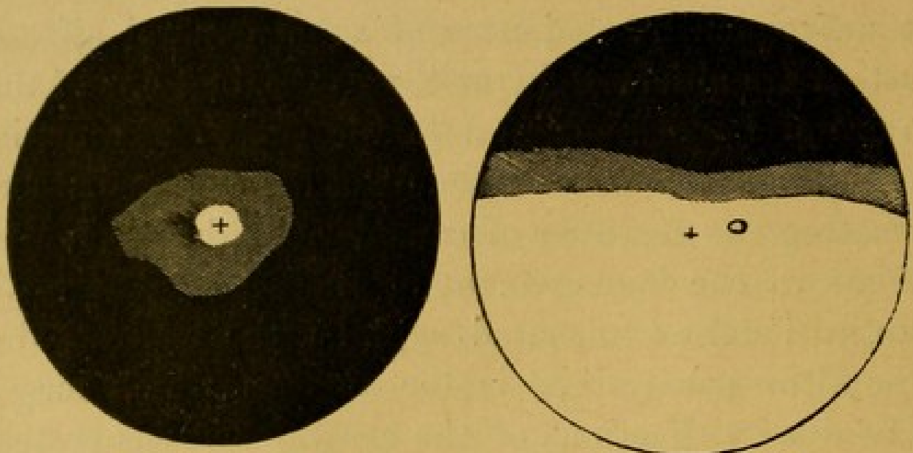
Not unfrequently, evidences of some general affection of the system are observed in making examinations of the eye. These are of importance in a double sense: as affecting the etiology, prognosis, and treatment of the ocular disease; and as indicating the necessity of considering other than the local symptoms in the management of the case. The evidences of constitutional or inherited syphilis, the contracted or dilated pupil or paralysis of motor muscles which may sometimes be due to affections of the central nervous system, the indications of Bright's disease or of meningitis disclosed by the ophthalmoscope, are instances of this.

LIMITATION OF THE VISUAL FIELD.

We know that we can distinguish objects clearly, not only at a point towards which the visual axis is directed, but that we have also more or less distinct perception of things lying within a space extending to a considerable distance around this point. This we term the field of vision; and it is often important, as regards diagnosis, prognosis, and treatment, to determine whether the visual perception of an eye exists to its normal degree and limit, or whether this has been diminished or lost in any part of the retina. Such results may be a consequence of separation of the retina or of growth of intra-ocular tumors; or may occur from loss of perceptive power in irido-choroiditis, in glaucoma, in neuritis, in amaurosis, or in cerebral affections.

We may ascertain the presence and amount of limitation by placing the patient in a dark room, at the distance of a foot before an illuminated black-board or screen of blue paper. A small cross is marked at the centre of this, on which the eye to be tested is fixed, while the other eye is covered. A bit of chalk at the end of a black stick is moved upwards, downwards, and obliquely before the screen, and the points where it ceases to be visible are marked by dots, which may be united by a continuous line which will include the area of limitation.

FIG. 4.



The figure to the right exhibits the effect of separation of the retina. The space occupied by the fluid, having utterly lost its perceptive power, is represented in the circular field of vision by a black space; next to this is a limited shaded margin, where slight perception, perhaps sufficient tó distinguish a candle flame, remains; and in the rest of the field vision may be tolerably good, so long as the separation is confined within moderate limits. Similar appearances sometimes follow the effusion of blood, in cases of apoplexy of the retina.

The figure to the left shows a small space in the centre of the field where vision remains distinct; a shaded halo marks the limit of imperfect perception, and beyond this all is dark. Such are the conditions found in some cases of glaucoma, and in retinitis pigmentosa.

Where, as in most cases, tracing the exact area is not essentially important, but where it is desired to determine the existence or absence of limitation of perception, it is sufficient to place the patient with his back towards a window or a lamp, and have him look with the tested eye at the nose of the surgeon, while he counts the fingers of the examiner, as these are moved at about twelve inches distance to different positions of the visual field.

If the pupil is closed, or veiled by corneal opacities or by cataract, two candles may be used in testing; at one of which the patient looks steadily, in a darkened room, while the other is moved in different directions in front of and about his eye.

Where it is desired to determine limitations of the field with greater accuracy, and to be able to judge from time to time whether further extension has occurred in consequence of the continued growth of a tumor or from other cause, Carter's perimeter, which combines convenience with accuracy, may be used. The patient fixes his eye on a point of the instrument, while a small white object fixed at a given distance upon a revolving quadrant of a circle is moved about this point. The limits of clear and of doubtful perception are measured upon the index table.

THE OPHTHALMOSCOPE.

One of the most invaluable of all our means of exploration of the eye is the ophthalmoscope. Hippocrates tells us, *Qui bene noscit, bene curat.* This priceless invention of Helmholtz, the grand result of an intelligent endeavor to adapt a scientific means to an end, and which has done so much to render ophthalmology an exact science, is even yet so comparatively new that the profession at large are scarcely aware that, in the simplicity of its principles, the ease with which any one can become skilled in its use, and in its accuracy as an instrument of precision, it surpasses most of the aids of which we have been accustomed to avail ourselves in the investigation of disease ; nor do they fully appreciate the immense advantages it affords, not only in the diagnosis of affections of the organ which it directly explores, but as a means of revealing previously unsuspected lesions of distant parts, making it therefore of great use to the general practitioner.

The most important service rendered by the ophthalmoscope is that for which it was first devised : the illumination of the deeper parts of the eye, so that their healthy condition or structural alterations can be clearly seen. The practitioner of to-day is no longer in the dark as regards these deep-seated parts, and is not obliged, for want of accurate knowledge, to include a large number of their affections under the designation "amaurosis," to which the well-known definition given by Walther applied but too well: "A condition where the patient sees nothing, and the doctor also — nothing:" "Jener Zustand, bei welchem der Kranke nichts sieht, aber der Arzt auch nichts." He can now speak of what he knows and testify of what he sees; and is relieved of many painful uncertainties in diagnosis, embarrassing to him and often detrimental to his patient. Accurate diagnosis forming the basis of successful treatment, the oculist can already point to brilliant therapeutic triumphs over diseases formerly deemed incurable, which have directly resulted from the knowledge acquired by means of this instrument.

The ophthalmoscope is also available as a means of determining and measuring different refractive conditions of the eye, as will be elsewhere explained.

Fig. 5. Illumination of the retina by a candle-flame.

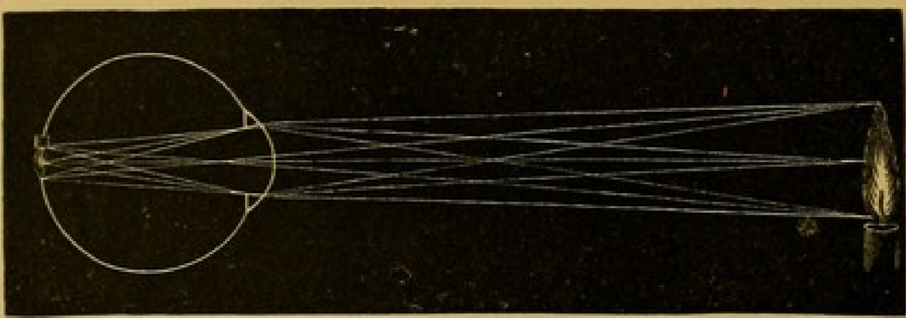


Figure 5 represents an eye having a portion of its fundus illuminated by rays from the flame of a candle. If now, as is shown in the figure, the eye is accommodated for distinct vision at the distance of the candle, a minute but clearly defined inverted image of the flame will be formed at the posterior pole, in the region of the macula lutea, while the general surface of the retina is left in comparative darkness. In order to obtain a view of this illuminated region it is necessary that some rays of light from it shall enter the eye of the observer; but these emergent rays can leave the observed eye only in the inverse direction to that in which the illuminating rays enter it, that is, in the exact direction of the candle. It is evident, however, that if the observer's head be interposed between the candle and the observed eye it will cut off the illuminating rays from all that part of the retina which is in the line of vision; while, on the other hand, if he attempt to obtain a view from a point beyond the candle, the emergent rays will be intercepted and his eye dazzled by the flame.

N. B. — In the plates illustrating the principles of the ophthalmoscope, what is termed a diagrammatic eye has been drawn, representing the total refraction of the cornea, aqueous, crystalline, and vitreous, as if effected by a single refracting medium of uniform density. The demonstration is thus simplified, and the confusion avoided which would result from an attempt to show the separate action of the crystalline lens in figures so limited in size.

If we look through the pupil and attempt to see the deeper parts of an eye with our unaided vision, the endeavor is fruitless, because, our own head being interposed between the source of light and the observed eye, all the posterior portion appears black from lack of sufficient illumination of the choroid and retina. It is only in certain positions, where the rays from an artificial light placed behind an observer enter an eye which is nearly in front of and at some distance from him, that he can occasionally see a bright reflex from the fundus of the eye, but without any distinct details. The principle of the ophthalmoscope, or eye mirror, is to virtually make the observer's eye the source of illumination ; from whence the rays of light are sent into the observed eye. The deeper portions of this eye being thus illuminated, they reflect back rays of light toward the mirror, which, passing through the hole in its centre, are seen by the observer, thus giving him a view of the interior of the patient's eye. Two things are essential for this purpose : a mirror, to be held before the eye of the observer for the suitable reflection of rays from the actual source of light into the eye to be inspected ; and a transparent or perforated central part of this mirror, so that some of the returning rays may pass directly through this central aperture to reach the refractive media, and form an image upon the retina of the observer's eye, which is placed behind the mirror. Helmholtz first accomplished this, by employing several superimposed plates of thin glass, held obliquely, to reflect the light of a lamp placed behind the observed eye. A portion of the rays passed through the glass and were lost ; but other portions were reflected into the observed eye, in the line of its axis or otherwise, according as the mirror plates were turned toward the centre or some other part of its fundus. The angle of reflection being the same as that of incidence, the emergent rays fell again upon the plates of glass. Some of these rays were thence deflected toward the original source of light, but others passed through the transparent surfaces, and entering the eye of the observer, which was behind them, were brought to a focus upon its retina.

FIG. 6. Original ophthalmoscope of Helmholtz, consisting of a plane mirror made up of several plates of transparent glass.

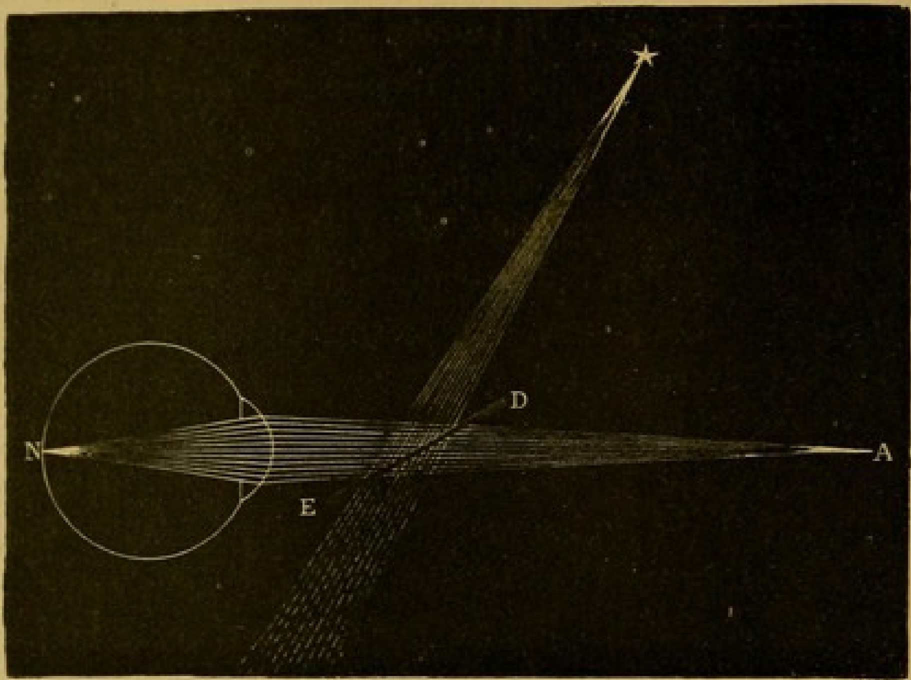


Figure 6 represents an eye placed so as to receive the rays of light reflected by the plane mirror D E from a single point * of any luminous body, such as the flame of a candle. The mirror being made of a transparent material, such as plate-glass, a portion of the illuminating rays from * will pass through it, in the direction of the dotted lines, and be lost, while another portion will be reflected into the observed eye, and will light up the point N at its fundus. The emergent rays from N will, in like manner, be in part reflected back to *, but a part will pass directly through the mirror in the direction of A, and thus may be received by the eye of an observer.

In all the various modifications of the ophthalmoscope the principle remains unchanged. It has been found convenient to substitute small metal or silvered mirrors, plane or slightly concave, the centre of which is perforated or unsilvered to allow of the passage of the emergent rays, for the simple reflecting plates; and numerous unessential modifications, particularly in methods of mounting, have been suggested, especially for the purpose of combining various lenses with the mirror, so as to gain clearer definition of details in the parts looked at. It is evident that by means of the central perforation the observer is able to receive in his own eye the reflected entering rays, and observe all the parts which these have illuminated; whereas, without this aperture in the mirror, the fundus of an eye could not be seen, the returning rays having such a direction as to enter the eye of the observer only when this is placed behind the centre of the mirror.

FIG. 7. Ophthalmoscope, consisting of plane mirror of metal or silvered glass with central perforation.

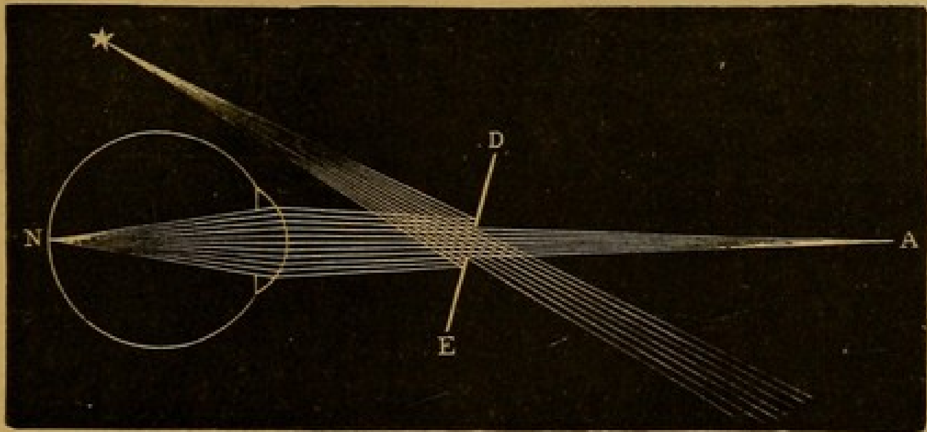


Figure 7 is the same as Figure 6, with the exception that the mirror D E is made of metal or silvered glass, with a small aperture through its centre. By this arrangement a portion of the illuminating pencil falling upon the surface of the mirror is reflected into the observed eye, and is brought to a focus at N, while the portion of the emergent pencil which falls upon the hole in the mirror passes through in the direction of A.

Two methods of exploration are in use, by the upright and by the inverted image; sometimes termed the direct and indirect methods.

Under favorable conditions of refraction, the eyes of both the observed and the observer being emmetropic, and adapted for their far point, the details of the fundus of the eye may be seen with the sole aid of the illuminating mirror, by bringing the ophthalmoscope and the observer's eye very close, within an inch or so, of the observed eye. The patient should look at a distance, so as to relax all effort of accommodation. The image thus seen is virtual and erect, and the structures are magnified by the action of the refracting media of the eye looked into. If, however, the observed or the observer is myopic, the requisite clearness of detail is only gained, in this direct method of examination, by placing

FIG. 8. Ophthalmoscope, with concave metallic or silvered glass mirror, showing greater extent of illumination ; also showing the use of a concave eye-glass.

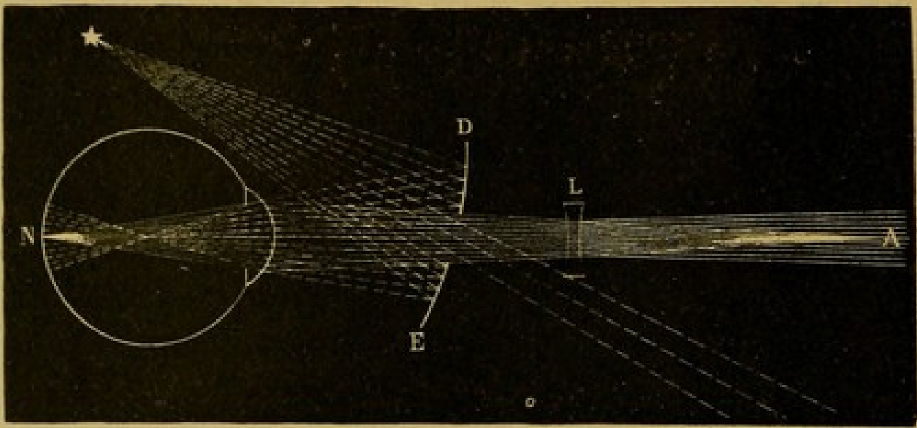


Figure 8 illustrates the use of a concave mirror, D E, instead of the plane ones shown in Figures 6 and 7. By comparing this figure with the two former, it will be seen that a very much larger pencil of light from the luminous point * is made to enter the pupil of the observed eye, thus insuring a very brilliant illumination of its fundus. It will be observed, also, that the illuminating rays converge to a focus in front of the retina, from which point they again diverge so as to light up a considerable surface instead of the single point N.

The small concave eye-glass L is placed behind the hole in the mirror in order to render the rays from the observed eye parallel or slightly divergent, thus fitting them to form a distinct image on the retina of the observer. The same form of eye-glass is required with the mirrors shown in the two former figures. If the patient or the observer happens to be strongly hypermetropic the eye-glass may often be dispensed with.

FIG. 9. Ophthalmoscope, combining the concave mirror and a convex objective lens, showing the greatly increased field of illumination. The illuminating rays only are represented.

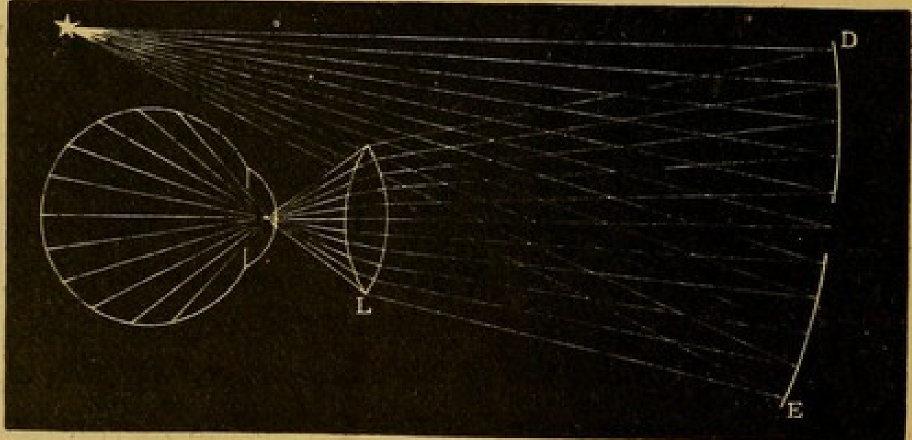


Figure 9 shows the combined effect of the concave mirror D E and the objective lens L in rendering the illuminating rays strongly convergent, and consequently lighting up a very large portion of the fundus of the observed eye.

concave glasses behind the mirror, to render the rays, which are convergent as they emerge from a myopic eye, parallel or divergent, and thus adapted for being brought to a focus in the observer's eye. Only a small extent of the fundus can be seen at once by this method, though different portions may be brought successively into view by changing the position of the mirror; but, on account of the enlarged images obtained, the direct method offers advantages for the study of the details either of healthy conditions or morbid changes. For the better observation of these, dilatation of the pupil by atropia may be resorted to if they cannot otherwise be sufficiently well seen.

Ophthalmoscopic examination may exceptionally be made by sunlight, of which the intensity is moderated by interposing a screen of tissue paper or ground glass. But artificial light is almost universally employed. Any steady flame of gas jet or lamp may be made use of, and the amount of light may be reduced, if required by any special intolerance of the patient, so that the reflex contraction of the pupil which results from a too bright illumination, and which hinders the readily obtaining a view of the fundus, may be avoided.

The patient should be seated in a darkened room, and with his eyes nearly on a level with or a little lower than those of the observer. The light should be at nearly the same level, and so far behind the temporal region that the side of the face and the eye are in shade. In the direct upright examination of the right eye, the light should be at the right side of the patient, and the physician should use his own right eye. For inspection of the left eye these positions should be reversed, in order that, when the eyes are brought so near as is required in this method, noses may not come into contact. The observer should learn so to hold the ophthalmoscope that its light may be steadily directed into the pupil. The patient is then told to turn the eye in different directions, so as to bring all parts of the fundus successively into view. The image thus formed is virtual, erect, magnified, and as if situated behind the retina.

Dilatation of the pupil is rarely resorted to by an experienced observer; but it may greatly aid a novice in these examinations, by enlarging the field of observation, and at the same time increasing the brightness of illumination. Atropia sulphate is a convenient mydriatic for this purpose; but it should not be used of greater strength than one or two grains to the ounce of water. After the inspection has been completed, the mydriatic effect may be partly or completely neutralized by the use of a solution of pilocarpine nitrate of twice the strength; so that the patient may be spared the annoyance of a continued dilatation, with its accompanying dazzling and loss of accommodative power. It is well, in any case, to warn the patient that his vision may be somewhat disturbed for a day or two after atropia has been used, to avoid his being alarmed at observing this as an unexpected phenomenon. Homatropin is regarded as a useful substitute, as causing a briefer duration of mydriasis when used of the same strength as the atropia sulphate.

Such an enlargement of the pupil is permissible, when, a lesion of some sort having been discovered, it is desired to examine this more in detail; especially in cases of tumors or other morbid changes situated near the periphery of the fundus.

The "direct" method above described is only exceptionally used for purposes of exploration to discover pathological changes; and principally for the study of details. It is, however, also employed for determining conditions of refraction with the ophthalmoscope, as will be hereafter explained.

The "indirect method," with the inverted image, is that which is most in use, on account of its greater convenience of application, of its being less annoying to both patient and physician than the close proximity required in the direct method, and of its affording a view of a larger field at one time, thus enabling parts to be studied in their relation with the neighboring structures, which, as a rule, is of more value than the fragmentary study of details.

In examination by the indirect method a convex lens of about two or two and a half inches focus (fifteen to eighteen dioptrics) is held near the observed eye. A less power, say of

FIG. 10. Ophthalmoscope, with concave mirror and convex objective lens, showing the formation of an inverted image. The illuminating rays are omitted.

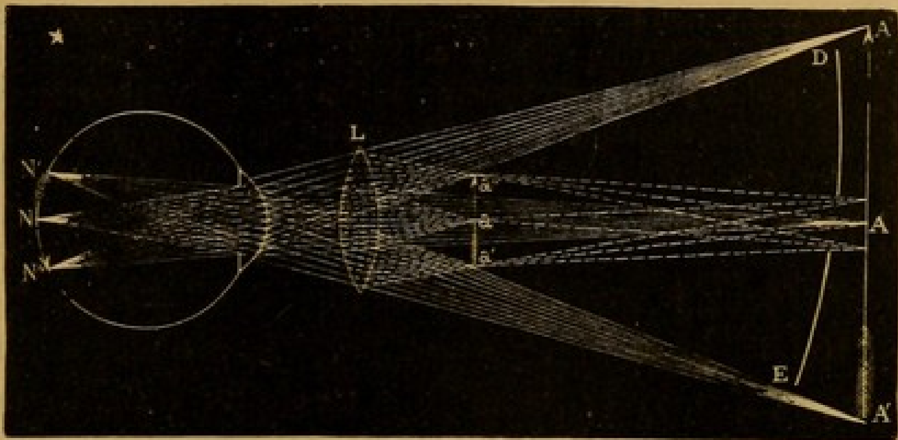


Figure 10 shows the action of the objective lens L in forming at a', a, a'' an inverted image of the portion of illuminated retina N', N, N''. The dotted lines to the right of a', a, a'' which pass through the hole in the mirror are continuations of the rays which by their convergence have formed the image a', a, a''. The whole image a', a, a'', corresponding to the whole surface N', N, N'', is therefore visible at a single glance to the eye of an observer placed directly behind the mirror, whereas without the objective lens only a very small portion of the retinal surface can be seen at a time, and the examination of any extensive region can only be made, as it were, piecemeal, by moving the mirror and thus bringing different parts successively into view.

FIG. 11. Diagram illustrating the position of the inverted image at or near the principal focus of the objective lens.

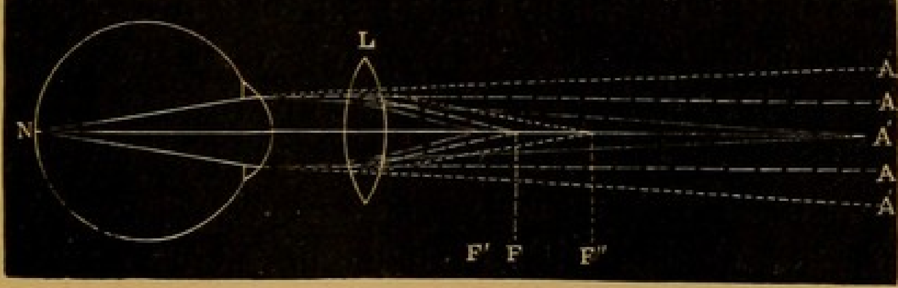


Figure 11 is intended to illustrate the various positions of the inverted image formed by the objective lens L, under different refractive conditions of the observed eye. The three conditions of myopia or forced accommodation, emmetropia, and hypermetropia are represented in the three directions of the emergent rays: namely, myopia by the rays which converge to A'; emmetropia by the parallel rays A, A; and hypermetropia by the divergent rays A'', A''. In the case of the emmetropic eye accommodated for an infinite distance, the rays A, A, which emerge parallel from the observed eye, are brought to a focus and form an inverted image of the retina at the principal focus F, of the objective lens L. If the observed eye is myopic or accommodated for near objects, say at the distance A′, the emergent rays, which are already somewhat convergent, will be brought to a focus at a point a little nearer to the lens L than its principal focus, say at F′. If, on the other hand, the observed eye is hypermetropic, the emergent rays, although somewhat divergent, are by no means sufficiently so to neutralize the convergent action of the powerful lens L; they are therefore brought to a focus, not at or within the principal focus of the lens L, but beyond it, say at F″. In the case of an excessively hypermetropic eye, or after the removal of the crystalline, it may be sometimes advantageous to employ an objective lens of greater power than usual, say one of less than two inches focal length; but for the vast majority of eyes a lens of from two to four inches focal length is sufficient.

four inches focus, is sometimes used for special purposes, where it is desired to have a larger image. The effect of this object-glass, as it may be termed, is twofold: first, in concentrating yet more the light from the mirror, so that after refraction by the crystalline it forms a large circle of dispersion at the fundus, giving a brighter illumination; and, secondly, in refracting the emergent rays reflected from the fundus as they pass through it, so as to focalize them and form a clearly defined, inverted, real, aerial image at or near the principal focus of the objective lens. The image thus formed comprises not merely a small point of the object looked at, but a considerable space around this; the field being larger, though the image is smaller, than when an object-glass of less focus is used. If the observed eye is myopic the observer brings his eye and the ophthalmoscopic mirror a little nearer, and removes it farther in a case of hyperopia. It is well to habituate one's self to making use of lenses of the same power, except when purposely exchanged for others for special reasons; as the observer is thus able better to compare one eye with another, and morbid with normal appearances, and also to form a more accurate and much quicker estimate of the conditions he may find, than when he employs sometimes one and at other times another glass, of different foci.

A myopic observer will best see this inverted image without the addition of any other lens; but for those who are emmetropic or hyperopic the image will be more clearly defined and enlarged by placing a convex glass of about ten inches focus behind the aperture in the ophthalmoscope, and thus close before the observer's eye, in a little clip provided for the purpose of receiving this or other small lenses which accompany the instrument. These are sometimes arranged in a revolving disc behind the aperture in the mirror.

FIG. 12. Use of convex eye-glass in the examination of the inverted retinal image.

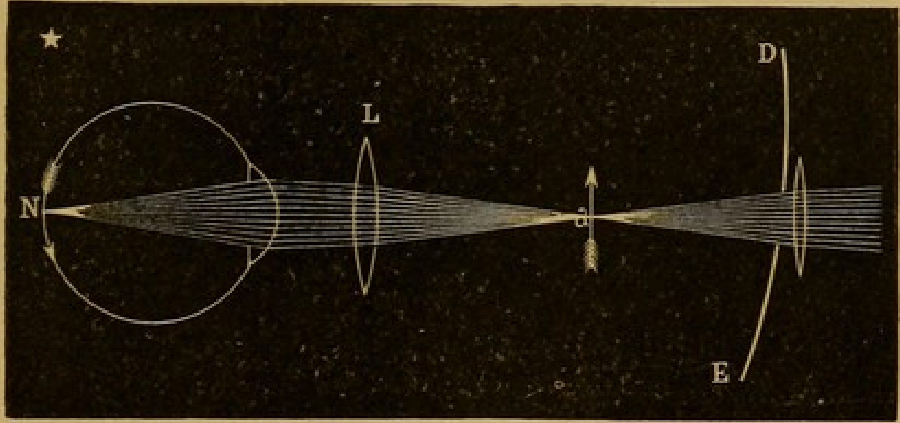


Figure 12 shows the use of a convex eye-glass in viewing the retina by means of its inverted image. If the objective lens L is chosen of moderate power, and especially if the observed eye is strongly hypermetropic, the image a will be formed so far from the lens L as to necessitate the removal of the observer, and consequently of the mirror, to an inconvenient distance. This difficulty is entirely obviated by the employment of a convex eye-glass placed behind the hole in the mirror D E, which gives the additional advantage of a more highly magnified image. The image may be magnified to almost any desired degree by the employment of a weak object-glass and strong eye-glass.

The position of the patient and of the light should be as already described for the upright image examination; but the observer retains the same position in the examination of both eyes, and may hold the ophthalmoscope in either the right or left hand.

In the examination of the right eye the patient should be told to look at some object in the direction over the observer's right shoulder. The globe is thus turned inwards to such a position that the optic disc will be in the line of vision of the observer; and the pupil does not contract, as it will do if the patient looks directly forward. The observer, placing his eye behind the mirror, held at from twelve to eighteen inches from the eye to be explored, and without using the object-glass, first turns the light for a moment upon the transparent media, that he may detect any opacities in the cornea, the anterior chamber, the field of the pupil, or the lens. If there

FIG 13. Use of the ophthalmoscope in the investigation of opacities or floating specks in the lens or vitreous.

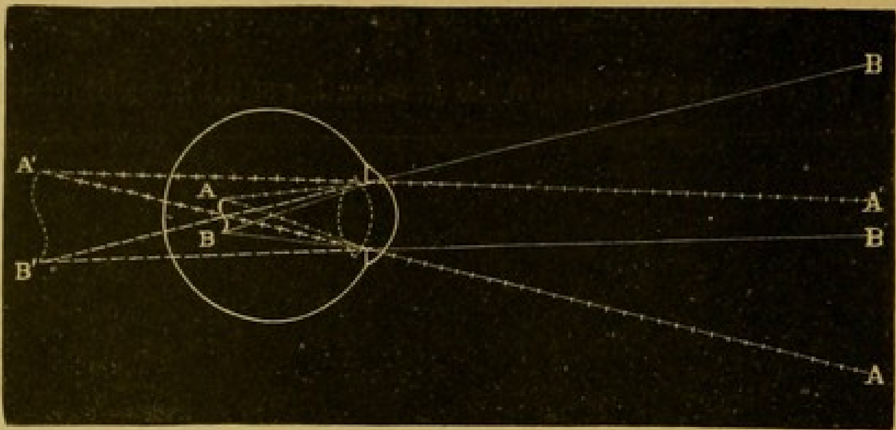


Figure 13 illustrates the use of the ophthalmoscope in the investigation of opacities or floating bodies in front of the retina. Let A B represent a floating body in the vitreous; being in front of the posterior focus of the eye, the rays from it emerge divergent from the eye, although less so than before traversing the crystalline and cornea. The rays from the point A, therefore, after emerging from the eye, assume the direction A″ A″, as if they had really come from the more distant point A′, and the rays from B assume the direction B″ B″, as if coming from the point B′. The effect is that the eye of an observer placed in front of the observed eye will see at A′ B′ an enlarged erect image of A B.

is any reason to surmise that the vitreous may be affected, opacities may be sought for by having the globe turned quickly in various directions, so as to discover them or to cause them to float across the field of the pupil. A faint light is best for the detection of any of the above conditions. Then, taking the object-glass by its edge between the thumb and forefinger of the hand not occupied with the ophthalmoscope, he steadies this hand upon the frontal region with the third and fourth fingers, and holding the object-glass at about its own focal distance in front of the patient's eye, so as to receive and concentrate the pencil of rays from the mirror, the observer at once sees the optic disc if the eye is properly directed. The image is aerial and inverted, and is formed and must be seen at the principal focus of the object-glass. If, from any peculiarity of refraction or exercise of accommodation, the disc is not thus clearly seen, the observer should approach the mirror and his eye nearer, or withdraw it farther from that of the patient. Should reflections of the form of the mirror from the object-glass interfere with accurate perception of the fundus oculi, the object lens may be slightly moved laterally, or turned a little obliquely. It is to be kept in mind, however, that holding the lens in this position gives to the optic disc an oval aspect similar to what it has in astigmatism. If the ten-inch convex lens is used, the mirror should be held at about the focal distance of this lens from the aerial image. The optic disc is chosen as the initial spot of the examination, because it is conspicuous by its form, color, and vascularity, and is so readily brought into view by turning the eyes as directed. Its situation known, the position of any appearances which may be observed in neighboring parts of the fundus is relatively determined, as these parts are brought successively into view by slight lateral and vertical movements of the object-glass and of the head of the observer, who takes care at the same time to vary a little the inclination of the ophthalmoscopic mirror, so as to keep the rays of light turned to the point which is made the object of inspection. More extended examination towards the periphery is then made by directing the patient to turn his eye upward, to the left and upward, to the right and upward, to the right and downward, to the left and downward, so as to bring all parts of the fundus into view. Last of all, he is told to look at the mirror, and thus brings the macula lutea to the centre of the field. Inspection of this point is deferred to the last moment, so that the light falling upon the macula, which is the most sensitive part of the retina, may not excite reflex contraction of the pupil, which makes the subsequent examination of other parts of the fundus more difficult, until these parts have been already explored.

For purposes of exploration the simpler forms of the ophthalmoscope are to be preferred to those which are more complicated. Binocular instruments, for forming an image in each eye, and many other complex arrangements, are pretty scientific toys rather than practically useful. Almost any

FIG. 14. The Binocular Ophthalmoscope.

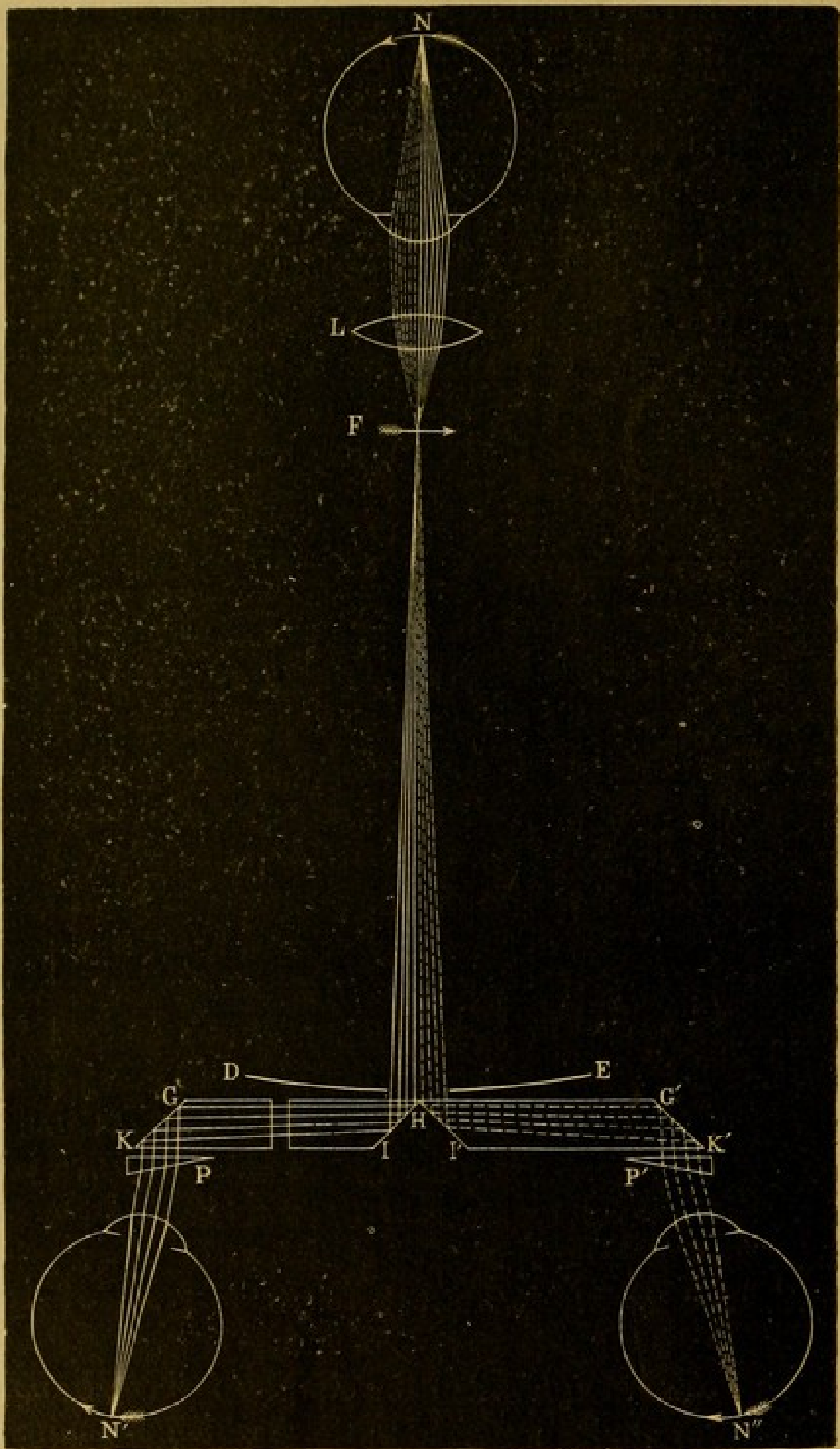
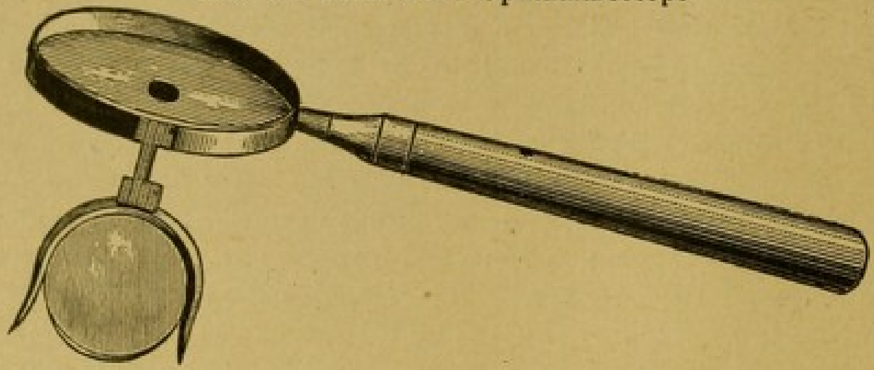


Figure 14 represents the optical principle of the binocular or stereoscopic ophthalmoscope. N is the fundus of the observed eye, and N′ and N″ of the left and right eye of the observer. The objective lens L forms at F an inverted image of the illuminated retina N. Instead, however, of viewing the image F directly through the hole in the mirror D E, the two rhombohedra H G K I and H G′ K′ I′ are interposed in such a position as to receive the rays as soon as they have passed through the hole, and to transmit them, by total reflection, half to the right hand toward G′ K′, and the other half to the left in the direction of G K. Here they undergo a second total reflection, and are then refracted slightly outward by the small prisms P and P′, to be received by the two eyes of the observer and brought to a focus upon his two retinæ, N′ and N″. It will be seen now, by inspecting the figure, that the rays from the left side of the point N, shown dotted in the diagram, after helping to form the image F, cross to the right side, so as to fall upon the right-hand rhombohedron H G′ K′ I′, and finally come to a focus and form an image upon the retina N″ of the right eye of the observer. The rays from the right side of N, on the other hand, are in like manner received by the left-hand rhombohedron H G K I, to be conveyed to the observer's left eye at N′. The result is that if there is any irregularity of surface at N, as, for instance, an excavated optic disc, the right and left hand bundles of rays form somewhat different images in the two eyes of the observer, and from the combination of the two impressions stereoscopic vision results. The binocular ophthalmoscope is also of use by enabling the observer to use both eyes at once, even where there is no irregularity sufficiently marked to produce the impression of solidity or excavation, — binocular having always an advantage over monocular vision.

instrument which an observer has learned to use with facility, and to which he is accustomed, can be readily made to serve all ordinary requirements. Among the very large number devised Liebreich's is one of the most portable and serviceable; and a description of it will be sufficient to indicate the important features which are common to all ophthalmoscopes. This is a concave mirror of one and a quarter inches diameter and eight inches focal radius, very thin at its unsilvered or perforated centre, which has a diameter of two millimetres. It is mounted on a handle which is sufficiently long for even the direct examination, and which does not require to be unscrewed when replacing it in its case. The mirror is large enough to screen the eye of the observer, without being so large as to dazzle the patient, and its focal radius gives an excellent illumination. At one edge of the mirror is hinged a small clip, to receive a ten-inch convex lens, the glass most frequently used, or one of several concave lenses which are in the case. This clip and its contained lens may be brought behind the sight hole at the centre of the mirror, or the clip with the auxiliary lens may be instantly swung aside and the reflector used alone, or with the object-glass only.

FIG. 15. Liebreich's Ophthalmoscope.



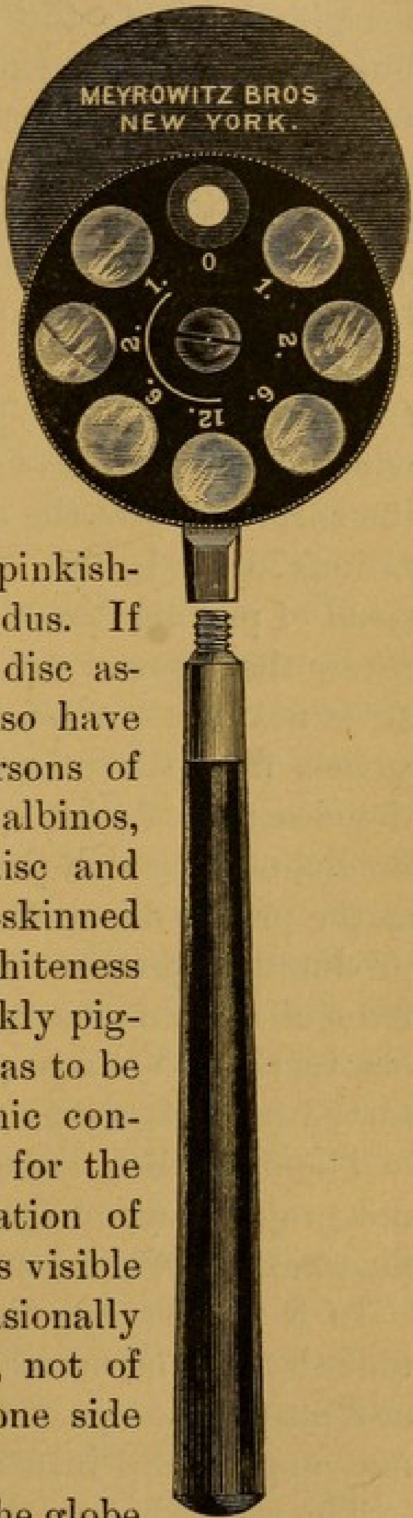
The convex glass of ten or twelve inches focus behind the mirror enables the observer to come nearer the eye, and thus to have a clearer image of the fundus, and makes the emergent rays parallel, so that the observer can see the image without using his own accommodation. A myopic observer, having an excess of refractive power in his own eye, may dispense with this convex lens behind the mirror. The box also contains large object lenses of two inches and two and a quarter inches focus.

Loring's students' ophthalmoscope has a revolving disc, with several convex and concave glasses behind the mirror, as shown in Plate 16.

In a large proportion of the cases examined a simple instrument is all that is required, and is most convenient as needing no adjustment. Other more elaborate ophthalmoscopes are valuable for certain purposes, especially in determining refraction, and will be again referred to.

It is quite difficult to describe appearances so varied and so delicate as those revealed to us in the interior of the eye by the ophthalmoscope. To be well understood they must be clinically studied, at first with the assistance of an instructor, and with the aid afforded by such works as the superb atlases of Liebreich and Jager. Yet some account of the normal and pathological appearances disclosed for the first time to this generation of oculists may assist those who are endeavoring to become familiar with them. In the normal eye the optic disc, or optic papilla, as it is sometimes termed, the terminal end of the optic nerve, is not at the extremity of the antero-posterior axis of the globe, but at two lines toward its nasal side, and is therefore seen when the eye is turned slightly inward. It has a marked difference of color from the contiguous portions of the fundus, and is thus readily distinguished when the eyeball is turned slightly inward. When illuminated by the pencils of light from the ophthalmoscope it appears as a slightly pinkish-white circle in the red field of the fundus. If the object-glass is held obliquely the disc assumes an oval form, which it may also have in astigmatism. In the eyes of persons of light complexion, and especially in albinos, there is less contrast between the disc and the contiguous surface than in darker-skinned persons, and in the dark races the whiteness of the disc, as compared with the darkly pigmented space around it, is so striking as to be perhaps mistaken for a morbid atrophic condition by those examining such eyes for the first time. Distinct circles of limitation of the sclera and choroid are sometimes visible at the margin of the disc, and occasionally a defined crescent of black pigment, not of pathological significance, is seen at one side of its border.

FIG. 16. Loring's Students' Ophthalmoscope.



The arteria centralis retinæ enters the globe through the centre of the optic nerve, and divides at once into two principal branches, superior and inferior, which at or near the margin of the disc usually subdivide into other branches. The veins have a similar distribution, and are readily distinguishable from the arteries by their larger size and darker color. Occasionally, instead of passing from the margin nearly to the centre of the disc before turning to bury themselves in the nerve tissue, the vessels bend backward, at a little distance from the disc border toward the nasal side, along a slight funnel-shaped depression termed physiological excavation. This must not be confounded with certain morbid changes seen in glaucoma or in nerve atrophy, hereafter to be described, where the whole area of the disc becomes depressed to its very margin, and often in an extreme degree. In a physiological excavation of the disc, which frequently shows a group of bluish-gray dots mottling the surface where the optic nerve fibres pass through perforations in the lamina cribrosa of the sclera, these fibres, instead of passing directly forward to the surface of the retina, where they spread out to form its inner layer, begin to separate near the lamina. The finer ramifications of the retinal vessels near the margin of the disc are an excellent test of the clearness of the ophthalmoscopic image, as they should be distinctly seen if the mirror is rightly directed, and is held at the proper distance. Arterial or venous pulsation may be produced by pressure upon the globe, and is one of the symptoms of certain diseases where the intra-ocular circulation is obstructed. Venous pulsation may now and then be observed in perfectly normal eyes.

The optic disc, though sometimes termed the papilla, does not project beyond the level of the surrounding retinal surfaces, except when congested by disease.

In a myopic eye the disc appears smaller and more distant than in the normal; in a hyperopic eye it seems larger and nearer the eye of the observer; in an astigmatic eye it may appear oval instead of round.

The retina is not to be distinguished with the ophthalmoscope, in health, as a distinct membrane. In eyes of dark pigmentation a thin haze may be seen, probably the limiting membrane. The macula lutea, or yellow spot, placed at the posterior axis of the globe, about two lines from the disc, toward the temporal side, is also seldom to be made out in healthy eyes, though it is a by no means unfrequent seat of morbid change, which may be conspicuously visible. If seen, it appears as a halo, darker than the surrounding parts, and sometimes showing a bright or a dark red central spot, where there is a slight depression, the fovea. It is destitute of large vessels, which would interfere with its function as the most delicately perceptive portion of the retina; but its abundant vascularity is furnished by a net-work too small to be seen with the ophthalmoscope.

The general color of the fundus depends upon the amount and the distribution of the choroidal pigment. Where this is small in quantity, the fundus has a bright red color, and the vasa vorticosa and other principal choroidal vessels can be distinctly seen, underlying the retinal vessels. Where the pigment is more abundant in the stroma of the choroid, the larger veins only are seen, and the intervening spaces are filled with the darker pigment deposits, which, instead of being of an orange red, become of brownish or slightly purplish red, especially in the dark-skinned races. Where both the stroma of the choroid and the retinal epithelial layer abound in pigment, the fundus has a uniform brownish-red color, and only the retinal vessels are visible. Where the amount of pigment is very deficient in the uvean membrane, the iris and choroid only imperfectly exclude the light from the posterior part of the eye, and there is often confusion of the retinal perceptions and photophobia.

Two congenital anomalies of the fundus may properly be mentioned here. A prolongation of the neurilemma of some of the fibres of the optic nerve into the retina is occasionally, though very rarely, observed, in the form of very white spaces beyond a portion of the margin of the disc, terminating in a fringe of fine radiating lines. There is evident thickening of these parts, and branches of the retinal vessels are often hidden in them, as if covered by an effusion.

Commonly, these spots are limited to a small space or two at the border of the disc; but if large, and extending for some distance beyond the border, they may impair the acuteness of vision. They have no tendency to increase. They might possibly be confounded with the changes about the disc which are seen in some cases and at certain stages of Bright's disease. Coloboma of the retina and choroid, almost always found where coloboma of the iris is present, is a defective development of the two halves of the internal structures of the eye. It is seen as an irregular white space at the fundus, generally with sharply defined outlines, the choroid and retina being wanting, and the reflex from the exposed sclera being visible. Vision is imperfect in proportion to the extent of the defective development. This condition might at first sight be mistaken for the large posterior staphyloma so often seen in high degrees of myopia; but coloboma is generally central in position, or above or below the centre, and unconnected with the optic disc, while staphyloma appears as if a prolongation of the disc, usually in the direction of the macula.

Another function of the ophthalmoscope is its use as an optometer, to determine the refractive power of the eye, the presence and degree of hypermetropia or myopia, or the existence of astigmatism. This is accomplished by examination in the direct method, aided by lenses of different foci placed behind the mirror. Dr. Loring, Dr. H. D. Noyes, and others have ingeniously adapted a series of small lenses set in revolving discs, which may be turned with the forefinger of the hand holding the ophthalmoscope, so as to bring them successively behind the sight-hole in the mirror. The observer tries one after another till he finds the power which enables him to see the finer ramifications of the vessels at the fundus with most distinctness, the patient meanwhile looking at an object across the room, so as to relax his accommodation. Sometimes the accommodation of the eye must be paralyzed, by a one per cent. solution of atropia sulphate, previous to the inspection; but it is generally sufficient for the patient to look at a distance. For examination of the right eye the observer uses his own right eye, and *vice versa.* Theoretically, the lens affording the best view of the fundus expresses the refractive condition of the eye and the focus of the glass which should relieve the defect; practically, it is found that the results thus obtained should not be exclusively relied on, but must be confirmed by actual testing of the glasses, so that the patient may be supplied with such as he can comfortably use in the varying requirements of vision. These questions will be considered more in detail in the chapters on refraction and accommodation.

CHAPTER II.

REMEDIAL MEANS.

A FEW words as to some general principles of treatment will not be out of place, before considering the affections of the eye in a classification as nearly as possible according to their anatomical seat.

Traumatic injuries will be considered in detail in another chapter. It is only important to say here that great care should be used in the first examination of these cases, especially where the eyeball has been wounded, and in many instances "a masterly inactivity" will be far more judicious than any active use of therapeutic means, except where manifest indications for a certain course are present.

Many of the external diseases, including those of the appendages of the eye and of the mucous membrane, the conjunctiva, can be regarded as local affections, and treated almost exclusively by local applications, without much resort to general remedies. Others require the judicious recognition of a controlling influence from an existing diathesis, and call for a combination of local treatment with measures adapted to alter this general condition; as in certain syphilitic or rheumatic affections of the cornea and iris. In many instances these latter would be injured instead of improved by the topical use of astringents or stimulants, so serviceable in the conjunctival maladies, but call for the local use of remedies of another class and of a wholly different effect, as for instance atropia, to prevent internal mischief. A third class, as for example affections of the retina resulting from lesions of the brain or kidney, cannot be reached by local means, but our efforts must be directed toward the original sources of disease.

It seems proper to call attention to the importance of caution on the part of the inexperienced practitioner as to the employment of very active agents. An ulcer of the cornea could perhaps be touched with a point of silver nitrate, by an expert, without harmful result, whereas the consequences might be disastrous if the same were done by a less practiced hand. Great reserve should be exercised in resorting to potent remedies, which when very carefully and discriminately used might be advantageous, but which by a slight error of judgment as to the fit moment for their application or the proper graduation of their strength to the individual case, might be fatal to the eye; because experience fully proves that though these means are admissible they are almost never indispensable, some other less hazardous remedy perfectly well serving the desired purpose in many instances.

Solutions are as a rule the best vehicle for the application of substances to the eye, rather than fatty preparations, or the powders still remaining among the relics of ancient therapeutics. The strength of solutions may be accurately graduated, and they distribute themselves equally over the entire surface; whereas ointments placed inside the lids, or calomel dusted upon the eye, often collect in masses, and act as foreign bodies or as caustics. Solutions can be dropped inside the lids from a spoon, which may be previously warmed in cold weather, or from a drop tube having a small cap of soft rubber at its upper end, with which a few drops can be drawn by suction from the phial and spurted into the eye. This latter, of recent introduction, is a very convenient means, and quite supersedes the use of camel's-hair pencils.

Astringent stimulating or sedative solutions are especially serviceable in inflammations of the conjunctival mucous membrane, characterized by smarting or itching sensations rather than by deep-seated aching pain. When the pain assumes the latter form it is generally an indication for the disuse of these means; which are valueless, if not injurious, in inflammations of other than the external envelope. Solutions of atropia and of pilocarpine, to act especially upon the iris, have largely and conveniently taken the place of the extracts of belladonna, etc., formerly employed. Atropia should not be made use of for conjunctival affections, as is frequently done, as it but increases the photophobia.

Solid crayons afford a useful means for obtaining an occasional greater astringent or stimulant effect than that of collyria. They should as a rule be applied by the surgeon himself, with a frequency and to an extent adapted to each case.

Local depletion should be by leeches applied to the temple and not too near the eye, but is less relied upon than formerly.

Counter irritation in the form of blisters and setons is now rarely resorted to, and is a relic of barber surgery.

Poultices are admissible only in inflammations of the appendages of the eye, and not allowable in disease of the eye itself except in suppurative inflammation of the entire globe. In other cases they are dangerous, as being liable to induce or augment corneal ulceration.

CHAPTER III.

TRAUMATIC INJURIES OF THE EYE.

CONTUSIONS OF THE GLOBE.

A GREAT variety of lesions may result from contusions of the eyeball, among which may be mentioned rupture of the cornea or sclera; laceration of the iris, or its separation from its ciliary attachments; dilatation of the pupil; dislocation of the crystalline lens or rupture of its capsule; effusions of blood beneath the conjunctiva, or into the anterior chamber or the vitreous, or into or beneath the tissue of the choroid or retina; separation of the retina; or rupture of the retina or choroid. These will be elsewhere referred to. The prognosis depends on the severity of the blow and the amount of damage inflicted, and it is often impossible to estimate this at once, or until the immediate effects of the shock have been recovered from.

Contused and other wounds of the orbital ridge are mentioned in speaking of amaurosis, which sometimes follows blows upon this region.

TRAUMATIC INJURIES OF THE CONJUNCTIVA.

The conjunctiva is very tolerant of other than chemical injuries, and may be extensively lacerated, or incised in operations, without danger of serious consequences. Should the wound be extensive, it may be closed by fine sutures; but this is seldom necessary. Indeed, a large amount of the ocular conjunctiva may be excised, as in operations for pterygium, or in the removal of tumors, and the parts left to themselves, in the certainty that the vacant space will be refilled within a few days.

But injuries from caustics or burns are much more dangerous. If the injured part is near the border of the cornea this structure may become ulcerated or sloughy, from impairment of its nutrition through the changes in the surrounding tissues. Where the conjunctiva is destroyed by chemical injury in portions of its ocular and palpebral folds which are opposite to each other, it is almost impossible to prevent the formation of adhesions between those parts of the surfaces of the lids and the globe which have become denuded of their mucous membrane. No interposition of any substance, an artificial eye, or a disc of metal, will prevent these adhesions from forming as cicatrization goes on; and if the cicatricial bands have more than a very limited extent, their section or excision is followed by a renewal and aggravation of the previous unfortunate condition; except where the loss of substance is so limited that it is possible to displace a portion of the ocular conjunctiva and slide it over the globe, so as to cover the exposed surface, bringing the edges together with sutures; thus opposing a continuous surface of mucous membrane upon the eyeball to the denuded space upon the inside of the lid, and preventing cohesion.

Should the amount of mucous membrane destroyed be very small, it may be possible to prevent adhesion by directing the patient to frequently draw the lid away from the eyeball with his finger, until the opposed surfaces have healed.

It is very seldom that an eye injured by caustic substances is seen in time for any serviceable use of antidotes; only simple lotions with milk and water, or salt and water, are therefore to be advised. Any fragments of lime or other foreign substance should of course be removed. A borax collyrium seems to be the best remedial means. Carbolic or other acid, however diluted, is objectionable, and strong astringents or stimulants are to be avoided in both traumatic and chemical injuries. If grains of gunpowder have penetrated the conjunctiva, their removal is difficult, but it is well to pick out, or to excise with fine scissors, such of these as are placed where they will be conspicuous. If they remain, they cause no serious inflammation, but they leave bluish spots, like marks of tattooing.

Foreign bodies of every size and description may find their way to various parts of the conjunctival surface. Small particles, such as grains of sand, cinders from locomotives, etc., when not driven with sufficient force to imbed them in the conjunctiva or cornea, are most frequently found beneath the upper lid, and nearly at its centre. The lid is to be everted and the offending substance removed. Sometimes the foreign body has already been expelled, though the irritation created by its presence has not yet subsided. A little time, lotions with milk and water or salt and water, or a collyrium of borax, will relieve these after-effects.

Larger objects, splinters of wood, grains of wheat, insects, etc., occasionally remain lodged for a considerable time in the palpebral fold, where they become inclosed and often concealed by exuberant conjunctival granulations, which soon disappear under the use of a very mild collyrium after the removal of the foreign substance. If such objects are not seen on everting the lid, they are sometimes discovered by drawing the lid away from the globe and directing the patient to turn the eye downward as far as possible, the head being thrown back.

Small particles of glass or sand are, on account of their transparency, sometimes seen only when carefully sought for with a magnifying glass.

WOUNDS OF THE SCLERA.

The globular form and firm structure of the sclera give to it great resisting power: any injury, therefore, which has overcome this resistance is usually accompanied also by grave lesions of other parts of the globe.

Rupture of the sclera may be produced by strong pressure, from a thrust of the horn of a beast, or from the thumb in an attempt to gouge the eyeball in fighting; and the crystalline lens is then not unfrequently forced through the wound. The treatment of this condition is referred to in the section on dislocations of the lens. These and other lacerated wounds of the sclera, being usually the result of great violence, admit of only an unfavorable prognosis, as do also many of the punctured wounds. Incised wounds, even those made by flying pieces of glass, are sometimes recovered from without serious loss of vision.

If any considerable amount of vitreous protrudes through the wound it may be excised by a stroke with sharp curved scissors, so as to avoid the dragging out of a yet larger portion. If the wound is of any considerable size, it may be closed with fine sutures; if small, it may be left to itself. The eyes should be kept closed and quiet, as if asleep.

Wounds of the sclera which involve the ciliary region belong in another category, on account of the liability not only to immediate but to subsequent irritation and inflammation of these delicate parts, too often causing a sympathetic affection and loss of the other eye. They are referred to in the description of sympathetic ophthalmia.

TRAUMATIC INJURIES OF THE CORNEA.

The cornea is very intolerant of certain kinds of injury, where rankling particles, from chestnut burs, the beard of grain, and the like, remain in it. In wheat-growing countries where harvesting machinery has not been introduced, the eyes of reapers are often brushed by the ears of grain, as handfuls are seized to be cut with the sickle. Minute barbed silicious particles are thus driven into the cornea, exciting there an inflammation quite out of proportion to the apparent amount of injury. Beginning with an abrasion of the epithelium, or a superficial grayish ulceration around the foreign body, if such remains in the cornea, a tendency to yellowish degeneration or to purulent infiltration soon manifests itself. The matter, impelled by movements of the lids, accumulates or distributes itself between the corneal lamellæ, forming the appearance termed onyx from its resemblance to the elliptical spot at the root of the finger-nail; or collects in small abscesses, which discharge externally in the ulcer, or make their way, perhaps sinuously, into the anterior chamber, where the pus settles at the depending part and forms hypopion. The amount of opaque fluid thus accumulating in the anterior chamber is increased from the irritation excited in the iris, which becomes secondarily affected. The hypopion is often largely made up of tenacious lymph rather than pus. Oblique illumination is of great service in studying the details of these conditions. When the iris is implicated there is often much circum-orbital pain, and this condition should be carefully watched, that precautions may be taken by a seasonable use of atropia to prevent closure of the pupil by plastic deposits. There is of course circum-corneal injection and more or less of secondary conjunctivitis, with secretions of an acrid nature. Injuries of the cornea from chips of metal sometimes give rise to similar ulceration and hypopion. Injuries from caustic substances or burns are followed by symptoms which vary in some important respects from those above described. At first, and perhaps for three or four days, the cornea seems to be only abraded; but after this period, and perhaps suddenly, a sloughy condition comes on, as if the vitality of the cornea had actually been more deeply affected than at first appeared, or as if the matter from the superficial ulceration had been driven between the laminæ of the cornea by the lid friction. If this degeneration is extensive and deep, it is rarely followed by recovery.

Most benefit may be hoped for from the use of tonics, and of such mild local applications as solutions of soda borate. Should any foreign substance remain in the cornea, it should be carefully removed. If hypopion has not formed and the iris is not implicated, two grains of pilocarpine nitrate may be used to change the tension of the cornea, and thus favor the removal of the ulcerations and the infiltration. Where the iris is involved, the use of myotics may be still continued, provided atropia is also occasionally employed to dilate the pupil and prevent synechiæ. When hypopion has accumulated, even in large quantity, it is often reabsorbed by the aqueous, without surgical interference; and this deposition and absorption may be several times repeated. But where its amount is excessive and it is accompanied by pain and tension, it may be evacuated with advantage by puncturing the cornea with Desmarres' broad paracentesis needle, either in the situation of the ulcer or at the lower margin at the seat of the hypopion, as may be thought advisable. Frequently, and especially where the accumulation is made up in part of plastic lymph, the matter cannot be at once wholly evacuated, but that which remains is afterwards dissolved in the aqueous which is freshly secreted; or it may be discharged the next day by a second puncture. Perforation of the cornea, by the progress of ulceration or by paracentesis, is often followed by immediate relief of pain, and perhaps by a rapid improvement in other respects; but this is by no means always the case, especially if the patient's general condition is feeble. Paracentesis should therefore not be too readily resorted to or too often repeated. It is better to wait a little and note the effect, doing it a second time only when the first evacuation has evidently had a favorable influence on the morbid conditions.

The cornea being a tissue of low vitality, active local or general depletive measures are hurtful; as are also applications of strong stimulants or astringents. Very warm fomentations have had their advocates, and are doubtless to be preferred to cold lotions in these passive inflammations, but neither of these is invariably useful, and one or the other, or neither, may be advised, according to the sensations of the patient and the apparent benefit derived. In very old or feeble persons care must be taken not to lower the vitality of the cornea by continuous application of cold, or to macerate and soften it by prolonged use of very warm, fomentations. Tonics and stimulants should be used *pro re nata.* It is very important that the eye should be kept quiet; but anything of the nature of a pressure bandage must be scrupulously avoided, as it tends to produce sloughing of the cornea.

Iridectomy is rarely indicated during the course of these corneal affections, but may be the means of restoring vision, after recovery from them, if extensive adhesions of the iris have closed or central opacities have veiled the pupil. It is, however, not always expedient or useful to make an artificial pupil in such cases, while the other eye has good vision; as, unless the new pupil can be formed at the lower or inner part of the iris, the limited degree of binocular vision thus obtained often confuses, rather than assists, the other eye. Operations for iridectomy should not be done too soon after recovery from ulceration; because the resulting opacities are often surprisingly thinned and narrowed by subsequent absorption, in which case no iridectomy would be needed; and, moreover, because it is safer to wait, before doing operations on the iris, till all traces of inflammatory action have subsided.

ABRASIONS OF THE CORNEA.

The epithelial layer of the cornea is sometimes more or less torn by sudden contact of an infant's rough finger-nail, the corner of a sheet of paper, or other object. This is frequently followed by intense circum-orbital pain, especially in women who are enfeebled by nursing. This may continue twenty-four hours or more, until the denuded surface is covered with a new epithelium. In rare cases it even persists for weeks or months. Lotions with milk and water, or an aqueous infusion of opium or of poppy capsules, and especially the frequent use of a collyrium of borax, will mitigate the suffering. Cold compresses upon the lids are sometimes grateful. Sedatives are occasionally required to relieve the intensity of the pain. Where the photophobia is excessive, contraction of the pupil by means of a solution of pilocarpine or eserine is useful. When the pain continues long after all traces of the injury have disappeared from the cornea, tonics are required; and if such general treatment does not afford relief, lactation must be given up, if this appears to enfeeble the patient.

FOREIGN BODIES IN CORNEA.

Grains of gunpowder are sometimes driven into the cornea with such force as to penetrate beneath the outer layers, and occasionally pass completely through it. When remaining in its substance they seldom excite inflammation; but grains which are in front of the field of the pupil should be carefully picked out, if seen early, so that they may not obstruct vision. Other large grains may also be extracted; but it is not necessary to insist on the removal of every small particle, at the risk of exciting corneal irritation by too long continued manipulation.

Cinders from locomotives are frequently implanted in the outer cornéal layers, and, being black, may easily be overlooked if they happen to be in front of the pupil. They should be removed at once with a cataract needle or some fine-pointed instrument. The same should be done for other foreign bodies blown into the eye, such as sand, seed-husks, and the like. These may sometimes be dislodged with a sharpened tooth-pick or other bit of wood, which appears less formidable to the patient than a steel instrument.

Stone-cutters and machinists are liable to have small particles of metal or grains of emery enter the cornea, which have broken off from the hammer or chisel, or flown from a lathe or wheel. In many workshops some one gets a reputation among his comrades for his skill in removing these with a bit of wood or the point of a knife. If the small fragment has not entered deeply it is easily taken out; but when it is more firmly implanted in the elastic corneal tissues the removal requires care and a proper instrument, otherwise the cornea may be extensively abraded in the fruitless efforts. Generally it is possible to extract such particles with a cataract needle having a short stem, or any fine-pointed instrument, after fixing the head of the patient and separating the lids with the thumb and finger of one hand; but where the eye has been made very sensitive by previous ineffectual attempts, it is occasionally almost impossible for the patient or the surgeon to control its movements, and it may be necessary to administer ether. This is especially necessary where the bit of metal has penetrated so far as to project into the anterior chamber. In this case it is sometimes requisite to first pass a needle into the anterior chamber, so as to support or push the metal forward with this, while a second instrument is used to extract it. Magnets may extract bits of iron which are only loosely implanted in the cornea, or which have fallen into the anterior chamber, in which case the electro-magnet is introduced through a small incision.

No treatment beyond a few hours' rest is generally needed after a foreign body has been extracted. The feeling of something scratching beneath the lid, from the rough edge of the depression in which the foreign body had been lodged, perhaps persists for a time; but this soon passes off, as does also the lachrymation and the injection. If there has been much abrasion, or the foreign body has remained sufficiently long *in situ* to cause a beginning of ulceration, a solution of borax may be given, to be used three or four times daily.

WOUNDS OF THE CORNEA.

As a rule, wounds of the cornea, if uncomplicated by protrusion of the iris, should be meddled with as little as possible. The eyes should be quietly closed as in sleep, the lids being kept shut by strips of insinglass plaster, if necessary, and the patient should lie on his back in a moderately darkened room, so that the aqueous may be retained by position. Compresses wet with cold water, frequently but gently changed, are sometimes used with benefit outside the lids; but in other cases even these may be better dispensed with. The patient should not attempt to see, and the surgeon should refrain from frequent examination of his eye. When the lid is raised for this purpose no pressure should be made on the globe. No collyria should be used, as they may do mischief by finding their way within the eyeball. Very large incised wounds are sometimes thus healed with but a slight scar; contused or lacerated wounds are more serious, but the prognosis is not always unfavorable.

If protrusion of the iris prevents contact of the edges of the wound, an effort may be made to reduce the hernia by means of a fine probe. These attempts, however, rarely succeed, or if they do so for the moment the hernia is reproduced. Where this occurs, or where the iris has been so long entangled as to have formed adhesions in the wound, it is best to excise at once as much as possible of the protruding mass, close to the cornea, by a quick stroke with fine-curved scissors; so as to allow the aqueous which distends the pouch to escape, causing collapse of the protruded iris, and bring together the edges of the corneal incision. Atropia or pilocarpine are rarely efficient in drawing back any such hernial projections, but they may be of service, after the excision, by preventing any new protrusion, — atropia being used if the wound is central, pilocarpine or eserine if it is marginal.

TRAUMATIC IRITIS.

The iris is very tolerant of extensive incised and even lacerated wounds, as is shown after iridectomy, and after blows which have torn the iris largely from its ciliary attachments (dialysis), even though copious hæmorrhage has filled the anterior chamber and compressed the surface of the iris. But it resents the presence of a foreign body in its substance, which, as well as punctured wounds, is often followed by plastic inflammation, having an unfortunate tendency to involve the cornea, ciliary body, and choroid. In a few instances, however, foreign bodies remain for a life-time implanted in the iris without causing destructive irritation. Non-interference, so long as the presence of the extraneous substance is well borne, is therefore justifiable in traumatic cases.

As a rule, extraction of the foreign body is indicated, etherization being first effected to secure immobility of the eye. A puncture with a broad needle, or incision with an iridectomy knife, according to the size and nature of the object, is made in the cornea, at such point as will best allow of seizing the extraneous body with the canula forceps or other small instrument adapted to the form and size of the thing to be removed, care being taken not to wound the capsule of the crystalline with the instrument or with the foreign body. It is sometimes possible to introduce the extracting canula forceps through so small a puncture that the aqueous is retained, and the cornea and iris thus kept apart till the object can be laid hold of and withdrawn. If the foreign body is a bit of iron or steel, a magnet is sometimes efficient in extracting it. The intruding body being removed, the iritis ordinarily subsides at once, if complications have not already formed. Mydriatics may be employed if adhesions are feared, and should always be used if any degree of inflammation has become established.

A similar plastic iritis, generally associated with cyclitis, or inflammation of the ciliary body, is sometimes excited by pressure of fragments of lens or capsule after cataract operations.

Sympathetic iritis, occurring in a sound eye on account of ciliary irritation in an injured eye, is complicated with inflammation of the ciliary body and choroid, and will be described under the head of irido-choroiditis.

Hernia of the iris, and its treatment when a result of wound, is described in the chapter on affections of the iris.

RUPTURE OF CHOROID.

Sharp blows upon the eyeball from a flying cork or missile, which have left no trace of wound, or even of abrasion of the external surface, sometimes cause rupture of the choroid, the force of the blow being propagated from the arch of the cornea, where it is received, to the internal structures, and taking effect at the deeper parts by causing shortening of the antero-posterior axis, bulging at the equator of the globe, and sudden tension of the choroid at the fundus of the eye. Hæmorrhage from the torn membrane into the vitreous often occurs to such an extent as to preclude inspection of the fundus and determination of the amount of injury until after its absorption is more or less advanced, and nearly abolishes vision for the time being.

The rupture is frequently crescentic in form, but may be irregular, or branched. The neighborhood of the macula lutea is oftenest the seat of lesion, which fact should lead to caution at the outset as regards the prognosis.

The resulting scar may be so slight as to involve only the choroid ; or, on the other hand, the injury may have been so great as to lay bare the sclera, or cause organized opacities in the vitreous, which remain permanent. Separation of the retina is more rare. Vision is finally regained in a greater or less degree, according to the extent and position of the lesions.

TRAUMATIC CATARACT

often results from sharp concussion of the globe, as from a blow from a piece of wood, a cork forcibly propelled from a bottle, the knot at the end of a whip-lash, or other non-penetrating injury. There may or may not be evident rupture of the capsule. In cases of non-rupture it would seem as if some other agency than mere tearing away of the suspensory ligaments must create the subsequent opacity, since we know that the nutrition of the lens somehow goes on, and its transparency is retained for a long time, after complete dislocation. When the capsule is ruptured by any such means, as also when it is punctured or torn by penetrating bodies, or is incised in operations, there results, unless the capsular lesion is very minute, an imbibition of aqueous by the lens, which, quickly or gradually, according to the size of the capsular aperture and the age of the subject, transforms the transparent lens substance into a white or bluish-white homogeneous mass, which, having greater bulk than the normal lens, and being pressed upon by the elastic capsule, exudes from the capsular wound and expands into large flakes, which become absorbed by the surrounding aqueous fluid, and perhaps wholly disappear, leaving a clear pupil. But if this expansion goes on too rapidly, or if on account of a still open corneal wound the aqueous does not accumulate and keep the anterior chamber filled, the flaky masses of the lens come into injurious contact with the iris, and excite irritation, which frequently extends to the ciliary region, and may induce destructive inflammation. Continued dilatation of the pupil with atropia is an important means of preventing or relieving such consequences; but it is difficult to maintain this if the corneal wound remains unclosed.

If the traumatic injury has been caused by a small foreign body, such as a bit of percussion gun-cap or of steel, which has passed through the cornea, this may be arrested by the anterior capsule of the lens, and remain fixed there, perhaps indefinitely; giving rise to only limited, if any, opacity of the lens substance. Or it may enter the lens and create cloudiness, but involve no other changes than perhaps gradual absorption of the crystalline, leaving the foreign body inclosed between the folds of capsule, where it is not a source of further danger to the eye. Or it traverses the lens and vitreous, or passes through the iris, to be lodged somewhere at the fundus of the globe, where its presence menaces the future safety of the organ.

If the lens has become cloudy, without the existence of a wound in the capsule sufficient for its absorption, a question arises as to the expediency of its removal by operation. This is sometimes advisable, especially for ladies, for cosmetic reasons, to relieve the conspicuous cloudiness in the field of the pupil; though the discovery of myotics has made an operation less requisite than formerly, since the objectional opacity can be in a large degree concealed by daily use of mild solutions of pilocarpine or of eserine; the pupil being thus contracted, and the iris drawn as a veil before the glaring white cataract, so that it is little observable. If appearances are of little consequence to the patient, we have only to consider whether he will be a gainer by the operation as regards sight. He will recover a certain degree of binocular vision; but this is distinct only with the aid of a glass, and the eye operated on, having no accommodation, does not harmonize with the more perfect visual act in the opposite eye, and at times confuses instead of aiding it; so that the monocular vision previous to the operation is often actually more comfortable and useful than the non-corresponding vision in the two eyes.

CHAPTER IV.

AFFECTIONS OF THE CONJUNCTIVA.

ANATOMY OF THE CONJUNCTIVA.

THE conjunctiva is a mucous membrane which lines the sac formed between the lids and the eyeball.

It consists of a fine connective tissue with occasional elastic fibres, and is covered externally with flat and cylindrical epithelium; its substance is abundantly supplied with nerves and blood-vessels, and between its loosely woven fibres are numerous lymph spaces, which even in health contain more or less small round cells. The palpebral portion of the conjunctiva is closely united to the tarsus, and in some places is thrown into small folds, which on section appear like papillæ.

In this portion of the conjunctiva are found the trachomatous new formations of granular conjunctivitis, and the cicatricial tissue which remains after their reabsorption.

The fold, or fornix conjunctivæ, forms a very loose connection between the palpebral and ocular portions, and thus allows the eyeball to move freely in all directions; here are found the small mucous glands, and at the outer part, under the upper lid, the openings for the tears secreted by the lachrymal gland.

The ocular conjunctiva is smooth, and as it approaches the corneal margin it is more firmly adherent to the underlying sclera, the fibres losing themselves in the cornea and sclera at the corneo-scleral margin. The epithelium of this part is thickened, and is continued directly over the cornea to form the epithelial layer of that tissue.

The blood-vessels of the tarsal conjunctiva and fornix are largely derived from the facial and temporal arteries, but on the ocular portion, especially near the cornea, the supply comes from the anterior ciliary arteries, which, dividing near the corneal margin, in part penetrate the sclera to supply the ciliary region, and in part form a circum-corneal zone of fine vessels in the deeper layers of the conjunctiva close to the sclera, which pass forward to anastomose with the vessels of the conjunctiva proper near the corneal margin.

In normal eyes this last system of vessels is not seen, but in cases of iritis or keratitis they are congested, and we notice a pink or reddish zone surrounding the cornea, and decreasing in brightness as it passes back over the sclera. The color is more or less uniform, the vessels being too fine to be distinguished separately. In conjunctivitis, on the contrary, especially in the early stages, the injection is more marked in the superficial vessels, is generally greater on the palpebral portions and at the fornix, and decreases as it approaches the cornea.

The nerves of the conjunctiva soon lose their sheaths, and form a plexus of fibres under the epithelium, where they end in bodies whose structure is still a matter of dispute.

The plica semilunaris is merely a loose fold of conjunctiva between the cornea and the inner canthus, which allows the eye to be turned freely outward without pulling on the caruncle.

HYPERÆMIA: SIMPLE CONJUNCTIVITIS.

In the condition of health the conjunctival vessels do not convey a large amount of blood; but this state of things may be very rapidly changed, and the whole or a part of the palpebral and ocular conjunctiva may become congested, and the transparency and color of the membrane altered, from the irritation caused by the presence of a foreign body, from slight burns or wounds, or from the action of mild irritants accidentally or intentionally applied to its surface. This hyperæmia is attended with slight sensitiveness to light and more or less copious lachrymation, but not to any great extent by increased mucous secretion; and there is little, if any, of the velvety thickening which marks the beginning of catarrhal inflammation. Its exciting cause being removed, the congestion soon subsides, even when left to itself, but perhaps more quickly under the use of mild remedies. A few drops of a solution of borax, ten grains to the ounce of camphor water, may be put into the eye from a teaspoon or a drop tube three or four times a day. This, if properly prepared and filtered, should not cause smarting, but rather a cooling, refreshing sensation. As a collyrium in the milder forms of conjunctivitis, and in corneal affections, this preparation is invaluable, and is much to be preferred to stronger astringents or stimulants. It does not spoil, even if kept a long time. It is sufficient to instill a few drops of a collyrium inside the lower lid, from whence the movements of the lid and globe will distribute it over the whole conjunctival surface. A solution of common salt, about a teaspoonful to eight ounces of water, also sometimes acts favorably upon the conjunctiva, when used in a similar manner. Cold or tepid water, or equal parts of milk and water, or infusions of tea or rose leaves carefully strained, may be used as lotions, if agreeable to the eye, but their effect is generally not important.

Blue or neutral tinted glasses may be worn if the eyes are very sensitive to light, or as a protection from wind or dust. Rest of the eyes is not essential, but may promote a more speedy recovery. No change of diet is necessary.

Hyperæmia of the conjunctiva frequently appears as a secondary condition, resulting from an inflammation of some of the contiguous structures. In such case it seldom requires special treatment, but will disappear only with the abatement of the primary affection. Should any palliative measures be thought desirable, soothing means rather than stimulating remedies should be employed; as the use of strong astringents or irritants in these circumstances will not remove the secondary conjunctival congestion, but may increase the original disease.

Similar injection of the conjunctiva is believed by some to result now and then from abnormal refractive conditions, such as hypermetropia, astigmatism, or insufficiency of the internal recti muscles, when the eyes have been fatigued by too close application to fine work. Properly selected glasses would be an important means of relief if such had been the exciting causes, and not mere coincidences.

CHEMOSIS.

Serous infiltration of the sub-conjunctival cellular tissue is a frequent accompaniment of traumatic injury, or of mild forms of conjunctivitis. Here it is of no importance, and is soon reabsorbed. It is also met with as a secondary condition in some cases of iritis, or other deep-seated inflammation. In any of these circumstances irritating applications should be avoided.

Serous chemosis, with a peculiar straw-colored aspect, may also appear as an early symptom of gonorrhœal conjunctivitis, and should put the practitioner at once on his guard.

Phlegmonous chemosis, where the conjunctiva and its underlying cellular tissue becomes densely infiltrated with plastic lymph, is seen in many cases of gonorrhœal, purulent, or diphtheritic conjunctivitis, and may endanger the nutrition of the cornea. It occurs also in ophthalmitis involving the entire globe.

ECCHYMOSIS.

Hæmorrhagic effusion into the sub-conjunctival cellular tissue may occur suddenly and from slight causes, without the patient being conscious of it until his attention is called to the eye by others. Coughing, sneezing, straining at stool, rubbing the eye, or exposure to wind may cause rupture of a small vessel. The effused blood is then spread over a greater or less surface by the movements of the eyelids, forming a crimson spot, but causing little or no injection or irritation of other parts of the conjunctiva. A collyrium of borax may be given, to relieve the patient from anxiety, and this may perhaps promote absorption, which, however, goes on with or without the use of such means. The effused layer gradually diminishes in thickness, though perhaps increased in extent, and the patch changes from red to yellow as the normal condition is approached. A few days usually suffice for the disappearance of the effusion unless the quantity is large.

Sub-conjunctival ecchymosis may also be a symptom of fracture at the base of the skull.

PINGUECULA.

A small roundish elevation, having a yellow fatty appearance, is sometimes formed by local hypertrophy of the conjunctival tissues, generally just beyond the border of the cornea at its temporal, or perhaps also at its nasal, side. It is rarely accompanied by much injection, though a few vessels sometimes enlarge if the eye has been irritated by dust or cold wind. Patients often anxiously inquire as to the nature and probable development of these appearances, and may be assured of their harmless nature and the non-necessity of their removal.

DERMOID TUMORS OF CONJUNCTIVA.

Dermoid growths, usually situated at the sclero-corneal border, and often encroaching largely upon the cornea, are occasionally seen as congenital defects. They form yellowish, somewhat elevated masses, partially encircling the cornea. The only proper treatment is their very careful dissection from the underlying tissues.

ENCYSTED TUMORS OF CONJUNCTIVA

sometimes appear as small transparent vesicles, easily removed if they do not disappear after being punctured. Entozoa have in a few instances developed beneath the conjunctiva, requiring to be extracted.

MALIGNANT GROWTHS IN CONJUNCTIVA.

Sarcomatous and melanotic formations are now and then met with in the conjunctiva. Excision of the anterior portion of the eye, or enucleation of the entire globe, should be at once performed, according to the apparent extent of the disease, unless it seems clearly evident that only the conjunctival tissue is implicated.

PTERYGIUM.

A wing or wedge shaped growth, composed of bands of glistening fibres and vessels, in some cases thin and transparent, in others thickened and fleshy, is sometimes developed in and beneath the conjunctiva, from near the inner canthus toward the cornea. Occasionally a like growth appears at the outer canthus. On reaching the margin of the cornea its further progress is for a time arrested by the close adhesion of the epithelial layer to the corneal substance; and it perhaps remains stationary for months, or even for years, slightly overlapping the corneal border. If it manifests no disposition to troublesome congestion it may be left without interference until it again begins a positive advance toward the centre of the cornea. It then more or less slowly or rapidly extends over the pupil. In this case, vision is not only temporarily obscured, but the corneal layers may be so far affected that when the growth is removed a permanent central opacity will be left, impairing the sight in a greater or less degree.

This affection is most common in those who have been exposed to vicissitudes of weather, and especially among seamen who have been much in warm latitudes. In rare instances it seems to originate from injury of the conjunctiva, or the presence of a foreign body at the corneal margin.

Various methods of treatment have been proposed: destruction by caustic, which is too dangerous; ligature; transplantation; and excision.

The best treatment is excision of that portion of the growth which has crept upon the cornea, and as far as midway from the border of the cornea to the caruncula. The remainder may be left in place. If excision of all the fibres has been complete, and the sclera is fully exposed to the extent mentioned, there is scarcely any risk of relapse. No attempt should be made to cover the raw surface of the sclera by bringing together the edges of the conjunctival wound, as the cure is thus rendered less certain. Imprudent exposure should be avoided for a few days after the operation. Mild tepid lotions are the only treatment needed.

SYPHILITIC DISEASE OF CONJUNCTIVA.

More rarely than the border of the lids the ocular conjunctiva becomes the seat of syphilitic ulceration, having hardened edges and a livid aspect, or of gummata, with in both cases a sluggish persistence. Mild local means, with attention to any complications in other structures, especially where the ulcer is near the corneal margin, together with measures to modify the constitutional diathesis, form the best treatment of this infrequent affection.

PHLYCTENULAR CONJUNCTIVITIS.

In children especially, though not unfrequently also in older persons, we meet with a form of eruptive conjunctivitis characterized by the formation of one or several small papulæ, generally situated near the corneal margin. These are slightly, or perhaps considerably, raised above the surrounding surface. After a time a small yellowish pustule may form at the summit, followed, when ruptured, by a depressed spot at this point. A fasciculus of vessels extends to or surrounds these phlyctenulæ; but the injection does not involve other parts of the conjunctiva. These elevations cause the sensation of a foreign body in the eye, more or less smarting or itching, some intolerance of light, and increased lachrymation, but little or no deep-seated aching pain, and only slight increase of mucous secretion.

In a few cases these papules are much larger, perhaps of the size of half a pea, and have then a more chronic duration; but most of the smaller spots have a disposition toward spontaneous cure in a week or ten days, if not too actively dealt with. But there is frequently a succession of these as the first disappear, unless the state of the conjunctiva is modified by continued use of local remedies and tonic general treatment.

The affection being thus comparatively trivial, and of favorable tendency, it is of the first importance to avoid harsh measures where milder means are amply sufficient for relief, especially as most of its subjects are of tender age. No change of diet is required. Exercise in fine weather is desirable, and the child can go to school if there is not too much intolerance of light, or use the eyes moderately at home, without danger. Tinted glasses may be worn to shield the eyes from light and wind.

Counter irritants should never be applied, nor is any general treatment necessary in most cases. But, though many eyes recover, if left to themselves, there is much advantage in using a soothing collyrium of eight or ten grains of borax to an ounce of water or of camphor water, of which a few drops are put into the eye three or four times a day. As this gives no pain it is seldom objected to even by very young or timid children, unless they have been already frightened by previous harsher remedies. The borax is also especially valuable for permanently modifying and improving the condition of the conjunctiva, and thus preventing relapses, and its use should be continued for this object, once or twice a day, for some time after the active symptoms have disappeared.

Solutions of atropia sulphate have been too indiscriminately used of late years in the treatment of this affection. These and all preparations of belladonna or other mydriatics should, on the contrary, be avoided, as not only unnecessary, but as worse than useless, inasmuch as their enlargement of the pupil increases the intolerance of light, and by thus causing spasmodic friction of the eyelids upon the phlyctenulæ adds to the discomfort of the patient, and actually retards the cure.

The larger flattened phlyctenulæ, of the same general nature, are less easily disposed of, and sometimes require tonics or change of air. Though not dangerous, they may cause much anxiety to the parents from their persistence. To the local means above described other mild collyria or unirritating lotions may be added, to endeavor, by varying the treatment, to obtain a new influence upon the disease. Solutions of five grains of alum or of common salt to the ounce of water may be used alternately with the borax, or substituted for this, if thought desirable. A touch inside the lower lid once in a day or two with a crayon of alum sometimes alters the sluggish condition and causes rapid improvement. This causes no pain of consequence, but only a sensation of warmth for a few moments. A drop or two of a solution of pilocarpine nitrate, two grains to the ounce, applied daily, often gives much relief to the photophobia, and seems to be otherwise useful in all forms of this affection.

Insufflations of calomel or other fine powders are still used in some localities in the treatment of phlyctenular conjunctivitis; but they have no special beneficial effects, and as mere stimulants they may be advantageously replaced by remedies in the form of mild solutions, of which the effect can be more accurately graduated. The intense suffering often experienced when calomel dust is put into the eyes of adults, who can describe their sensations, should warn us to be sparing of this needless infliction for children.

It is worthy of remark that a very sudden amelioration of symptoms is often noticed in this affection, as also in ulceration of the cornea in children; and this equally occurs after the trial of some new remedy, or where there has been no change in treatment. Atmospheric conditions sometimes account for this change for the better; in other cases, the improvement having reached a certain point, the healing processes go on more rapidly than before, or the disease terminates by its own limitation, as above stated.

MUCO-PURULENT CONJUNCTIVITIS.

Several of the most important and most frequent of the affections of the conjunctiva are marked not merely by hyperæmia, or by inflammation of limited extent, as in the conditions already described, but by a general injection and alteration of the membrane, with a more or less abundant increase of its secretions. These affections have many features in common, but have also essential differences in their symptoms, their causes, and their course, which require their recognition and description as distinct diseases, as given in the following sections. Most of them have a destructive rather than a benign tendency, and except in their earliest stages and mildest forms are seldom removed by the sole efforts of nature. These form a large proportion of those diseases of the eye which come under the care of the general practitioner, and it is of the first importance that he should be able to deal with them promptly and skillfully, so as, at the outset, to avert serious danger and avoid tedious continuance of the disease by the early use of suitable remedies; or, if the case is not seen until the affection has become chronic, that he should control the primary disease and remove the secondary morbid conditions by persevering and judicious treatment. By far the largest proportion of the inmates of charitable institutions for the blind have been reduced to this condition by the results of conjunctival affections; and it is sad to know that the sight might have been saved in nearly all of them by proper treatment.

CATARRHAL CONJUNCTIVITIS.

After exposure to wind or dust a person often complains of a sensation of smarting or itching, as if sand were in the eye. This is not only accompanied, as in simple conjunctivitis, by increased lachrymation, but by a more or less abundant mucous secretion, and by a uniform vivid injection and velvety thickening of the palpebral and a considerable vascularity of the ocular portion of the conjunctiva. These phenomena may appear so suddenly that it is not uncommon for patients, who, perhaps, may themselves be physicians, to insist that something must have been blown into the eye. Of course, in such cases, the front of the eyeball and the inner surfaces of both lids should be carefully inspected, to detect any foreign body which may possibly be present; but in most instances none will be found, and the velvety condition of the palpebral conjunctiva, very different from the simple hyperæmia excited by a foreign substance, will mark the distinctive catarrhal nature of the symptoms. The irritation caused by particles of dust and exposure to cold, damp winds is a common exciting cause. In California and on our Western prairies these influences are especially felt.

At certain seasons, most frequently, though not invariably, in the spring or early summer, epidemics of this affection appear, and a large number of persons will be more or less severely attacked; but the milder cases thus occurring quickly subside or yield readily to treatment. Some of the German authors describe these epidemic attacks as a distinct variety of the catarrhal form, under the designation "Springtime Catarrh."

If unchecked, the conjunctival alterations become more marked; the velvety palpebral surface, especially the lining of the upper lid, is villous, from hypertrophy of its papillæ, and the eyeball shows increased injection, which is greatest at that portion of the conjunctiva nearest the palpebral fold, and less intense near the cornea. As in other forms of conjunctivitis, the injection has everywhere a bright scarlet color; the reticulated vessels cross and anastomose in all directions, and by rubbing the lid to and fro against them they may be freely moved over the surface of the sclera. These peculiarities serve to distinguish inflammation of this investing mucous membrane from affections of the internal structures of the globe, in which the injection has a more purplish or lake tint and the vessels radiate outward from the corneal margin, and cannot be moved by sliding the conjunctiva upon the sclera. A certain amount of conjunctival injection is, however, often secondarily developed as a concomitant of these deeper-seated affections, and follows their fortunes.

The character of the pain affords another distinctive feature of conjunctivitis: it is a smarting or itching sensation, often, though not invariably, increased towards evening, limited to the eye and the lids; and not the deep-seated aching pain, often extending to the supra-orbital or other branches of the fifth pair of nerves, which accompanies iritis or other inflammations of the internal parts of the eyeball. But if the cornea has become ulcerated the nature of the pain is similar to that experienced in internal inflammation.

By their increased weight and their constant friction upon the globe, the rugous inner surfaces of the lids at length produce vascularity, thickening, or abrasion of the epithelial layer of the cornea, or ulceration of its proper tissue. Especially is this the case where the prominence of the conjunctival papillæ is complicated by the development of trachomatous granulations, which render the disease more intractable. These will be elsewhere described.

Though the secretions in catarrhal conjunctivitis do not have the virulent contagious qualities which are found in the purulent forms of inflammation, it is nevertheless prudent to avoid any contact of these secretions with a healthy conjunctiva. If only one eye is diseased, this should be washed after the other, and the same napkins or handkerchiefs should not be used for both eyes, nor by any other person, as whole families may become affected through carelessness in this respect. If seen early, and the attack is light, the mildest treatment is usually sufficient to arrest the disease, which is then very amenable to remedies. Lotions with cold water or milk and water, tea or rose-leaf infusions, or salt and water, several times a day, or the application of light compresses wrung out of cold water and changed as they become heated, are often efficacious. If, however, they are not grateful to the patient, they may be exchanged with advantage for tepid lotions.

Mucilaginous infusions of quince seeds, marshmallow root, sassafras pith, and the like were formerly in professional as well as popular favor; but they are objectionable, because they increase the gummy condition of the edges of the lids, and they have no curative value. Infusions of rose or tea leaves, carefully strained, may be used as lotions; but infusions of camomile flowers, which are popular favorites, have the disadvantage that unless filtered through paper it is difficult to prevent silicious particles of the petals from remaining in the liquid to irritate the eye. A solution of borax, of about ten grains to the ounce, can be used with more benefit than these lotions, a few drops being put into the eye four times daily, and is a painless and usually a grateful application. Harsh astringents or stimulants are harmful rather than serviceable. An application of a crayon of alum to the inner surface of the lid once a day may shorten the attack, in some instances.

When the catarrhal attack is more severe or less recent, with considerable thickening of the conjunctiva and much mucous secretion, more active measures must be employed. The collyrium of borax is here inefficient, and the best eye-water is a solution of zinc sulphate put into the eye three or four times daily. This often suffices, if faithfully used, without other means. A solution of such strength as to cause smarting for only two or three minutes is in my judgment the best. If the pain continues for a long time after its introduction the remedy is less beneficial, its astringent effect being then partially neutralized by its over-stimulation of the conjunctiva. One or two grains to the ounce of water or of rose water is quite strong enough in most cases I generally advise what I think will be a suitable strength, but tell the patient to mix a spoonful of it with a spoonful of water, if it causes too much smarting, and to apply this dilution instead of the full strength, for a time at least. In a few chronic cases four grains to the ounce is well borne, and is to be preferred. Solutions of copper sulphate, silver nitrate, and cadmium sulphate are too stimulating in proportion to their astringent action, and are inferior to and less safe than the zinc collyrium. Alum in solution has no value in these cases, but when applied in the form of crayon to the lining of the lid it may occasionally be of service as an auxiliary to the zinc solution. Lead acetate should be absolutely excluded from use in ocular therapeutics. It is liable to be decomposed and deposited upon the cornea, as an indelible opacity, whenever abrasion or ulcer of the cornea is present, — a condition which may occur at any time in numerous eye affections, — and it has little efficacy in any circumstances. Being thus valueless and dangerous, it would be better to "reform it altogether."

At the outset of attacks which promise to be severe, one or two light applications of a crayon of copper sulphate to the conjunctiva of the upper lid, combined with the zinc collyrium, will often act as an abortive treatment, and cut short the disease.

The eyes should be kept free from accumulating secretions by bathing them with water or mild lotions; and at bedtime a very little simple ointment, or rose-water ointment, may be applied to the edges of the lids, to prevent their agglutination and allow of the free escape of the secretions during the night. Should the skin about the edges of the lids become excoriated or reddened by the discharges, its surface may be protected by an occasional application of simple or benzoated zinc ointment during the day. Where the affection is chronic, and especially when a hypertrophied villous condition of the conjunctiva has become established, the strength of the collyrium may be increased, but not to such an extent as to cause too persistent pain and much flushing of the blood-vessels. Its action should be reinforced by a touch with a smooth crayon of copper sulphate inside the upper lid, daily, or two or three times a week. As a rule, the touch should be light and quick, but over as large a surface of the everted lid as possible. Where the villi have a flabby aspect, or are accompanied by trachomatous granulations, the touch may be less rapid, and the crystal may be pressed harder against the lid, so as to allow more of its substance to be dissolved upon the diseased surface. The first applications of the copper are sometimes painful, but afterward only transient and not severe pain is caused, unless the crayon has been too vigorously rubbed over the lid. If the pain persists too long, it is an indication for the less free or less frequent application of the crayon. Bathing the eyes with cool water often mitigates and shortens the effect.

Good crayons of copper sulphate can only be formed from the harder parts of the crystals as obtained from the laboratories; and as the crystals are broken up to dry them more quickly, and in being packed closely in barrels for the market, it has been difficult to procure suitable pieces. Of late, however, as their value has become more and more appreciated, crayons of copper sulphate are kept for sale by some druggists and instrument makers. If the crystals are properly selected the crayons wear perfectly smooth, they do not effloresce, and a single crayon will last a long time. They should be carefully wiped after each application, by which means they are as clean as a bit of glass or polished metal, and may be used without danger in successive cases. If not well chosen, the crystal may be porous at some parts, and will not only wear rough so as to scratch the surface of the conjunctiva, but may retain particles of virulent secretion. The crayons should be of the size and form of a lead pencil, and may be fastened in any crayon holder, those of brass, used by artists, answering the purpose. Crayons of alum are easily shaped from alum crystals, and therefore readily obtainable; but they are useful in mild cases only, and are by no means substitutes for the crayon of copper.

Applied as directed, a crayon of copper sulphate acts as an astringent and stimulant, without destroying the surface of the mucous membrane. Caustic applications, such as crayons of silver nitrate, or the *lapis mitigatus*, so called, prepared by fusing potassa nitrate with silver nitrate in proportions of one or of two thirds, or strong solutions of silver nitrate, are also employed in the treatment of conjunctival affections; but these are less efficacious, because if of any considerable strength they cause a superficial slough, requiring a reparative process to be set up, and they are too stimulating in proportion to their astringent action. They are more painful than the crayon of copper, and far less safe in inexperienced hands. If used, the excess of caustic should be neutralized by a solution of sodium chloride, applied immediately.

Chronic cases of all forms of conjunctivitis are most often met with among the poorer classes, who neglect the earlier symptoms, which have a disposition towards recovery, or which could be quickly relieved by suitable treatment, or resort to popular remedies which are recommended by friends, until perhaps the disease reaches such a point that they are no longer able to work, and where it has a tendency to persist indefinitely. When, at this stage, they apply for advice, the treatment may require months instead of days, before the morbid structural changes can be removed. Another difficulty with which we have to contend is the disposition or the necessity of such patients to discontinue their attendance as soon as they are partially relieved, while morbid conditions still linger, especially in the conjunctiva of the upper lid, which readily become sources of relapse. The disease must be wholly extinguished before the patient can be regarded as quite safe. The disease being a local affection, we must rely principally on local remedies. Heroic treatment, in the way of counter irritation, copious local or general depletion, or other antiphlogistic means, once so freely resorted to, is no longer in favor. In fact, the impoverished condition of many in the laboring classes, whose rations have diminished with their ability to earn them, calls for tonics rather than reducing measures. In robust patients, recently attacked, a cathartic or two is sometimes of service as a derivative. Cleanliness, especially of the eyes, should be insisted on. Exposure to damp, or to cold winds, or smoke, or dust, must be avoided. Whatever collyria are prescribed should be regularly used at home, as these are important auxiliaries to the remedies applied by the physician himself. On stormy days, as a rule, the patient should not come for treatment, as the injury from exposure to the weather might be greater than the harm from a day or two of non-attendance.

Chronic conditions of the lids and of the cornea, resulting from complications, in cases which at the outset had only simple features, will be referred to in describing granular and trachomatous conjunctivitis.

LACHRYMAL CONJUNCTIVITIS.

In chronic inflammations of the lachrymal sac, where there is a reflux of muco-purulent fluid through the puncta, together with more or less obstruction to the outflow of the conjunctival secretions from the eye, a mild but persistent form of conjunctivitis is not seldom met with. The usual local remedies having little effect while these exciting causes continue, efforts must be directed to the removal of the lachrymal obstruction. Should the puncta be so far everted by the chronic thickening of the parts that they no longer convey the secretions from the eye, the lower punctum and lachrymal canal may be divided for a little distance with fine scissors, to carry the aperture of the canal so far back as to allow of the conveyance away of the accumulating fluids. To the relief thus given the use of mild astringent collyria may be added if necessary.

CONJUNCTIVITIS FROM CONTINUED PRESENCE OF FOREIGN BODIES.

Where artificial eyes have been improperly worn day and night, or worn after their surface has lost its polish and become like ground glass, or where they are ill fitted, passive inflammation of the conjunctiva is induced, with gradual thickening of the membrane and hypertrophy of its papillæ, and with copious secretion. If the faulty conditions are allowed to continue, the changes of structure increase to such an extent that granulations fill the orbital cavity and expel the artificial eye. A similar development sometimes forms about other foreign bodies of some size, which have been pushed beneath the lid, and have remained a long time undiscovered.

If, to obtain room for reintroduction of the artificial eye, these fungous growths are excised, permanent contraction of the conjunctival cavity ensues, and either no eye can be worn, or a smaller one must be adapted. But if the foreign body is removed, or the eye laid aside for a short time, the large granulations speedily contract, and the previous condition is restored without other treatment than mild lotions. Care must of course be taken that no new irritation is set up by endeavoring again to wear a rough or a badly fitted eye.

CONJUNCTIVITIS AFTER USE OF ATROPIA.

In some very rare instances of idiosyncrasy the continued use of atropia gives rise to symptoms of poisoning in the conjunctiva and the surrounding skin. The conjunctiva is much injected, and chemosis forms in the cellular tissue beneath it, while the skin of the lids and cheek is hot and erythematous. The symptoms subside at once if the atropia is discontinued, and a patient is sometimes afterwards able to tolerate a less frequent use of the remedy. Duboisia has been proposed as a substitute for atropia in these cases; but its merits in this respect are not established.

EXANTHEMATOUS CONJUNCTIVITIS.

Variola, measles, and scarlatina are not unfrequently accompanied by a conjunctivitis having nearly the catarrhal form, and often subsiding, with little or no treatment, as the patient recovers. If more severe, or if inclined to linger, the symptoms yield to the mildest of the remedies advised in catarrhal affections. Rarely, in variola, where the eruption has been confluent about the face, and the constitutional symptoms have been severe, the conjunctivitis assumes a purulent form, and secondary ulceration of the cornea may occur, after the disappearance of the eruption, as a result of the loss of general vitality.

PURULENT CONJUNCTIVITIS.

A form of conjunctivitis, sometimes termed, from the circumstances in which it frequently originates, ophthalmia of armies, or Egyptian ophthalmia, is almost endemic in certain localities; as, for instance, in some countries, and in camps, barracks, and asylums, where many persons are crowded together.

Its initial symptoms resemble, in a measure, those of catarrhal conjunctivitis; but the disease speedily assumes a far more serious form, and becomes a violent and destructive as well as a highly contagious inflammation.

In isolated cases it may supervene upon catarrhal conjunctivitis which had been too harshly treated, or where the patient has been exposed to cold. But its favorite seat is in garrisons, pauper institutions, or reform schools, where, unless great care is taken to enforce cleanliness, it rapidly extends to large numbers of the inmates. Some authorities, among them surgeons of the Belgian army, have believed that the disease may be transmitted through the air by floating particles of secretions; but it is easier to suppose that the conveyance is by direct contact, especially when we know the negligent habits of soldiers and others in regard to towels, basins, and articles in common use. In Egypt, the purulent secretion is carried by flies from eyes which are affected to those which are sound, the people taking no pains to remove the loathsome discharge from the lids, or to drive off the flies from their own healthy children. In fact, it is there common for men to purposely inoculate the right eye with the contagious secretion, in the hope, by the loss of this eye, to escape conscription for the army. I have known the same to be done by children of a pauper school, that they might be admitted to the hospital and avoid study.

The invasion of the disease is generally sudden and violent, the lid within a short time becoming greatly swollen and livid, and the whole palpebral and ocular conjunctiva and its subjacent cellular tissue being turgid and infiltrated with serous or phlegmonous chemosis. Where the cellular tissue is thus filled with plastic exudation the corneal circulation is so interfered with, and its epithelial layer so constantly macerated in the pus collected within the chemotic ring, that sloughing or ulceration often occurs from imperfect nutrition and the close contact of the virulent secretions, or results from the greatly increased intra-ocular tension. A copious flow of thin yellowish secretion is a marked feature of this disease. The pain is severe, not only in the eyeball, but along the course of the supra-orbital nerve; but where the cornea has given way there is often immediate relief of the severity of the symptoms, from the change in tension. In some cases of corneal sloughing the entire globe suppurates.

If the symptoms begin to subside before the cornea has become destructively involved, the prognosis is favorable; though every pains must still be taken to prevent accumulation of the secretions within the swollen lids, lest the cornea may be affected through its continued maceration in the corrosive fluids, especially if abrasion should occur in any part of its epithelial covering. The hypertrophied condition of the conjunctiva and the infiltration of the lid disappear but slowly; the conjunctival follicles often hanging in pedunculated masses from the upper lid, and shrinking only very gradually as convalescence progresses.

Seclusion of those affected from contact with others, so as to limit the spreading of the disease, is of the first importance, especially in public institutions. Each individual should have his own utensils, towels, handkerchiefs, and washing apparatus. Where large numbers of children have been attacked, I have seen great advantage in dispensing with basins, and having them wash at sinks, where water should trickle upon their hands from a faucet, and escape at once through the waste-pipe below; so that there could be no possibility of the same water being used, through indolence or negligence, by other children. Everything brought into contact with the secretions should be destroyed, or thoroughly cleansed at a temperature so high as to eradicate every contagious germ. Personal contact of the diseased with healthy children, or even with those affected in a different degree, should be prevented. To insure the execution of these precautionary measures intelligent nurses only should be intrusted with responsibility, instead of the pauper attendants often employed in public asylums.

When only one eye is attacked the other should be protected from contagion by being carefully covered. An excellent shield is made, as proposed by Buller, by inserting a watch crystal into a frame of water-proof cloth, which is fastened over the eye by a band around the head, and its edge secured with collodion. This guards the eye from harm without interfering with its use. The utmost cleanliness is essential. The copious discharges should be frequently removed by absorbent cotton or rags wet with tepid water. These are preferable to sponges, as they can be thrown away or burned after use. If extreme œdema of the lids hinders a free escape of the purulent fluid, it should be very frequently washed away by means of a small syringe and warm water, introduced beneath the swollen lid; care being taken that the cornea is not abraded by the point of the syringe, and that none of the refluent injection enters the nurse's eye.

Folded compresses, kept cold by ice and changed every few minutes, may be laid upon the eye, if they are grateful to the patient. With these should be combined the internal administration of such sedatives as suffice to control the severe pain, and, if thought desirable, derivatives to act on the intestinal canal. Tonics are often required. Local depletion or counter irritants are ineffectual. The application of caustics as abortive means was formerly recommended, but proved useless. Poultices should never be allowed as long as there is any hope of saving the eye, as they increase the disposition to ulceration and sloughing of the cornea, and are one of the most frequent causes of destruction of the eye; but if the cornea is already destroyed, and the whole contents of the eyeball are disorganized, poultices may be used to hasten the evacuation of the sloughy mass. In this latter case, however, it is better to render the patient insensible by ether, and then at once scoop out the gangrenous substance, leaving only the sclera. The cure is thus greatly hastened and the chances of purulent infection removed.

Very frequent use of mild astringents, by means of a syringe if necessary, serves at the same time to cleanse the eye and to keep up a remedial influence. During the acute stage, borax or alum solutions, of ten grains to the ounce, may be used every hour, if the secretion is abundant; and solutions of zinc sulphate, one or two grains to the ounce, according to the sensation of pain produced, may be employed three times a day. Once or twice a day a crayon of alum may be introduced beneath the upper lid and passed over its conjunctival surface, if its effect is apparently good. Crayons of copper sulphate, or of lapis mitigatus or lapis infernalis, or solutions of these, should be avoided.

If the tension of the lids is extreme, causing much pain and endangering the cornea by the pressure they exert, the outer commissure should be divided with a pair of strong scissors, and the wound kept from uniting, as long as may be necessary, by now and then pulling the edges apart. Where a dense phlegmonous chemosis forms an elevated ring around the cornea, threatening its nutrition, the chemosis may be incised, in lines radiating outward from the cornea; otherwise, scarifications of the conjunctiva should be avoided. The excellent effects of pilocarpine and eserine in corneal ulceration and in modifying intra-ocular tension would indicate a trial of these remedies in this affection.

In the after-stages the crayon of copper sulphate, with a collyrium of zinc sulphate of from one to four grains to the ounce, is used with advantage in hastening the patient's progress and removing the sequelæ of the disease. If large pedunculated granulations hang from the inner surface of the lids, the summits of those which are most prominent may sometimes be excised, to expedite their disappearance; but care must be taken that portions of the conjunctival tissue are not cut away, so as to cause subsequent contraction.

As in gonorrhœal, so also in this form of conjunctivitis, it has been proposed to freely cauterize the surface with silver nitrate, in the hope of substituting a traumatic for the specific form of inflammation; but this method has failed to justify the expectations of its advocates.

GONORRHŒAL CONJUNCTIVITIS.

Contact of a particle of gonorrhœal secretion with the conjunctival surface is quickly followed by a most intense inflammation. For evident reasons men are more frequently thus inoculated than women; their fingers being more liable to be soiled with the virulent discharge, and their eyes afterwards incautiously touched. A few hours may suffice to develop the disease; and so severe and rapid is its course that one or both eyes may be lost from sloughing of the cornea within twenty-four hours from the time of infection as has been proved in instances where the moment at which a drop of fluid from the urethra entered the eye has been positively known.

Every patient suffering from gonorrhœa should therefore be cautioned by his physician to use the greatest care in cleansing the hands after every contact with the genitals, or with the soiled linen, during or after micturition.

The theory that this disease, like gonorrhœal rheumatism, may have a metastatic origin, is not sustained by facts.

Except in the greater violence of the inflammation, the symptoms have a certain resemblance to those of purulent conjunctivitis, as above described. In cases of doubt, it is important, when the patient is first seen, to learn the facts as to the general condition and the possible presence of specific disease in the urethra. Purulent conjunctivitis most frequently, though not invariably, affects both eyes; gonorrhœal inflammation, at the outset, generally one eye only.

The earliest manifestations are seen in a perhaps only slight hyperæmia of the conjunctiva, but accompanied by a chemosis which is quite in excess of what would be expected with such a degree of injection, and with a straw-colored serous discharge, which is often observed in considerable quantity, even at this early period, but which is soon replaced by a copious purulent secretion. Great swelling and lividity of the lids rapidly ensues; the villi of the palpebral conjunctiva become very prominent; and the sub-conjunctival cellular tissue of the globe is infiltrated with plastic exudation, forming phlegmonous chemosis, which projects as a dense ring around and partially over the cornea, sometimes nearly concealing it, and seriously impeding its nutrition. The tension of the eyeball is increased, and it is very sensitive to pressure. This inflammatory tumefaction causes great pain, extending along the circum-orbital nerves over the whole of that side of the head.

On account of the swollen condition of the lids any examination of the eye is made with difficulty, and care must be used not to make pressure on the globe in endeavoring to raise the upper lid, lest rupture of the cornea and loss of the eye should occur if the cornea has become thinned by ulceration. To obviate this danger, and to gain a better view of the eye, it is best to employ elevators, rather than the fingers, to draw the lids apart.

The prognosis is unfavorable, on account of the extreme violence of the disease; yet, though recoveries in severe cases are rare, a favorable termination is by no means hopeless. I have seen some even of the worst cases result fortunately.

In the hope that a non-virulent traumatic inflammation might be substituted for the specific condition, some authors have advised free cauterization of the conjunctiva with the crayon of silver nitrate; but this attempt has proved unavailing.

Early and free division of the outer commissure of the lids with strong scissors or bistoury, so as to relieve their tension and pressure upon the eye, should be performed; and the edges of the wound should be drawn apart daily, to prevent reunion, until the disease subsides. Cold compresses, very often renewed, may be laid upon the lids, if the effect is good; but if they cause a chill or discomfort to the patient, they should be given up, lest the vitality of the cornea should be lowered. Warm fomentations or poultices are dangerous. Scarification of the chemosed conjunctiva around the cornea, in radiating lines, is sometimes justifiable, if the nutrition of the cornea seems to be threatened; but the value of this means has perhaps been overrated, and it should be only cautiously resorted to, especially as a patient losing an eye is very apt to attribute its loss to any operative procedure which may have been employed. The healthy eye should be carefully protected from inoculation by the use of the watch-glass shield, or other sufficient means, to exclude the purulent matter.

Assiduous attention and the use of mild means afford the best chance of recovery. The secretions should not be allowed to collect in large quantity inside the lids, to be there decomposed, and become by their acridity a source of increased irritation, but must be removed by frequent careful syringing, the nozzle of the syringe being passed under the upper lid, which is often so swollen as to overlap the lower lid and rest upon the cheek. If the lids can still be opened without much difficulty, a drop tube may be used in place of the syringe. Except in warm weather, the injections should be tepid. Solutions of common salt, two teaspoonfuls to a pint of water, or of borax, ten grains to the ounce, may be used every hour, or every half hour if necessary, for thorough cleansing. Later, these may be alternated with a solution of alum, five grains to the ounce, or of zinc sulphate, half a grain to the ounce. The crayon of alum may be introduced under the upper lid once or twice a day. But, until the more acute symptoms have subsided, no stronger astringents or stimulants should be applied; and not even then, if the cornea is ulcerated, or if, after perforation of the cornea, hernia of the iris has occurred.

After the chronic stage of convalescence is established, the secretion may be lessened, and the thickened conjunctiva most rapidly restored to its normal state, by light applications of the crayon of copper sulphate to the everted lid, and the frequent use of mild solutions of zinc sulphate alternated with borax or boracic acid.

Lesions of the cornea form the principal element of danger in this disease. These are often indicated by increase of pain, and by a sanious discharge. Central, or eroding marginal ulcerations are very frequent, and, once formed in a tissue originally of low organization, and which has become yet more enfeebled in vitality, they are prone to deepen and extend. Perforation, with protrusion of the iris, may result; or the cornea may be, as it were, strangulated by the dense infiltration beyond its margin, and, becoming hazy and softened, gives way, so as to form a prominent staphyloma; or it may degenerate into a sloughing mass, the separation of which is followed by evacuation of more or less of the contents of the globe.

If central perforation is threatened, solutions of atropia sulphate, two grains to the ounce of water, may be used to dilate the pupil, and thus draw the iris away from being involved in the aperture; if the ulcer is marginal, pilocarpine or eserine should be employed, with the same object of preventing hernia of the iris. Pilocarpine or eserine may also have a good influence early in the attack in preventing corneal ulceration by changing intra-ocular tension.

Should a small prolapse of the iris occur, it may often be hindered from becoming yet more protruded through the corneal perforation by excising its apex by a quick stroke with curved scissors, without seizing it with forceps. Being no longer distended with aqueous humor, the hernia collapses, and the corneal ulceration often heals, especially if the virulence of the disease has already abated, with only a small adhesion of the iris to the scar, and with good vision if the scar is not too central. Extensive haziness, and even considerable superficial ulceration of the cornea, may exist, and yet may leave after recovery scarcely any traces in the form of permanent opacity. If the entire cornea is destroyed, more or less atrophy of the globe ensues. An artificial eye can then be worn without danger of exciting sympathetic symptoms in the other eye. Where a staphylomatous prominence takes the place of the cornea, this should usually be partially or wholly excised, so as to remove a source of irritation and deformity, and a possible cause of sympathetic inflammation of the other eye.

FOLLICULAR CONJUNCTIVITIS.

A form of conjunctivitis which is not very unfrequent, and which is sometimes found, as is also catarrhal inflammation, in those who are in good circumstances, is marked by the development of small roundish or oval elevations of the surface, more abundant in the palpebral folds and toward the angles of the lids than elsewhere, and which are earlier formed and more numerous in the lower than in the upper lid. They have a somewhat regular arrangement, in rows parallel with the palpebral folds, and seem to be transformations of lymph follicles. They may be rapidly or more slowly developed, showing themselves in the more acute cases within a few days after the first injection of the conjunctiva, whilst in some chronic forms they cause little annoyance, and may not be observed, where the secretion is only moderate, till they have extended over a large portion of the lids. The conjunctiva of the globe is usually comparatively little affected, though in some cases the disease extends itself over the whole surface, and is attended with much muco-purulent secretion. The milder and acute forms of the disease often yield readily, but in some instances it obstinately lingers. This affection differs from catarrhal conjunctivitis in the less degree of pain, injection, and secretion, and from granular conjunctivitis by the favorable results which may always be expected. Whatever the duration of the symptoms, they involve no permanent structural changes in the affected membrane or contiguous parts; once removed they leave no traces.

The treatment should be nearly the same as in catarrhal conjunctivitis, with, perhaps, more attention to the constitutional conditions. Change of air is beneficial in a certain number of the chronic cases. Care should be taken in families to avoid contagion, toward which a tendency seems to exist, especially where there is much secretion from the eye.

GRANULAR CONJUNCTIVITIS: TRACHOMA.

Mere hypertrophy of the conjunctival papillæ may become a source of danger to the cornea, from long-continued friction, although these are comparatively soft and yielding; but in trachoma we have a rugous surface, quickly or gradually developed, of an entirely different and more formidable character, and far more frequently a source of mischief.

This disease, regarded by most authorities as the sole condition to which the term "granulation" may properly be applied, consists of a deposit, in the conjunctiva, of small masses of firm neoplastic exudation, having the form of round or oval, semi-transparent, sago-like grains, which project more and more above the surface of the lids, and have then a rasping effect upon the eyeball, and especially upon the cornea. They are destitute of vitality, and once thrown out in the lining of the lids they become a chronic incubus, and are absorbed only with difficulty, leaving behind them more or less contraction of the tissues in which they were lodged.

Though in the majority of cases associated with and complicating the acuter forms of conjunctivitis, trachomatous formations may exist independently of these, having their origin in an accumulation and condensation of the elements found in the lymphatic circulation. Where the conjunctiva covers the tarsal cartilage these granulations have a flattened surface, but at the angles of the lids and in the palpebral folds they have a rounder form and often a greater size, from being less compressed by the lids against the globe. Becoming chronic, they vary in color and lose their transparency. Except sometimes near the canthi, they do not acquire the great prominence attained by the flabby granulations observed as sequelæ of purulent conjunctivitis or in chronic catarrhal inflammation. They are most abundant and most mischievous in the upper lid. In certain cases the conjunctiva becomes, as it were, infiltrated with the morbid product, and converted into a structure of almost cartilaginous hardness.

These deposits act as foreign bodies, causing absorption of the containing membrane and the underlying structures, just as even the hardest portions of the body are removed by the continued pressure of aneurismal enlargements; and, as neither the parts thus eroded nor the space occupied by the trachomatous masses are replaced by normal tissues, the conjunctiva and the tarsal cartilage become shrunken and incurvated, where the disease has been long neglected, and has only slowly yielded to treatment. The resulting entropium, or inversion of the edge of the lid, and trichiasis, inversion of the eyelashes, are in their turn a source of added danger to the cornea, by the direct and constant friction of the border of the cartilage and of the inverted cilia upon its surface, already, perhaps, abraded by the perpetual rubbing of the granulations. If the roughness of the inner surface of the lid is at last removed by absorption of the morbid deposits, the conjunctival lining assumes, and thenceforth retains, a glazed appearance and a pale or mottled color. In extreme cases, both the palpebral and ocular conjunctiva are much atrophied, the upper and lower palpebral sinuses grow very shallow, bands of contraction extend from the lids to the globe, and the ocular conjunctiva and the epithelial layer of the cornea resemble in appearance a bit of dry fish-skin (xerosis).

Where the patient has delayed to apply for skillful treatment, as is too often the case with the laboring classes, months and even years may elapse before the disease is completely suppressed; for so long as granulations still remain in the upper palpebral fold or elsewhere the patient is not secure from danger of relapse, but slight causes may suffice to rekindle and extend the morbid processes. Such persons should be told, at the outset, that they must expect a tedious cure, and that they must on no account allow themselves to be deceived by a partial improvement, and to prematurely suppose that further treatment may be discontinued with safety.

Though exceptionally met with otherwise, trachoma is emphatically a disease of poverty, arising from bad hygienic conditions, faulty nutrition, and exposure to inclement weather, dust, or other irritants. It is contagious by direct contact of the secretions with other eyes, and is often extended in families, in barracks and asylums, to numbers of persons whose surroundings had already predisposed them to this disease, in consequence of neglect of cleanliness in ablutions or otherwise, and the conveyance in this way of the conjunctival discharges to healthy eyes. Except when thus communicated, trachoma is rarely seen in children, but it is found oftenest in young adults.

The injection attending granulation of the palpebral surfaces readily spreads thence to the globe, partly by continuity of structure, partly as a result of irritation. This is especially the case as regards the upper portion of the ocular conjunctiva, which is in closest connection with that of the lid. After a time the pericorneal zone of vessels is congested, and the injection extends itself upon the cornea, causing the important change which is termed pannus. As it is the upper half of the cornea which is principally subjected to the friction of the lid, by which it is covered in most positions of the eye, this portion of its epithelial layer is often clouded and vascular, while its lower part is in nearly a normal state of transparency. This vascularity where no vessels should exist is a sufficient indication of the presence of chronic granulation, without a look at the lid itself.

The injection varies in degree, from a thin net-work to a dense, thickened mass, called pannus crassus, from its resemblance to a piece of red flannel cloth. After a time, the vascularity extends over the entire front of the globe, and it is often impossible to distinguish the outlines of the cornea and sclera, or to see anything in the anterior chamber, the iris, or pupil. A person thus affected in both eyes becomes temporarily blind; but, provided ulceration and perforation of the cornea has not occurred, or the membrane of Descemet or the iris become involved, which is seldom the case, the prognosis is favorable, though the recovery may be slow. In fact, pannus often serves as a protection to the cornea, persisting as it does, when once formed, until the excessive roughness of the granulations has been removed.

Treatment of trachoma must be directed to its characterizing feature, and especially to improvement of the condition of the upper lid, which, as has been stated, is at once the seat of the largest degree of morbid alteration, and the principal source of the secondary changes which endanger the safety of the eye. In proportion as this is accomplished the other affected structures slowly return toward a normal state. But any attempt to restore the transparency or lessen the vascularity of the cornea by other means, such as division of the vessels forming the pannus, or by excision of these vessels or of a ring of the surrounding conjunctiva (syndectomy), is not only futile but harmful. So long as the hard and prominent granulations continue their perpetual friction over the cornea, these vessels, once formed, are not obliterated, but remain, as it were, an essential condition of the disease, and are perhaps even necessary, in some circumstances, to the vitality of the cornea, and to the subsequent absorption of its temporary opacity. As the lid grows smoother, these vessels, as well as those of the ocular conjunctiva, gradually diminish, and at length disappear; but the process must follow, and cannot precede, a mitigation of the severity of the original disease. When pannus has already become developed, the patient, when first seen by the surgeon, should be told that he must not expect much gain in vision until there has been a marked relief of the other symptoms, because of the slowness with which transparency of the cornea is regained; and that he must be satisfied, for a time, if he perceives a lessening of pain and of the discharge from the eye, which are the earliest indications that improvement has begun.

Scarification of the palpebral granulations or of the ocular conjunctiva should not be resorted to. Slight immediate relief seems sometimes to follow such local depletion, but this

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is more than counterbalanced by the increased injection which attends the process of repair of the small incisions, and, by the second day, the condition is the same as before scarification. All ingrowing eyelashes should of course be plucked out as soon and as often as they begin to scratch the globe. Counter irritation is of no value; in fact, blisters and setons are fortunately becoming obsolete in ocular therapeutics.

General depletion, or local applications of leeches or of Heurteloupe's or other cupping apparatus, are useless in the chronic stages of this affection; and in the earlier periods they are inefficient if other local means are neglected, and unnecessary if these are judiciously employed. As many of the patients are already suffering for want of sufficient and proper food, it is of prime importance that they should have a better regimen, as well as tonics, if needed. Zehender, in his admirable "Lehrbuch des Augenheilkunde," expresses precisely the results of my own experience when he says: "The best means for destroying the granular formations consists in a careful and periodically repeated stimulation of the conjunctiva with such means as will create a slight inflammatory action, sufficient to excite the secretory functions, producing a breaking down of the granulations and favoring their absorption. This periodical stimulation must not be too light, as its effect will be almost null; but it must not be too intense, as destruction and ulceration of the conjunctival surface might thus be easily induced. That procedure must be regarded as the best for attaining the desired end which effects a cure slowly but with the most regularity and permanence, and with the least injury to the conjunctival structure. Among the applications suitable for this purpose, the crayon of copper sulphate has a wide reputation, and is almost universally employed."

The crayon should be applied to the everted upper lid, and may be rubbed more firmly over the surface of the granulations than is necessary in catarrhal or follicular conjunctivitis; the more chronic trachomatous affection both tolerating and needing a stronger touch with the astringent. The first applications sometimes give more pain than subsequent touching with equal force. After the first two or three times the pain is generally transient; unless, indeed, ulceration exists in the cornea, in which case the remedy should be more lightly used, or partially suspended, until the ulcer is healed. If possible, the remedy should not be wholly laid aside even whilst ulceration is present, as nothing else is so effective in diminishing the friction which has been the exciting cause of the corneal symptoms. As a rule, it is not necessary to touch the lower lid with the crayon, as this is less affected than the upper lid, and from its less width is more disposed to spontaneous improvement, and as, moreover, enough of the remedy is carried by the tears over this lid to do good service. Bathing the eyes with water after the crayon has been applied sometimes lessens the smarting which it causes.

The lids may be touched every day, or less often, according to the effect produced. If the pain and temporary flushing are of but short duration, daily applications are probably not too frequent for the patient's advantage. If these effects last longer, the crayon may be more seldom used; or perhaps a lighter touch with it may be better borne and more effective than a stronger application at longer intervals. If the patient cannot present himself as often as seems to be desirable, the treatment may possibly be equally successful, but in most instances will require more time. Sæmisch, in the "Handbuch der Augenheilkunde," speaks of the copper crayon as being longer tolerated by the eye than any similar agent. The crayon of alum has no potency in this disease.

It is important to combine with this more effective means the frequent use of an astringent collyrium, to keep up an influence on the affected parts. For this purpose the zinc sulphate is well adapted, a few drops of a solution of from one to four grains in an ounce of water being put into the eye three or four times daily. If the strength which we first advise causes smarting for more than two or three minutes it should be diluted with an equal amount of water, until it is found to be well tolerated by the conjunctiva; if, on the contrary, it is little felt and the case is a sluggish one, a stronger solution is given.

Solutions of zinc acetate, copper sulphate, cadmium sulphate, or alum may sometimes be substituted, tentatively, for the zinc sulphate, to give possibly an impetus to the cure by obtaining a fresh effect, or to satisfy the patient, who is anxious, in these chronic cases, that something more should be done to hasten his progress; but the effect of any of these substitutes must be watched, and if this is not satisfactory the use of the zinc should be resumed, because experience has proved that though, from the conditions of the case, the patient gains but very slowly, he is likely as a rule to improve more rapidly under its influence than under other remedies or with frequent changes of treatment.

Scarcely any curable affection of the eye is so great a strain upon the patience of both the subject of the disease and his physician as is this; since in its chronic forms it persists so obstinately, yielding only by nearly imperceptible degrees. The rough, hard palpebral surface causes corneal injection and ulceration, and these conditions react to aggravate the trachoma which originated them; calling for the most careful exercise of skill to adapt the treatment precisely to the existing situation.

If the secretion is copious, it may be removed by bathing the eyes at intervals during the day, and should be prevented from accumulating during the night by putting a very little simple or rose-water ointment along the edges of the closed lids at bed-time. Should the edges or skin of the lids become excoriated by an abundant flow of secretion, zinc ointment can be applied to the affected surface to relieve and prevent the renewal of this condition. Medicated ointments, of silver nitrate or of various compounds of mercury, were formerly much employed in ocular therapeutics; but their action when put inside the lids is less easily graduated than that of solutions, and in some instances becomes dangerous from the accumulation of their active ingredients in caustic masses.

Furthermore, if kept any time, they may grow rancid and highly irritant, without the change having been observed.

Lead acetate, in powder or solution, had for a while an undeserved repute as a remedy for trachoma, especially among Belgian military surgeons. The powder was dusted over the palpebral conjunctiva, in the hope that the interstices between the granulations would be filled up by it, and thus a smooth surface would come into contact with the cornea.

I have long maintained that all preparations of lead should be stricken from the list of remedies which may be used in the eye. There is no necessity for employing it, since every benefit which is claimed to be derived from its use can be obtained with more certainty from zinc sulphate, or some other astringent which is not decomposed and deposited, as is the lead acetate, if there happens to exist or to supervene any corneal ulceration.

Silver nitrate, still considerably employed, seems to act, whether used pure or mitigated by combination with potassa nitrate, or in solutions of various strength, as a pure stimulant, with proportionally little astringent effect, and often causes too great irritation to allow of its being recommended for general use, though it may not be an unsafe remedy in experienced hands.

Alum curds, though often harmless, have too much of the nature of poultices, frequently becoming a source of mischief by favoring ulceration of the cornea. Unless in quite exceptional circumstances, such usually valueless applications should not be advised, as there is already a popular disposition to resort to them on all occasions, which should not be encouraged. Cold or warm compresses, sometimes useful in acute conjunctivitis, afford no relief in chronic trachoma, but are better replaced by cold or tepid ablutions with water, or with water to which salt is added.

One means proposed by some authorities for the relief of pannus of the cornea resulting from long-continued friction of trachomatous lids, is inoculation of the eye with gonorrhœal matter. Were this a sole and always effectual means of relief the procedure would be justifiable, but I have learned, on inquiring at institutions where I have seen patients thus treated, that several months or a year of treatment as an in-patient were required, after the inoculation and the consequent establishment of purulent conjunctivitis, before the cornea became even moderately clear; and occasionally eyes thus treated are lost. If a case of even severe pannus is removed from unhealthy surroundings and well cared for in a hospital for months, the pannus should be relieved by the treatment I have described as suitable, without incurring the discomfort and risk attending this process. I cannot therefore regard this inoculation as justifiable.

In not infrequent cases where the silver nitrate has been used for a long time as a local application, especially when a solution of this substance is given as a collyrium to be used at home, the conjunctiva acquires an olive, sometimes even a black stain, which is very unsightly. As this is of course indelible, great care must be taken not to use silver nitrate too freely in chronic cases.

MEMBRANOUS CONJUNCTIVITIS.

In a few cases, where the structural condition of the conjunctiva is similar to that found in purulent inflammation, the discharge, instead of being a purulent fluid, forms a membranous layer only slightly adherent to the conjunctiva. If this is removed, the membrane beneath is found to be red, thickened, and papillous, but there is no such tenacious adhesion or phlegmonous infiltration of the underlying conjunctiva as in the diphtheritic form of inflammation. The disease is less virulent than purulent conjunctivitis, and may be subdued by mild astringent means often repeated.

DIPHTHERITIC CONJUNCTIVITIS.

Common in North Germany and Holland, especially during winter and spring-time, diphtheritic conjunctivitis is rare in other European countries, and only very exceptionally seen in America. Of six cases which have come under my own observation, three were children in the same family, who were attacked not simultaneously, but on reaching about the same age. Only one of these six cases was an adult. The distinguishing feature of the disease is a thickening of the conjunctiva by an exudative product, and the formation upon its surface of a membranous deposit of similar material, instead of the muco-purulent secretion usually poured out in conjunctivitis. When this amorphous deposit is first formed it is with difficulty separated from the conjunctiva, and an attempt to remove it is followed by oozing of blood; but after a time, perhaps even in a few hours, this false membrane becomes detached at its edges, though still clinging at its centre to the tarsal cartilage. If removed, it is found to be of very firm consistence and has a dull yellow or gray color, and it is rapidly re-formed. The infiltrated lids are greatly swollen, and are harder and much more sensitive to the touch, though less livid, than in gonorrhœal conjunctivitis. Their inner surface has a glistening grayish or mottled aspect. The ocular conjunctiva and its underlying cellular tissue is transformed to a condition of dense fibrinous chemosis, showing here and there dots of extravasated blood. Severe pain accompanies these structural alterations. The obstacle they create to the proper nutrition of the cornea becomes a frequent cause of crescentic ulceration or of necrotic changes, followed by perforation or by sloughing, with more or less complete subsequent atrophy of the globe.

After several days, if the disease takes a favorable turn, the diphtheritic infiltration and exudation is lessened, or gives place to a purulent secretion; and the glistening and marbled surface of the conjunctiva takes on the red villous aspect of a less virulent inflammation. The transformation of tissue is so considerable that diphtheritic conjunctivitis is, even oftener than trachoma, followed by processes of contraction and of incurvation of the tarsal cartilages and obliteration of the conjunctival sinuses, as the pathological products are removed by absorption.

Authorities agree that this affection is one of the most dangerous and least amenable to treatment. General tonic measures are advised for the support of the system and removal of the diathesis; and as local means, the application of iced compresses, to lessen the intense heat of the parts, is generally approved. All unite in forbidding the use of caustics. Anodynes and anti-febrile treatment are often required.

In one half the cases within my own experience successful results were obtained. The treatment consisted of cold compresses, frequent removal of so much of the false membrane as could be readily detached, constant use of simple cleansing applications and of the milder astringent collyria of borax or alum, with an occasional touch inside the lids with an alum crayon; and later, when the discharges had assumed a grayish blennorrhœic instead of plastic character, light touches with the crayon of copper sulphate.

CONJUNCTIVITIS OF NEW-BORN CHILDREN.

No disease is more fatal to the eyes, when neglected or improperly managed, than the severe forms of conjunctivitis in new-born children, ophthalmia neonatorum; but, on the other hand, none offers better results from judicious treatment.

The fact that infants are frequently attacked, within a few days after birth, by a mild form of catarrhal conjunctivitis, which readily yields to the simplest means, or may even subside without other treatment than attention to cleanliness, has led nurses, and sometimes physicians themselves, to think lightly of symptoms which manifest themselves in the eyes of the newly born. Many practitioners have seen numerous cases of this milder affection without having chanced to encounter the severer form; and when at length surprised by this latter, they are, as it were, off their guard. Nurses who observe a beginning of swelling of the lids, or even a copious secretion, often think these symptoms of no importance, and omit to mention them to the physician, contenting themselves with assuring the mother that they have often seen such eyes, and cured them with breast milk, alum curds, or poultices.

Since even these apparently mild attacks may be sometimes transformed into the more dangerous disease, we should be on the alert to watch the earliest indications of morbid action. No harm is done by early attention to a trivial ailment; and, in case the severer disease is actually present, immediate and assiduous care is important for obtaining a successful result.

About the third or fourth day after birth a slight reddish line along the centre of the upper lid may be the first intimation that anything is going wrong, and marks the beginning of ophthalmia neonatorum. If the lid is then opened, more or less injection of the conjunctiva and a slight amount of yellowish secretion may be observed.

A few hours often suffice to convert these inconsiderable changes into the symptoms of the most intense inflammation. The lids become enormously swollen, perhaps projecting beyond the eyebrows, and the upper lid often covers the lower, and rests upon the malar prominence. A large quantity of thin yellowish or greenish-yellow purulent fluid escapes from within the lids, or if confined beneath them is discharged in great quantity if the upper lid is raised. At this stage the cornea cannot be seen without the aid of an elevator, or even of elevators for each lid, it being unsafe to attempt to separate the lids with the fingers in order to examine the condition of the cornea, lest, if already thinned, it should give way. If the physician does not have elevators at hand, they may be extemporized by bending the handle of a teaspoon or a hairpin, or a probe bent into the same form to the proper shape. Such examination should not be neglected, and should be made sufficiently often to give the assurance that no haziness or ulceration is present. Before making this inspection, the palpebral cavity, and thus the surface of the cornea, should be freed from secretion by carefully wiping it away with bits of soft rag or absorbent cotton, or, if necessary, by syringing with warm water. As the symptoms abate, the cornea may usually be seen, without resort to the elevator, by separating the lids with the fingers, but no pressure should be made upon the eyeball. This careful watchfulness of the state of the cornea must be continued till convalescence is well established, as its vitality often becomes affected at a late period of the disease, after having held out until this time, in consequence of its long-continued maceration in the abundant purulent secretion, or from the pressure of the lids, or from impaired nutrition. Assurance should therefore be obtained by inspection that all is going on well, as over-confidence may result in great disappointment, when it is too late to remedy the mischief done.

Specific or irritating urethral or vaginal discharge brought into contact with the eye during parturition is probably a frequent cause of this affection ; but it may also apparently be induced by other irritating substances, such as soap or spirits entering the eyes during the first washing of the child, or perhaps by mere exposure to cold and dampness. It is needless to say that great care should be used in the first ablutions, that nothing hurtful may enter the eyes. Where there is any special reason to suspect danger of inoculation from morbid secretions of the mother, the lids should at once be carefully washed, if possible, before the child opens its eyes.

Neglect of cleanliness, reliance on inefficient or dangerous means, such as breast milk or poultices, and unduly harsh treatment are equally to be avoided. We are able sometimes to cut short the attack, and in all cases may expect a favorable termination, if the child is seen before fatal changes have occurred in the eye.

Foremost among therapeutic means must be placed the maintenance of cleanliness: the eyes must be kept free from the rapidly formed purulent fluids. Some even regard this as the sole requisite treatment. It is certain that if this is not faithfully and constantly done fatal results to the eyes will probably ensue, whatever other remedies may be employed. Everything may depend upon the nurse's fidelity.

If the infiltration of the lids is but moderate, it is often possible to cleanse the eyes sufficiently by careful separation of the lids with the fingers or thumbs of the two hands, and the instillation of warm water, or milk and water, or salt and water; all such applications to be warmed if the weather is cold. This cleansing should be done frequently, and all secretion wiped away from the edges of the lids with the prepared absorbent cotton, so useful for such purposes, or a bit of soft linen. These should then be thrown away or burned, to prevent their being a possible vehicle of contagion.

Where the œdema of the lids prevents their being opened, it is best to use a small syringe for cleansing the palpebral cavity. Its nozzle, which must be smooth, is introduced beneath the overhanging upper lid, and the fluid injected so as to wash out all accumulations. This is to be done more or less often according to the amount of the secretion, which in severe cases forms in almost incredible quantities: every hour, or even every half hour, in the day-time may not be too often during the period of greatest violence of the disease, the frequency being afterwards lessened to correspond with the indications of improvement. In the night the child's sleep should not be frequently disturbed, but injections should be made, if needed, when it is awake. The nurse or mother should be taught how to remove the secretions and make the injections with most ease and thoroughness.

If the cornea becomes hazy, it should be carefully watched to detect ulceration; care being taken not to abrade its surface in using the elevators. Haziness, or even superficial ulceration, does not necessarily involve an unfavorable prognosis, especially where the other symptoms are abating in severity. Should the livid and swollen eyelids seem to press dangerously upon the cornea, the outer commissure may be divided by a quick stroke of scissors, and should be prevented from reunion for a few days, if necessary, by occasionally drawing apart the edges of the wound. This involves little pain, and no perceptible scar will remain at the outer canthus, but the occasions for resorting to the operation are very rare. Should central ulcer appear, threatening perforation of the cornea, a drop or two of a two-grain solution of atropia sulphate may be put into the eye daily; but no stronger solution should be used, as infants are very susceptible to the action of this drug, and symptoms of belladonna poisoning have followed its incautious application. Where the ulcer is marginal, pilocarpine is to be substituted for atropine. Medicated, alternately with the merely cleansing, injections may be employed; solutions of ten grains of borax or five grains of alum to an ounce of water being beneficial. In cold weather the injections may be rendered tepid, and thus a less shock to the infant, by putting the syringe into warm water. A solution of zinc sulphate, of not more than half a grain to the ounce, may be occasionally substituted for the alum or borax during the stage of convalescence. Stronger applications, whether caustic, stimulant, or astringent, should be avoided, as being unnecessary and dangerous. Some practitioners still regard solutions of silver nitrate as a valuable remedy in this affection; but that these are superfluous is proved by the invariably good results of the milder treatment I have indicated, when this is promptly and diligently employed; that they are dangerous in inexperienced hands is universally acknowledged. The application of solutions of the nitrate or of the crayon of lapis mitigatus (one or two thirds silver nitrate combined with potash nitrate) to the inside of the lid, and its instant neutralization by a solution of salt in water, is sometimes made with safety by the experienced specialist, but is by no means easy or safe for the inexpert, and it is certainly unnecessary and very painful. The conjunctiva of the new-born is exquisitely sensitive to harsh remedies. The treatment by alum, or alum combined in solution with a small amount of zinc sulphate, has been used for several generations at the Royal Ophthalmic Hospital at Moorfields, London, and is still in favor with most of its able surgeons.

Zehender, though approving the use of the silver nitrate, asserts that ninety-nine per cent. of the cases of this disease are relieved simply by frequent and thorough ablutions with the syringe.

Injections should be made with sufficient force to thoroughly cleanse the conjunctival sac, but not so forcibly as to cause the fluid, mixed with purulent secretion, to spurt back into the face of the nurse, and inoculate her eye with the disease. Instances are on record where eyes of physicians or nurses have been thus infected and destroyed.

Contagion must also be guarded against by enjoining the greatest care in handling towels, rags, sponges, or utensils with which the virulent discharges have come in contact. The fingers should be scrupulously cleansed after they have touched the diseased eyes, lest they might incautiously convey to another eye some atom of the purulent matter. All persons about the child should be warned to be cautious in handling or fondling it, and not to touch portions of its dress or bed-clothes which might possibly have been soiled from the eye discharge without taking immediate precautions by washing the hands.

If the lids become everted from the intense swelling of their mucous lining, or in the act of crying, they should be gently restored, if possible, to their normal position, and if necessary held there for a few moments by the finger, or the finger supporting a soft compress, till the spasm which caused their eversion subsides sufficiently to allow of their keeping their place. If needed to prevent agglutination during the night, a little simple or rose-water ointment may be applied to the edges of the lids.

As the conjunctiva improves, the lids lose their tense and livid appearance, and the skin is wrinkled and flabby. The cornea may become hazy at a late period, and when the state of the conjunctiva is improving, but the prognosis as regards ulceration is then favorable, and the haziness soon disappears as recovery goes on.

The nutrition of the babe must be carefully looked to, from the first, and if not suitably furnished by the mother must be provided for from some other source. After the subsidence of the acute symptoms the astringents should be continued two or three times a day, to remove the conjunctival thickening which persists.

CHAPTER V.

AFFECTIONS OF THE SCLERA.

ANATOMY OF THE SCLERA.

THE sclera forms the external enveloping membrane of the eye, and by its firmness and rigidity serves to protect the internal parts from injury and to give the requisite shape to the eyeball.

It is directly continuous with the cornea, and is composed of the same delicate fibres. Instead, however, of being arranged in regular layers, as in the cornea, the bundles of fibres are interwoven in all directions, and thus give to the surface its white color. Between the fibres are the lymph spaces, continuous with those of the cornea, and here and there are found a few fixed cells, in addition to the round wandering cells of the lymph spaces.

A little to the inner side of the axis of the eye is a round opening in the sclera, through which the optic nerve passes into the eye. The fibres of the nerve sheath are continued directly into the sclera, and are lost in its substance, except a few that unite with fibres from the sclera itself, and form a sieve-like net-work (lamina cribrosa) across the inner end of the ocular foramen. Surrounding the entrance of the optic nerve are the small openings through which the ciliary nerves and arteries find their way into the eyeball, and further forward in the equatorial region are the large venæ vorticosæ, which perforate the sclera in a very oblique direction and form the principal channel of exit of the blood from the eye.

The external muscles of the eye are attached to the globe by means of their tendinous insertions, which enter the anterior portion of the sclera very obliquely, and are soon lost in its substance. Near the insertions of the recti muscles the anterior ciliary arteries penetrate the eyeball.

In the anterior portion of the sclera, near the corneal boundary, is found the canal of Schlemm, which forms a continuous ring surrounding the anterior chamber and lying in the inner layers of the sclera between the cornea and the origin of the iris. It is lined with endothelium, and is supposed to be connected with the anterior chamber, thus forming one of the channels of exit for the aqueous humor; a few small blood-vessels are also found in this region.

The inner surface of the sclera is covered with a fine endothelium which lines the perichoroidal space, across which pass the numerous blood-vessels and nerves which serve to loosely bind the two membranes together.

Externally, the posterior surface of the sclera, which forms one wall of the lymph space between that membrane and Tenon's capsule, is covered with an endothelial layer. The anterior portion of the sclera has a loose covering of episcleral fibres which bind it to the conjunctiva, and this connection becomes more dense as it approaches the margin of the cornea.

SCLERITIS.

The sclera is comparatively insusceptible of inflammation; but a most troublesome and tedious and oftentimes dangerous affection, implicating the tissue lying between the sclera and conjunctiva, just beyond the border of the cornea, and termed epi-scleritis, is not unfrequently met with. Its subjects are oftenest women who have a rheumatic diathesis, or whose menstruation is in some respect abnormal; but the disease may affect those of either sex. Its affinity with rheumatism is often shown in its disposition to recur in the next year at the same season, or in subsequent years after the first attack, or, in some cases, irregularly. That part of the circum-corneal zone near the insertion of one of the recti muscles, usually the externus or internus, is the favorite initial seat of the disease. The surface about this point is elevated, and a violet-colored sluggish congestion takes place, which remains indolent and limited to its original seat; or extends so as even to involve the entire zone; or, without extending, may have periods of increase and of comparative subsidence; or may extend to the iris, with disposition to plastic exudation; or involve the peripheral or even the central parts of the cornea, causing a peculiar interstitial opacity, which does not wholly disappear by subsequent absorption. During exacerbations there is often considerable pain and photophobia, but at other times these symptoms are not urgent. In slight cases, the raised nodules, but for their purplish color, might almost be mistaken for the papulæ formed in the same positions in phlyctenular conjunctivitis.

If left to itself the disease may continue, with accessions and remissions, for eight or nine months, even when not so severe as to affect other contiguous parts of the eye. In extreme cases, involving the cornea or the iris, the pain is aggravated and the prognosis made more uncertain by these complications; and they require watchfulness to prevent any permanent injury of adjacent structures.

Till lately, palliation of the symptoms, rather than any abbreviation of the disease, seemed to be all which could be effected by therapeutic means. But recently, thanks especially to De Wecker, of Paris, the subcutaneous injection of a few drops of a two per cent. solution of pilocarpine nitrate has been proved to exert a wonderful influence in this hitherto most intractable affection. Five or six, or more, drops may be injected daily or three times a week into the arm or leg; the amount and the frequency of the injection being graduated according to its sialogogue and sudorific effect in individual cases. Flushing, heat, and perspiration, with a copious flow of saliva, should follow within a few minutes after the injection; these symptoms subsiding in twenty or thirty minutes from their appearance. No subsequent inconvenience is felt, unless the dose has been so large as to produce nausea, which should be avoided. As slight scars remain where the injection has been repeatedly made, the leg rather than the arm may be the place selected, where it is desirable that such scars should not be conspicuous when short sleeves are worn.

In many even severe cases the symptoms quickly yield to this remedy; in other instances success is more gradual; and it cannot be said to be invariable; but certainly no other treatment — anti-rheumatic, tonic, or alterative — appears to compare with the use of pilocarpine in efficacy. Locally applied to the eye it seems to have little, if any, influence upon the disease.

When a case has become chronic, and grave changes have occurred in the cornea or iris, or the sclera has become thinned, the prognosis is less favorable. If not too deep and extensive the lamellar corneal opacities may be reabsorbed, but they have much disposition to persist. If the border of the iris has formed adhesions with the lens capsule, solutions of atropia, of two or four grains to the ounce, may be used to detach these. In a few cases, where nearly the entire border and area of the pupil have become filled with plastic lymph, iridectomy, to form an artificial pupil, may be imperatively called for as the sole resource. This has formerly seemed to be also useful, in some instances, in arresting the unfavorable progress of severe attacks, and, possibly, as a preventive; but it is difficult to be sure as to this point where we have to do with so variable and uncertain a disease. The operation is therefore not justifiable with a view to prevention merely.

Attention to the general health is important, as a prophylactic. Early treatment is desirable in case of a renewal of the symptoms, as it certainly appears to be often effectual in lightening the attack.

STAPHYLOMA OF THE SCLERA.

In rare instances the sclera may become so thinned as to give way, in the form of irregular protrusions, at some part or the whole of the circumference of the membrane; the bulging sometimes having a resemblance to a bunch of purple grapes (from which the name of the disease), because of the dark choroid showing itself through the atrophied sclera. Such changes are, however, oftenest met with as a sequel to disease of the choroid or ciliary body, or associated with the general enlargement of the sclera, termed hydrophthalmia, and will be described more in detail elsewhere. They may be distinguished from staphyloma caused by intra-ocular growths by their greater transparency on oblique illumination, and by their yielding elasticity when touched with a probe.

Posterior staphyloma will be referred to in the chapter on myopia, with which condition of refraction it is most frequently associated.

CHAPTER VI.

AFFECTIONS OF THE CORNEA.

ANATOMY OF THE CORNEA.

THE cornea is a transparent membrane, continuous with the sclera, but having a sharper curvature. It forms the anterior portion of the shell of the eyeball, and is set into the sclera like a watch crystal into its frame, the sclera being continued slightly over its external surface.

The cornea consists of a perfectly transparent parenchyma, covered with epithelium and supplied with minute lymph spaces, through which its nutrition is kept up. The nerves lose their sheaths soon after entering its substance, and pass through it as transparent axis cylinders, and the true blood-vessels are confined to a narrow zone at the periphery. In order to study its minute structure we must employ chemical and coloring agents to distinguish its component parts.

The outer surface of the cornea is covered with a stratified layer of flat and cylindrical epithelium, which is continuous with the epithelium of the conjunctiva. Below this comes a fine homogeneous stratum, Bowman's layer, which is closely connected with the parenchyma of the cornea, and is supposed to consist of true corneal fibres densely packed together. No lymph spaces or cells are found in it, and when it is destroyed by ulcerative processes it is not re-formed.

The principal substance of the cornea is made up of fine lamellæ arranged in layers parallel to the surface of the cornea, like the leaves of a book ; after maceration, the cementing substance which holds the layers together is dissolved out, and the delicate fibres can be seen, having in the different layers different directions, though usually parallel in any one layer.

Between the corneal fibres and layers are the lymph canals, which anastomose in various directions, and often enlarge into stellate spaces, in which are found the fixed corneal cells nearly filling the spaces with their delicate granular bodies and projecting arms. These large cells are nucleated and quite flat, and generally lie parallel to the surface of the cornea.

The fine lymph spaces are direct continuations of those of the sclera, and round wandering cells may often be found in them; in inflammatory conditions of the cornea they become crowded with these wandering cells to such a degree as to impair the transparency of the cornea, or even to lead to destructive inflammation.

Behind the corneal tissue proper comes the posterior limiting layer, Descemet's membrane, similar to Bowman's layer, but thinner, and on its inner surface is found a single layer of endothelial cells, which line the whole anterior chamber, being reflected back from the cornea over the anterior surface of the iris.

In health the blood-vessels of the cornea are confined to a narrow zone at the corneo-scleral junction, and the nutrition must ordinarily take place through the lymph spaces.

The branches of the anterior ciliary nerves enter the posterior layers of the cornea at its periphery. They soon lose their neurilemma, and proceed, constantly branching, to form a fine plexus of nerve fibres under the external epithelium, from which offsets are sent up between the epithelial cells.

PHLYCTENULAR KERATITIS.

Such phlyctenulæ (herpes corneæ) as are so frequently found in the conjunctiva just beyond the corneal margin are now and then found on the cornea itself, generally near its edge, though sometimes more centrally placed. They usually present less the appearance of a papule than when formed upon the conjunctiva, because of the closer connection of the epithelial layer with the corneal tissue, but are marked by a small grayish or reddish spot, toward and around which a vessel or two, or a narrow fasciculus of vascularity, extends from the conjunctiva. There is usually photophobia, and more pain is felt than when the eruption occupies the yielding conjunctival surface. If more than one phlyctenula has formed, there may be a moderate injection of the neighboring conjunctiva.

Where the exudation at the affected point is considerable, or becomes pustular, it may result in a grayish ulceration, nearly always superficial, which retards the convalescence. In fact, the course of the symptoms, even in the mildest cases, is more chronic than in papular conjunctivitis, on account of the less active absorption of morbid products from the non-vascular cornea. No uneasiness need be felt, however, as to the result, even where the symptoms are more severe or lingering, though active treatment may be needed to palliate the temporary discomfort. This end is best attained by the use of a solution of two grains to the ounce of one of the salts of pilocarpine, once or twice in twenty-four hours. It is painless in its application, and lessens the intolerance of light by contracting the pupil, while it seems also to have a directly beneficial effect on the corneal inflammation. A ten-grain solution of borax may be dropped into the eye three or four times a day, with a soothing effect in lessening the sensation of a foreign body under the lid, and as a means of promoting recovery. Tepid lotions can be used if agreeable. The symptoms are only aggravated and their duration prolonged by active astringent or irritating collyria. Insufflations of calomel or other powders are sometimes exceedingly painful, and have no effect in shortening the disease, while they may be injurious if ulceration exists. Atropia is to be avoided, because its enlargement of the pupil increases the photophobia. Immersion of the head of the struggling child for some seconds in cold water, in order to relieve photophobia by the shock, is a practice more honored by the omission than by the observance.

Like phlyctenular conjunctivitis, this affection is essentially self-limited; but there is the same tendency to a repetition of the morbid processes. It is therefore important to continue the use of the solution of borax, which is quite painless, once or twice a day, if the child is old enough to allow this to be done without a resort to force; so as to fortify both the cornea and the conjunctiva against recurrence of the disease. Tonics and good and abundant food are also efficient means of removing any tendency to relapse. If, as sometimes happens, a fresh formation of phlyctenulæ should appear within a few days, or if the accompanying ulcers show some disposition to extend before time enough has elapsed for a modification of the general and local condition, it furnishes no reason for a resort to more active treatment, as the symptoms will again yield to mild means. Care should be taken to avoid exposure to high or to damp, cold winds, and children, who are oftenest subjects of the disease, should be warmly clothed in severe weather.

BULLÆ UPON THE CORNEA.

Very rarely, a large vesicle formed from the epithelial layer occurs at the centre of the cornea (pemphigus corneæ), perhaps covering half its surface, and giving rise to severe ocular and circum-orbital pain, great photophobia, and general depressing symptoms, until it is burst by the spasmodic friction it excites in the lids, or is removed by other means. If it merely bursts and flattens, the altered and loosened epithelium continues to cause irritation, though in a less degree. If this is taken away with forceps, the surface beneath is often found to be slightly hazy, and in many cases a new blister takes the place of the former one within a few days, its elevation above the surface being accompanied by a renewal of the pain and photophobia and increased lachrymation; the pain frequently affecting the branches of the fifth pair of nerves over the whole side of the head.

Removal of the degenerated epithelium with very delicate forceps and the frequent use of a solution of borax or other very mild collyrium seems to be the best mode of treatment. Pilocarpine and eserine are also serviceable in relieving the photophobia, and, alternated with atropia if complications exist in the form of iritis, they may have a favorable influence in the cure. The internal use of arsenic combined with tonics is also to be recommended.

The disease may disappear after one or two removals of the altered epithelium, or the vesicles are again and again reproduced for a considerable time, even for months, without seeming to be much influenced by treatment. This prolonged duration is fortunately the exception. When it occurs, it may be followed by temporary opacity of the outer layers of the cornea; which is gradually cleared away.

ULCER OF CORNEA IN CHILDREN.

Corneal ulceration seldom appears in infancy, except as a secondary lesion in the conjunctivitis of the new-born; but it is exceedingly common in children of from three to twelve years of age, especially in such children as are badly fed, clothed, and lodged, and who exhibit what we term the strumous diathesis. Ulcers may coexist with phlyctenulæ of the conjunctiva near the corneal margin, though there has been no eruption upon the cornea itself.

Photophobia is an almost universal symptom, and its presence in great intensity serves in most instances as a diagnostic sign of corneal ulcer, though it does not indicate with any certainty the severity of the ulcerative process in a given case. The child sometimes shuns every ray of light, refusing his toys, and even perhaps his food, for the sake of keeping the eyes constantly screened during the day, and burying his face in the pillow at night. When the photophobia is less severe, or has become mitigated, the child may be able to open its eyes in the afternoon and evening, though still keeping them firmly closed in the morning. In many cases there is evidently much pain, and the disposition is quite changed, the child being peevish and fretful. Vision is unaffected, as far as the retina is concerned, though it may be lessened by the ulcer, if this is extensive.

As usual when the eyes are painful and intolerant of light, there is a copious flow of tears, mingled with conjunctival secretions ; and these, either from their constant flow or their acridity, excoriate the edges and outer surface of the lids, and often the skin of the cheek and brow. These parts, being kept wet, and continually rubbed either with the hands or by a shade worn in close contact with them, soon become covered with an eczematous eruption or thick yellowish crusts.

When the symptoms are moderate, and will allow of this being done, it is desirable to obtain a view of the cornea while playing with the child, or by attracting his attention by some toy, or otherwise, so that he may open the lids sufficiently for our purpose. If this is for the moment impossible because of the degree of photophobia, it is often better, if the child is to remain under our care, to omit a forcible inspection at the first visit, which is very seldom essential, and to advise suitable temporary remedies, in the hope that the child, not having been frightened by the doctor, may at the next visit give a better opportunity for examination. If this course is not adopted at first, it becomes subsequently almost impossible to obtain any inspection of the eye without a resort to force, on account of the child's crying at the first intimation of the physician's presence. But if the child is only to be seen at a single consultation, or if there is reason to suppose that serious changes are going on, it may be necessary to ascertain the precise condition of his cornea, in order to determine the diagnosis and treatment. If in such case gentle attempts to open the lids with the fingers are spasmodically resisted, it is neither desirable nor safe to persist in this endeavor, but the child should be at once placed upon the lap of another person, near a window, in such a position that his back is towards the medical adviser. The head is then drawn down and fixed between the physician's knees, and is thus completely at command. The person holding the child controls his hands and body, and the feet are left unconfined. The upper lid can now be raised with an elevator, which will expose the cornea. Very rarely it is necessary to use an elevator for both the upper and lower lids. The position and extent of the ulcer, its transparent or clouded surface, as also the presence and situation of any perforation of the cornea or hernia of the iris, should such exist, are to be carefully noted, as furnishing important indications as to prognosis and treatment. An experienced observer can usually feel satisfied, from the appearance of an ulcer, whether it is advancing or being healed. A slight cloudiness over a surface which had been only a transparent erosion, or a rounded contour of the margin of the ulcer, may denote the formation of new epithelium ; or a sloughy film at the bottom of an ulcer may be a warning of threatened perforation. Unfortunately, the ulcer is central in a large proportion of cases, and if it penetrates deeply is likely to leave behind it a greater or less opacity.

There is little injection or thickening of either the palpebral or ocular conjunctiva in many of these cases of ulceration, and the conjunctival secretions are not much increased in quantity. The circum-corneal zone of deeper-seated vessels becomes injected in varying degrees, according to the severity and the duration of the ulcerative process.

Formerly, the treatment of strumous or scrofulous ophthalmia, as the above group of symptoms was termed, was of a most energetic character. Blisters on the temples or behind the ears, setons or issues in the temple, neck, or arm, leeches, insufflations of calomel, and the use of silver nitrate in substance or in strong solutions, or collyria containing bichloride, wine of opium, etc., were the means employed. The words of Stellwag in regard to counter irritants, "The profession has been compelled to call these remedies instruments of martyrdom, which do no good," may well be also kept in mind in respect to other heroic means, though some of these still have their advocates.

Later, the extracts of belladonna and stramonium, and afterward the more convenient atropia sulphate, supplanted, with manifest advantage, the more severe remedies. The theory upon which atropia was employed has been that it not only served to prevent hernia of the iris in case of central perforation of the cornea, but that it had a positively sedative influence, and thus a curative effect upon the cornea. For many years I accepted this treatment by atropia, with suitable auxiliaries, as being the best within our knowledge, and a great improvement upon the more violent measures of the olden time. But I could never satisfy myself that any sedative action was exercised by atropia or other mydriatics, in affections of the cornea. On the contrary, the increased sensitiveness to light caused by the wide expansion of the pupil seemed to more than counterbalance any possible benefit; because the spasmodic closure thus excited in the lids and their close friction over the ulcer could have only a painful and harmful effect, tending to extend and deepen the ulcer; to favor, in some measure, a forced infiltration of necrotic material from the ulcer between the layers of the cornea; and to increase the danger of a giving way of the cornea at its thin part and the protrusion of the iris through the perforation. This is no mere theory, but the conclusion reached after thoughtful and extended observation.

The use of means calculated to intensify one of the most constant and characteristic symptoms of a disease, and in so doing to augment other morbid conditions, could scarcely be regarded as fulfilling the probable requirements for successful treatment. A substitution of remedies which relieved this urgent symptom appeared, therefore, to be a judicious as well as a scientific adaptation of means to an end, which was worthy of a practical trial. The discovery within a short time of the myotic qualities of Calabar bean (physostigma venenosum), and of jaborandi, with their alkaloids, eserine and pilocarpine, by means of which we obtain the long-wished-for power of contracting the pupil at will, has placed at our disposal two invaluable remedies. My experience in careful trials of these myotics in corneal affections has been confirmed by that of other observers in Germany and elsewhere; some of them speaking of these as the remedies of the future in corneal affections; and it seems to be demonstrated that the advantages hoped for from their use are to be realized.

Pilocarpine and eserine not only fulfill the important indication of limiting the amount of light passing through the pupil of the over-sensitive eye, as is done by nature herself, in contracting the pupil in this disease, but, according to the testimony of reliable authorities, these agents also have a favorable influence upon the ulceration by changing the tension of the cornea. However this may be, there seems to be no question as to the practical therapeutic value of these remedies in ulcerations and other corneal affections. A drop or two of a solution of pilocarpine nitrate or chlor-hydrate, two grains to the ounce, may be put into the eye twice daily. Pilocarpine has the advantage over eserine of causing less of the temporary supra-orbital pain which sometimes follows the use of the latter; but either of these agents which are obtainable may be employed. Should there be any suspicion of coexistent iritis, a drop of a solution of atropia may be employed occasionally; but iritis is a comparatively rare complication in children. The myotic effect continues for several hours. Stronger solutions (one or two per cent.) have been most often used by European oculists; but these have in some cases caused inconvenient symptoms, and should be avoided where the patient is a young child. We may combine with this means the use of a collyrium of ten grains of borax to an ounce of camphor water, putting a few drops into the eye three times a day, and doing so without a struggle if possible. Its effect is grateful, and a child will often allow this to be put into his eye when he resists all other applications. The disappearance of the prominent symptoms is often sudden, from the moment of the formation of a new epithelium over the exposed surface. Good diet and suitable clothing should be insisted on. Cookies and sweetmeats should be allowed only after meals, and not between them. Sea-bathing and change of air are frequently beneficial.

If the general condition is unsatisfactory, dialyzed iron, syrup of the iodide of iron, or other tonics may be given with benefit. In the house the light should be moderated, and in going out the eyes are to be shaded but should not be bandaged. The state of health and the hygienic conditions surrounding the child have a marked influence; and with a large number of the out-patients of hospitals and dispensaries who have corneal disease, nourishing food is as important as the medical treatment. It is desirable to protect both eyes with a shade of black silk: if only one is shaded the intolerance of light continues, and the eyes are kept closed; whereas if both are shielded the child will often open his lids and look out beneath the shade. A simple bit of silk, with no card-board stiffening, is coolest and lightest. The child can pull it a little lower when the light is too strong, and push it up when the amount of light or the sensibility of his eye is less. In going out, which is desirable in fine weather, a blue veil or tinted glasses may be worn in addition to the shade. The child should be warmly clothed, and protected from cold draughts.

Simple, or rose-water, or zinc oxide ointments may be used to protect the skin of the lids and cheek from excoriation, or to remove eczematous crusts already formed. If the edges of the lids and the ciliary bulbs are much diseased, about the size of the head of a pin of an ointment, made by combining one part of the ointment of mercury nitrate with six parts of simple ointment or rose-water ointment, may be melted on the end of a finger and applied along the edges of the closed lids at bed-time, or after the child is asleep, three times weekly; one of the simple ointments being used, if needed, on the intervening nights. If the inside of the nose is made sore by the discharge of the irritating secretions through the lachrymal passages, a little of a diluted ointment of mercury nitrate or of zinc oxide may be melted upon a small feather and applied up the nose twice a week; two or three applications being often sufficient to remove the morbid state of the part. The ointment of mercury nitrate (citrine ointment) seems, when carefully prepared, the best; but other ointments, containing red or yellow mercury oxide, in proportions of not more than gr. i. ad ℈i., are more or less used for the same object. All of these should be applied in minute quantity and to the closed lids, that they may not find their way into the eye, which is often the worse for the entrance of fatty substances.

ULCERATION OF CORNEA IN ADULTS.

Ulcer of the cornea may occur in the course of various affections other than those of the eye, some of which conditions deserve especial notice.

POST-VARIOLOUS ULCERATION.

Ulcer of the cornea is seldom, if ever, seen in variola as a result of the formation of a pustule upon its surface during the eruptive period of the disease, but occurs as one of its sequelæ, and as a consequence of the impaired nutrition of the system, of which the cornea, being only indirectly supplied from the circulation, is prompt to feel the effect.

Ulceration, interstitial abscess, or a general sloughy disposition of the cornea are each occasionally observed in these circumstances, and require for their treatment such tonic measures as may sustain the system, and such local means as will limit the extent of destruction of the corneal tissue. Ten-grain solutions of borax, frequently instilled, or the use of five or ten-grain solutions of alum, are to be preferred to stronger applications. The depression of vitality is, however, so great that the prognosis is somewhat unfavorable, and more or less opacity, usually central, frequently results. Sometimes extensive loss of substance is followed by staphylomatous projection. Corneal ulceration after diphtheria is rarely seen in America ; if met with, the treatment should be as above indicated.

PARALYTIC ULCERATION.

Paralysis of the facial nerve, affecting the branches which supply the orbicularis muscle, and thus preventing closure of the lids, exposes the cornea to the action of wind and dust, and is often followed by ulceration of this delicate structure.

Once established, the ulcer is difficult of cure, from the very circumstances which created it. Prevention is therefore of prime importance, and this is best accomplished by frequent instillation of a soothing collyrium, as, for instance, a ten-grain solution of borax, so that the cornea may be kept lubricated, thus relieving the dryness caused by exposure to the air, and removing any irritating particles which had become lodged upon its surface. Protection of the eye by glasses or goggles is also a safeguard. Should ulceration actually form, the same means, very often used, with a two-grain solution of pilocarpine, will be best adapted to effect healing, and, if necessary, the lids may be temporarily brought together by suture of their edges, or by isinglass plaster and collodion.

ULCERATION FROM ECTROPIUM.

The cornea sometimes becomes exposed and ulcerated, especially in old people, from gradual thickening of the conjunctiva, everting the lower lid and causing the condition often termed "blear-eyed." The same preventive means should be used as recommended for paralytic cases. We must furthermore endeavor to restore the normal state of the conjunctiva, and thus relieve the ectropium, by mild astringents. If, in this condition, the everted portion of the conjunctiva is touched with the crayon of copper sulphate the effect is unfavorable, the part being only hardened; but if the crayon is lightly applied to a non-everted part, at the lower palpebral fold, twice or thrice weekly, a mild collyrium being also used three or four times daily, the conjunctiva grows less thickened and injected, and the everted surface being gradually drawn inward may then be also slowly improved by direct application of the same remedies. Much time and patience are required to obtain the object, but if these are not bestowed the condition almost certainly becomes worse from continued exposure, and may result not only in great discomfort from the constant outflow of tears upon the cheek, but finally in loss of the eye from destructive ulceration of the cornea, unless this can be prevented by relief of the ectropium by surgical means.

ULCER OF CORNEA FROM DEBILITY.

General depression of the vitality of the system from illness or in advanced age often renders ulcers of the cornea, which would otherwise be trivial, much more dangerous. Not unfrequently it is complicated with interstitial abscess, which may find an outlet externally, or may discharge its contents into the anterior chamber, causing an accumulation of matter there which is termed hypopion: in either case the danger of perforation of the cornea is considerable.

Tonics, and perhaps stimulants, with moderate out-door exercise without exposure of the eyes to bad weather, are of much value. No strong astringents should be used, but pilocarpine in two-grain solution may be daily applied, and borax solution frequently dropped into the eye. Atropia should not be used unless central perforation of the cornea is threatened. Paracentesis corneæ is sometimes indicated to relieve the hypopion, but should be only cautiously resorted to. It may be repeated in case the hypopion re-accumulates, if the first evacuation has seemed to be advantageous.

CREEPING ULCER OF CORNEA.

Ulcus serpens is a sluggish and very intractable affection, not often met with in vigorous persons, but not distinctly traceable to any cause. It is often marginal, and crescentic in form, gradually extending in area and depth till it causes destruction of a large surface, and is perhaps complicated with iritis and hypopion. Tonics, with mild local means often repeated, are required. The comparative infrequency of this form of ulcer has made it as yet impossible to judge, from a small number of cases, whether pilocarpine can be successfully used, where iritis is not present; but its effects have appeared to be favorable. Paracentesis is often indicated, but division of the cornea through the whole extent of the ulcer, and daily reopening of the wound with a probe for a considerable period, so as to empty the anterior chamber, which has been advised by Sæmisch and others, is a less reasonable method, since large adhesions of the iris to the corneal cicatrix are nearly certain to result, and if the pupil is not occluded it is often so masked by the large and opaque scar that an artificial pupil affords the sole means for recovery of vision. This procedure does not seem to have more curative influence than paracentesis alone.

ULCERATION AFTER CEREBRO-SPINAL MENINGITIS.

Opacity or ulceration of the cornea sometimes occurs in the later stages of cerebro-spinal meningitis, associated with the irido-choroiditis so frequently met with in this affection. The eyes are generally already disorganized by the internal disease, which is elsewhere described, and the cornea seldom regains its normal transparency.

HERPES ZOSTER OPHTHALMICUS.

Herpes frontalis or ophthalmicus may be described here, because corneal ulceration, although but a secondary condition and not the cause of the most urgent symptoms, is yet of the greatest final importance, since it becomes a source of danger to the eye, even long after the subsidence of the original neurosis.

This affection is limited to the ophthalmic division of the fifth pair of nerves, generally to the frontal and nasal branches, and involves the overlying skin, where it manifests itself externally as a vesicular and pustular eruption, followed on its disappearance by scars in the region supplied by these nerves, which much resemble those of variola.

At the outset, the patient complains of severe supra-orbital pain, or an exanthematous redness, often mistaken for erysipelas, occupies a portion of the forehead or nose. The diagnosis is soon made clear by the agonizing pain which declares itself, by the fact that neither the redness nor pain extends beyond the median line or to other parts of the face, and by the appearance of the distinctive pustular eruption characterizing herpes zoster or "shingles."

A wide band of eruption often extends upward from the centre of the orbital ridge upon the forehead and scalp. Scattered pustules are also sometimes seen upon the side of the nose and as far as its tip. Infiltration of the lid, attended with more or less conjunctival injection and increased secretion, now appears; the pupil is perhaps widely dilated, as if by a mydriatic; the iris may become congested. At a later period haziness and ulcer of the cornea may ensue, though, according to Mr. Hutchinson, this occurs only when the nasal branch of the nerve is implicated. As this disease oftenest affects those advanced in life, the corneal ulcer partakes of the form and the sluggish tendencies met with in such persons, as well as of the characteristics of paralytic ulcer. Moreover, ulceration may occur, not during or directly subsequent to the acute symptoms, but only at a considerable time after these have been recovered from; seemingly because of the non-restoration of a normal condition of the peripheral nerve branches, which are perhaps compressed in the cicatrized skin, so that the vitality of the cornea becomes impaired.

The active symptoms continue from one to three or four weeks; but the neuralgia may persist, and even be at times intolerable, for a long period, the skin at the same time remaining hard and numb. The ultimate sequelæ now and then appear in the cornea only after the lapse of some months or a year.

Tonics are needed to avert secondary complications, and as curative means. Sedatives, unless in very large doses, have little control over the severe and exhausting pain, which has been known to terminate fatally in an aged person; but they can perhaps be used subcutaneously with most benefit. The conjunctival infiltration and congestion, being a result of the neurosis of adjacent parts, requires only the mildest applications, and subsides as the disease lessens. Pilocarpine is not necessarily employed to overcome the dilatation of the pupil, but is indicated if the cornea shows faint traces of haziness. If, however, the iris is affected, it is important to occasionally dilate the pupil, temporarily, to prevent a possible adhesion of its margin to the crystalline, the pilocarpine being resumed as soon as this object is secured, if called for by the state of the cornea.

If, soon or later after the subsidence of active symptoms, the cornea becomes hazy or ulcerated, the treatment already advised in conditions of low vitality should be pursued. To prevent, if possible, any such sequelæ, it is desirable to continue tonic measures for a considerable period after apparent convalescence, and to place the patient in the best hygienic circumstances.

CONICAL CORNEA.

A transparent conical alteration of form of the cornea, sometimes termed staphyloma pellucida, but not resulting, like opaque staphyloma, from acute disease, is occasionally met with. It generally begins in youth, usually affecting one eye sooner than the other, and is gradually progressive. The initial cause of this yielding of the corneal structure is probably a deficiency of thickness or firmness of its substance, rather than any positive increase of intra-ocular pressure.

The patient complains of dimness of vision, especially at a distance, and difficulty in using the eyes; these symptoms being only partially, if at all, relieved by concave or cylindrical glasses. Vision is perhaps improved, as it frequently is in myopia or astigmatism, by partly closing the lids, or by looking through a stenopæic slit. No structural changes of the internal parts of the eye are disclosed by the ophthalmoscope, though the image of the fundus appears irregular in proportion to the degree of abnormal curvature in the cornea.

The slight beginning of this deviation of curvature is not easily recognized, but may be discovered by close observation of the reflection of the image of a window from the cornea, the lines of which will approach each other more nearly at the centre than at the margin; or it may be detected by measuring the refraction of different parts of the cornea with the ophthalmoscope, used as an optometer, which discloses irregular astigmatism. When the conical projection has become considerable it is readily perceived, especially if seen in profile. As the disease advances useful vision may be nearly lost, and much ciliary neuralgia, photophobia, and injection of the ocular vessels may be produced by the pressure of the lids against the cone, with perhaps some increase of intra-ocular tension from the irritability thus occasioned. The apex of the cone yields more and more, and often grows cloudy from want of lubrication or from altered nutrition, without, however, showing a disposition to ulcerate unless in extreme cases.

Early preventive treatment, in avoidance of continuous use of the eyes upon small objects, especially with the head bent forward, and of violent exercise which might congest the cerebral and ocular vessels, these precautions being continued until adult age has fortified the system, has sometimes, in my experience, seemingly arrested the further development of previously progressive conical change. When not appearing until after maturity, no care apparently influences the course of the disease. Other more active means, as, for instance, repeated paracentesis of the cornea, are ineffectual in checking the disease, and sometimes seem to give it an impetus. No lessening of the changes already existing is to be expected, unless from operation. Pressure bandages are in the highest degree dangerous, as being likely to cause ulceration of the thin apex of the cone, and wholly irrational, as it is impossible to keep the apex in such a position as to be pressed upon. Concave glasses, or stenopæic slits in a plate of metal or hard rubber, serve as palliatives in the less advanced degrees of the affection. Displacement of the pupil to form a vertical slit, by iridodesis, in which operation the iris is drawn toward the lower edge, or toward both the upper and the lower edges, of the cornea, to form adhesions there, has not proved a sufficient relief to commend it to favor, and is by no means without danger of exciting sympathetic ophthalmia in the other eye.

Modern operators are agreed that our best resource is to be found in an endeavor to restore, in a degree, the normal curvature of the cornea, by removal of the apex of the cone. Graefe advised excision of a portion of the outer layers two mm. in diameter with a narrow knife, without penetration of the anterior chamber. To the space thus thinned he applied next day a fine-pointed crayon of lapis mitigatus, so as to cause a small slough of the remaining layer and open the chamber. But though lightly applied, and instantly neutralized with a solution of salt, it was difficult to precisely limit the action of the caustic, and extensive infiltration with a subsequent large central opacity often resulted. Trephining instruments of one m. diameter, made to revolve rapidly on touching a spring, and to cut out a disc from the apex of the cone, have been used by several authorities, but do not seem to have fulfilled expectations. Both of the above methods are uncertain in the result to be obtained, the scar being sometimes so extensive that an artificial pupil is required to give the patient vision. A plan which has better borne the test of trial is the careful excision of a small oval flap at the apex, and this could be combined with the bringing together of the edges of the wound by a suture, by means of fine corneal needles armed with a minute filament of silk, passed through the outer layers of the cornea. No such extension of opacity occurs after these excisions as when caustic is used, and, as long since proved in using sutures of the cornea after cataract extraction, these minute sutures are well tolerated. No very brilliant results are usually to be expected from any operative measures, but even a moderate amount of improvement is often acceptable to the patient.

In the rare instances where extremely conical cornea in adults is accompanied by great pain or increased intra-ocular tension, with nearly complete loss of sight, paracentesis may be a palliative, and iridectomy sometimes gives even more relief. If the symptoms continue urgent, enervation, by division of the optic and ciliary nerves, is to be preferred to enucleation of the globe, and might be desirable without previously doing iridectomy, in cases where vision is already lost.

ANTERIOR HYDROPHTHALMIA.

Instead of a conical projection, with little or no alteration of diameter of the cornea or of the eye, the cornea sometimes becomes greatly enlarged without marked change in curvature. The other anterior portions of the globe, including the sclera, the ciliary body, and the iris, with the anterior chamber, are at the same time increased in dimensions and lose their normal appearance. The sclera and ciliary body become thinned and discolored, and sometimes painful, from distention. In some cases the aspect of the eye is repulsive, from the great enlargement, and in these instances rupture of the thinned anterior hemisphere is generally the ultimate result.

Attempts to arrest the disease by an early or late performance of iridectomy have been unavailing, and have frequently been followed by severe inflammation, and even by threatening cerebral symptoms. If the disease is evidently progressive, and perhaps a cause of pain, without the deformity having become too marked, enervation of the globe, which no longer affords useful vision, may be done by section of the optic and ciliary nerves, in the hope that the morbid processes may be arrested. Should this fail, the anterior portion of the globe, including the ciliary region, should be excised, and the edges of the wound united by fine sutures, so as to retain as much of the abnormally fluid vitreous as possible; or, at least, to have a better stump for supporting an artificial eye than where enucleation has been performed. Only simple cold dressings are needed. The method of doing these operations will be described in the following section.

STAPHYLOMA OF THE CORNEA.

Large, and especially sloughing ulcerations of the cornea may cause it to become thin and yield; or produce perforations, through which hernia of the iris may occur; or may lay the iris completely bare. As the loss of substance is repaired, the resulting cicatricial tissue consists of plastic deposits combined with more or less relics of altered corneal and iris tissue. This cicatrix has less power of resistance than the healthy cornea, and it frequently yields at some point, or in its entire area. In the first case, where the bulging is but partial and slight, especially if it is marginal, tolerably good vision may be preserved. Where it is total it is often progressive in its tendency, because of the lateral pressure of the recti muscles upon the globe; and its projection may involve the crystalline, which then lies in contact and more or less united with the cicatricial structure. Purulent conjunctivitis, especially that of new-born children, where there is a loss of the whole or of a large portion of the cornea, is a frequent cause of this pathological condition.

In partial staphyloma, iridectomy is occasionally useful, and should, if possible, be done downward and inward, so as to give the greatest facility of vision.

When protrusion begins, it may increase slowly or rapidly, as a consequence of the friction and traction made upon it in the movements of the eyelids. Its surface is thus irritated and the parts underlying and surrounding it disturbed, until from these causes, and the pressure of the recti muscles and of an increased intra-ocular secretion which is liable to be excited, the staphyloma may acquire such size as to interfere with the closing of the lids, and become a source of great deformity and discomfort. It may then give way by the spontaneous formation of an aperture, or from rupture by a blow or otherwise. The opening may remain fistulous, or may speedily or slowly close. Should it continue open for a time, the scar may meanwhile be condensed, and on reclosure of the fistula remain firm and flattened. If more quickly closed, the staphyloma, as a general rule, is again slowly reproduced.

Should this take place, it may be necessary to remove a part or the whole of the protrusion, to relieve the patient from the annoyance and deformity it occasions, and to avoid all danger of sympathetic inflammation of the other eye. The risk of the latter event is increased by complications which often ensue upon the staphyloma: such as increased tension, choroiditis, separation of the retina, or cataract. Secondary inflammation of the sound eye may occur without other warning than an injected and sensitive condition of the staphylomatous globe, and is a not infrequent result of any blow or other injury of such an eye. If a tentative expectant treatment is advised for a time, the patient or his friends should be cautioned to give instant attention to any symptoms of increased or renewed irritability in the diseased eye, whether resulting from friction of the lids, from an injury, or from cold; and to lose no time before presenting himself for inspection. Puncture, or excision of the whole or of a portion of the staphyloma, including even the ciliary region, may be done, according to the degree to which the parts are involved. Where the bulging is of limited extent and its surface not much thinned, puncture with a broad needle, repeated once or more if necessary, may prove adequate to secure its flattening. If the projection is again renewed, an incision is to be made with an iridectomy or a narrow cataract knife, so large that immediate reunion shall not take place, but the anterior chamber shall remain collapsed sufficiently long to allow the cicatrix to be firm enough to resist pressure from the reaccumulating aqueous humor. If this does not succeed after a trial or two, excision is the best resource. If the staphyloma is small, an elliptical portion may be taken from its centre, and the edges of the incision closed with fine sutures with small cornea needles, without disturbing the crystalline lens. In this way a nearly normal-sized globe, not repulsive in appearance, is obtained. If larger and thin, nearly the entire cornea may be removed; or the incision may be carried farther back, if the ciliary region has become much involved. The lens often escapes during this excision; if it does not, and especially if it is cataractous, it should be extracted before closing the wound. The necessary instruments are a narrow cataract knife, a forceps, a pair of curved scissors, fine needles armed with finest silk, a needle holder, and a spring or other elevator to keep the lids apart. The patient being etherized, the narrow knife should be carried through the centre of the base of that portion of the staphyloma which it is proposed to remove, the edge of the knife being turned toward the lower margin of the orbit, and the incision completed by forming a flap which includes the lower half of the part to be excised. This flap is then seized with fine forceps and the upper half of the base of the staphyloma cut off with the scissors, so as to make an elliptical wound. The opposite edges are then to be drawn together, with several sutures if the wound is extensive, so as to retain as much as possible of the contents of the globe. Under anæsthesia there is no difficulty in placing these fine sutures close to the margin of the wound, and they may then be left to come away; or, if some remain after the wound is firmly closed, they are easily cut. Quiet and cold dressings are all the treatment required. This method is to be preferred to the operation formerly done, — by transfixing the eye in the ciliary region, previous to the incision, with three or four large curved needles armed with coarse silk, which needles were drawn through and the sutures tied after the excision, — as it does far less violence to the eye, and by favoring immediate union is less likely to result in inflammation and suppuration of the vitreous, which involve much pain and some danger.

In a few cases of extensive alteration of the globe, where it had become irritable, rupture by a blow, or any operation for excision of staphyloma, may be followed by phlegmon and suppuration. The pain is less than in inflammation of the globe in other circumstances, as the degenerated products can here escape through the large hiatus in the anterior parietes; but should the symptoms be severe, great relief is given and the process of elimination much abridged by at once scooping out the sloughing contents of the globe with an elevator; leaving only the sclera to form a stump for the support of an artificial eye. After suppurative processes have been set up, or this operation has been done, warm rather than cold applications should be made. Here the recovery is generally slower than where enucleation has been done; but the after-condition is better, without or with an artificial eye, than when the whole globe has been removed, and there is less risk of septicæmic infection. It is not always necessary to include the ciliary region, even when somewhat diseased, in doing the operation, as disorganization of the uveal tract seems to render a less extensive ablation sufficient to protect the other eye from sympathetic dangers.

Iridectomy has been proposed as a means of arresting advancing staphyloma; but it appears to be of no avail, and is therefore an undesirable measure, in most cases.

ARCUS SENILIS.

In old age, and occasionally in younger persons, the cornea often shows a cloudy arc or a complete ring near its margin. This may affect one or both eyes, generally first appearing at the upper part of the cornea. It is caused by a fatty degeneration of the superficial lamellar and corneal cells, and has been supposed to be associated with fatty degeneration of the heart, which seems to be sometimes merely a coincidence, not a necessary relationship. Persons are often alarmed on first discovering this loss of transparency; but we can assure them that the slight fatty change is not to be regarded as a disease, and need give them no concern, inasmuch as it never affects the clearness of the central parts of the cornea or obscures vision. Furthermore, it does not prevent the healing of incisions made through it in doing cataract and other operations.

INTERSTITIAL KERATITIS.

This disease, the result of inherited syphilis, is frequently accompanied by other evidences of the specific taint. The face is pale and flattened, of an aspect quite characteristic; the bridge of the nose depressed; the skin of the face is coarse, and often shows small scars, and cicatrices of fissures at the angles of the mouth, resulting from infantile syphilis.

These changes are alone often sufficient for the diagnosis. If the second teeth have appeared, the central upper and sometimes lower incisors have a peculiar crescentic notched extremity, quite different from the serrated edge sometimes seen in strumous subjects. The other incisors and canines are often small, peg-shaped, with tuberculated prominences, and of bad color; all of which appearances are peculiar to this affection, those of the central incisors being especially characteristic.

FIG. 17.

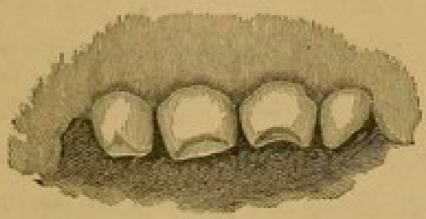


FIG. 18.

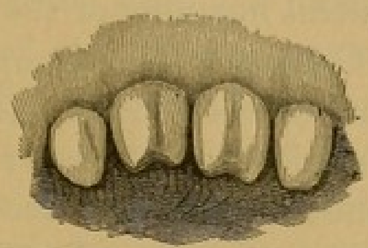
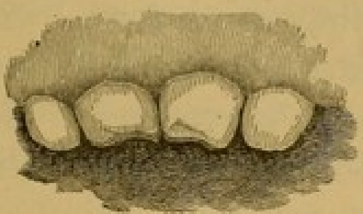


FIG. 19.



Figures 17 and 18 show the condition of the teeth in a boy and girl aged about twelve and fourteen. In Figure 19, from a girl of seventeen, the notched appearance has already become lessened by wear of the teeth.

The centre of the cornea is first affected, showing a group of minute dots of cloudiness, easily separable from each other when viewed with a lens, and distributed through the corneal tissue, not upon either its external or internal surface. As these dots become infinitely numerous and extend over a larger space, the cornea appears like ground glass, or as if vapor had condensed upon it in cold weather. The centre is always most clouded, the margin least so, while the intervening portions have a varied and sometimes mottled distribution of the opacity. This cloudiness may reach such a degree that the eye has temporarily only a perception of light. More or less circum-corneal injection, sometimes becoming extended into the cornea itself, and a considerable intolerance of light, with perhaps some pain, are also present.

Some weeks, or possibly months, after the attack in the first eye, the second is likewise affected; the symptoms perhaps increasing in this eye, while diminishing in the other. Occasionally the cornea loses its polish, and becomes congested, especially at its margin, by a fine capillary injection; and the prognosis as regards a complete recovery is in these cases less favorable. In one patient I observed in one of the eyes a marked softening, with at least minus two degrees of ocular tension, and formed a very unfavorable prognosis; but this condition slowly changed for the better, and T at last became normal; vision remaining, however, somewhat defective, even twenty years after the attack, from slight central haziness of the cornea.

Generally the symptoms manifest themselves about the time of the second dentition, and may or may not have been preceded, at an early period of life, by syphilitic eruptions about the face and the arms. When they declare themselves before the second teeth have appeared, these generally exhibit the characteristic marks when they come forth. The affection may also be first seen at a later period of juvenescence, but very rarely after the adult age is reached. Most of the cases are of an age from seven to fifteen years. Girls are oftener affected than boys.

A mild form of iritis, and probably choroiditis, sometimes accompanies interstitial keratitis; and as the iris may be concealed from view by the corneal opacity, it is important, where implication of the iris is suspected, to make occasional use of atropia, to prevent the formation of synechiæ.

Interstitial keratitis is of slow progress, a year or more sometimes elapsing before recovery; yet the prognosis for an almost complete restoration of transparency is favorable in all but the severest cases; and even in these the opacity, though lingering for a long time, is ultimately nearly absorbed, allowing of useful vision. It is expedient to inform the parents or friends, at the outset, that the disease will not only be tedious, but that the second eye will probably be affected, and that the child may, for a considerable interval during the continuance of the disease, have very little vision. If not thus forewarned, their confidence in the medical adviser may be shaken, and not unreasonably, during the long period of no apparent improvement. Many cases, however, are more speedily relieved. Relapses now and then prolong convalescence, but no second attack occurs after complete recovery. After a time the teeth no longer show their peculiar marks, except on close inspection, their notched edges wearing away; but where the change takes place too slowly the teeth can be filed off by a dentist, if it is desired to obliterate this evidence, conspicuous to a professional eye, of constitutional affection.

We are indebted to Mr. Hutchinson for the complete demonstration of the certain dependence of this disease upon hereditary syphilitic taint. His carefully recorded histories of cases, including those of the parents, as published in the Reports of the Royal London Ophthalmic Hospital, also prove that a very large number of the children born to these infected parents are either prematurely or still born, or die in early infancy, often with specific symptoms; and, furthermore, that a large proportion of the cases of interstitial keratitis had also suffered from infantile syphilis, in one or other of its forms. He has, moreover, shown that the specific influence is gradually lessened in the parents; their children becoming more viable, and a smaller proportion of them exhibiting inherited syphilitic disease at any period, either at birth or later.

Local treatment is of but secondary importance in this constitutional disease. Atropia may be used to prevent complications in the iris, especially if the corneal opacity hinders the actual state of the pupil from being seen. Myotics may be had recourse to, often with great advantage, if there is much photophobia, atropia being now and then temporarily substituted. A borax collyrium can be employed as a local sedative. Stimulating or astringent collyria are useless, or, if employed, should be so weak as to cause little irritation.

Tonic general treatment and good diet, with hydrargyrum cum creta or potassium iodide in moderate doses, are the means to be chiefly relied on. The patient should go out in fine weather, having the eyes protected against a strong glare, or cold damp winds, by a shade, or by tinted glasses. Care must be taken to prevent the patient and his friends from becoming despondent during the period of almost complete abolition of vision.

THE PROCESSES OF INFILTRATION AND ULCERATION IN THE CORNEA.

It is of consequence to distinguish these active inflammatory conditions of the cornea, which by their importance call for special consideration here, from those more or less permanent opacities which have resulted from previous disease, and which will be elsewhere described. Both these conditions are accompanied by more or less congestion of the circum-corneal vessels, which sometimes extend as a vascular net-work upon the cornea itself, and by photophobia, abundant lachrymation, and ciliary pain, according to the intensity of the inflammation.

In simple infiltration of the cornea its fine lymph spaces become crowded with small round cells, and this change may take place through the whole depth of the corneal tissue, or is confined to definite points of the parenchyma. With oblique illumination this appears as a light gray opacity, superficial or deep, circumscribed or diffuse, according to its position. The affected part of the cornea has a dull aspect, like a mirror which has been breathed upon ; and if examined with a strong lens, minute dots can sometimes be seen in countless numbers. An apparent alteration of the form of the cornea, which is sometimes observed, is merely an illusion occasioned by the cloudiness, and not a real change.

In this form of infiltration the corneal tissue and the fixed corneal cells are not destroyed, and if the process goes no further the prognosis of a complete restoration of transparency can be made. If the process takes a more inflammatory form, and, instead of a simple exudation, we get also a breaking down of the corneal fibres and cells, we have then a true abscess in the substance of the cornea. At first this is surrounded by clear corneal tissue or by only a slight border of infiltration, but it may go on involving these adjacent tissues in the destructive process, and finally reach the surface, and discharge its contents either into the anterior chamber of the eye, where they form hypopion, or through the external layers upon the free surface of the globe, forming a deep ulcer of the cornea. If the abscess has been very deep-seated, a transparent elevation may sometimes be observed at the bottom of the resulting ulcer, the membrane of Descemet being pushed forward by the pressure of the aqueous in the anterior chamber.

If the abscess be central, the prognosis for a restoration of perfect vision is unfavorable, since, if the destruction of true corneal tissue is considerable, the scar which forms never becomes perfectly transparent.

In corneal ulceration, instead of an infiltration beginning in the deeper tissues, we have a heaping up of cells beneath the epithelial layer, with more or less destruction of the epithelium, and some infiltration of the neighboring superficial layers of the cornea, forming a halo of slight cloudiness, which may or may not be involved in the ulcerative process. If this goes on, the surrounding infiltration becomes more opaque, and more and more of the corneal cells and fibres are destroyed, causing a loss of substance, which can be readily seen by noting the irregular reflection of a window-sash from the uneven surface of the cornea at the affected part.

After a while the process ceases to extend, the irregular bottom of the ulcer grows clearer, and the edges of the excavation lose the sharp-cut look of advancing erosion, and are rounded, as a new formation of epithelial cells takes place. Lastly, a development of fine blood-vessels is noticed, extending from the corneal border towards the ulcer. As these changes go on, the photophobia and pain lessen or disappear, the small deep or shallow pit formed by the ulcer fills up slowly with a new tissue very closely resembling the cornea in structure, and finally the epithelium forms an external covering, which is continuous with that of the rest of the cornea, and has about the same curvature of surface. Permanent irregularity may, however, be produced where the superficial ulceration has been very extensive, and this causes abnormal refraction at this part, and lessens the acuteness of vision.

Where the anterior elastic layer of the cornea (Bowman's layer) is destroyed, the prognosis as to ultimate transparency of the opaque scar varies with the age and vigor of the patient. In very young children the cicatrix is often scarcely to be found after a few years, but in adults the new tissue rarely attains the same transparency as the cornea proper.

Vessels may still be observed in some cases long after the healing of the ulceration, and, by keeping up a circulation in the affected part, seem to promote the absorption of the opacity. As transparency is restored they gradually dwindle and disappear.

Frequent use of cleansing but unirritating means, as mentioned in describing special forms of ulceration, is of great importance. Hot fomentations to the lids are much employed by some authorities, but it seems to be doubtful whether they favor healing by exciting vascularity, or whether, on the contrary, they increase the tendency to further destruction of corneal tissue.

For a considerable period atropia has been regarded with great favor as a remedy in corneal affections, being supposed to act as a sedative as well as to lessen the corneal tension. The value of this means, as regards these presumed effects, is made problematical by more recent observations, which render it doubtful if atropia has any sedative influence, while it certainly increases the intolerance of light. Pilocarpine and eserine, the myotics only so recently discovered, have already gained an important place among European oculists as most efficient means of treatment in corneal affections uncomplicated with iritis; being in fact spoken of by Von Wecker and others as "the remedies of the future in corneal disease."

By lessening the photophobia they relieve the harmful friction of the spasmodically closed lids upon the cornea, and are said by several authorities to diminish intra-ocular pressure, and thus favor corneal recuperation. I have certainly found these myotics of great practical value.

General steamy haziness of the cornea may be a temporary effect of increased ocular tension, as in glaucoma or commencing ophthalmitis. This subsides where the intra-ocular pressure is terminated by resolution or removed by operation, without having produced permanent structural changes; but its appearance always calls for prompt and serious attention as indicating impending danger, which is to be avoided only by early and judicious interference.

CORNEAL FISTULA.

After perforating ulcer of the cornea, especially where the opening has been large or complicated with hernia iridis, a minute fistulous opening sometimes remains, which may persist, with perhaps intervals of temporary closure, for a long time. The centre of the ulcer, being covered by only a thin layer, gives way again and again during the healing process, under pressure of the accumulating aqueous humor, until at length a fistulous canal is established through the cornea. The most effectual means of closing these openings is irritation of their tract, if possible soon after there has been a fresh escape of aqueous, by careful punctures with a fine cataract needle, so as to excite a deposit of plastic material in sufficient amount to seal the orifice.

I have found the same means also effectual in closing the fistula which is now and then seen after iridectomy for glaucoma, where a cystoid scar has formed in consequence of the continuance of some degree of intra-ocular pressure. After the healing of the external wound the aqueous sometimes repeatedly escapes in these cases, diffusing itself beneath the conjunctiva like a chemosis. This is soon reabsorbed, but at each repetition of the outflow there is a temporary lessening of vision from collapse of the anterior chamber, and a certain

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amount of discomfort, if not of pain. It is best not to interfere too soon to close what is possibly at first a safety-valve against renewal of intra-ocular tension; but after all apprehension on this score can be laid aside it is desirable to prevent the recurrence of the sudden gushes of aqueous by stimulating and healing the minute orifice at the border of the cornea and sclera, as above recommended.

OPACITIES OF THE CORNEA.

Though opacities of the cornea are not to be reckoned in the list of active diseases, they are a pathological condition of much consequence in themselves, and which it is important to discriminate from the acute processes which give rise to them; moreover, we are often anxiously consulted as to their prognosis, so that for all these reasons they deserve a special consideration.

These opacities may be of every degree, from the faintest haze, barely if at all distinguishable with the naked eye, and only disclosed by the concentrated rays of oblique illumination, to the dense opacity involving all the corneal layers. The terms nebula, macula, albugo, and leucoma are used to designate these various amounts of cloudiness, nebula marking the slightest, leucoma the greatest, loss of transparency.

However slight the opacity, it diminishes the acuteness of vision, if it is central, by obstructing the passage of light; and where diffused it is more an obstacle than a smaller but denser opacity. Where it exists in one cornea only, somewhat to one side from the centre, strabismus is sometimes induced by the effort of this eye to bring itself into a position where rays of light may enter the pupil unobstructed and assist in vision.

The prognosis as to the duration and the possible absorption of these cloudy scars depends on other conditions than the mere degree of their opacity. As a rule, the younger the subject and the more recent the ulceration which caused the cloudiness, the better is the chance of its diminution or ultimate disappearance. Opacities following conjunctivitis neonatorum, or from ulcers in childhood, often clear up in a wonderful degree ; while in older persons, with the same amount of haziness, far less can be promised. Except in very young subjects complete recovery of transparency is not to be expected if the opacity has extended deeper than the epithelial layer.

If the opacity resulted from the use of lead acetate while corneal ulcer was present, it may either have the form of white crusts slightly projecting above the surface, or of bluish-white clouds more or less deeply incorporated with the corneal tissue, or these conditions may coexist. The crusts may be scraped or shaved off, but the haziness caused by interstitial deposition of lead in the cicatrix of the ulcer is indelible. Except in these cases of superficial formation, the cicatricial tissue of corneal opacity is not generally removable by operation. If pared away, the loss of substance is generally replaced by opaque, and not by transparent, material ; so that nothing is gained by the surgical attempt, which is not without its risks.

Where the leucoma is dense and central, vision is sometimes improved by the use of atropia to dilate the pupil, so as to allow rays of light from beyond the edge of the scar to enter it. This plan is applicable in those unfortunate cases where one eye has been lost and the cornea of the other greatly damaged by previous inflammation, and where the surgeon hesitates to incur the risk of iridectomy or other operative measures in the sole remaining eye. Except in the very rare cases where atropia sulphate excites conjunctival irritation, its use can be continued for years without loss of its mydriatic power and without injury to the patient ; a drop or two of a two-grain solution being put into the eye every morning.

When the centre of the cornea is hopelessly opaque, but its marginal portion remains more or less transparent, and the iris, behind this margin, is in a healthy state, vision may often be much improved by iridectomy ; especially if the position of the transparency will admit of its being done toward the inner or lower side of the cornea. The iridectomy may be outward or even upward, if the patient has no vision and the cornea is clear only in these parts. But this operation should not be too hastily determined on where the other eye is healthy or nearly so, as vision through the artificial pupil is often so imperfect as to confuse rather than assist the sound eye. This is especially true if iridectomy is done outward or upward in these cases, perhaps even compelling the person to close the eye operated on to avoid confusion. Should only a small space of cornea remain clear, the incision for the iridectomy should be made in the opaque portion, so that the transparent part may not be still further reduced by the scar of the wound. Iridodesis, or displacement of the pupil by drawing out a portion of iris and leaving it to be included in the scar of the wound, is dangerous, as it may be followed by cyclitis extending sympathetically to the other eye. Attempts to restore vision by inserting a small glass stud in the central leucoma, or to substitute the transplanted cornea of an animal, have not been successful.

Tattooing the centre of a conspicuous opacity with India ink, so as to gain the semblance of a black pupil, is sometimes of service cosmetically. The lids are separated by a spring elevator, and the conjunctiva taken hold of, to fix the globe, with a pair of rubber-garnished forceps, so that no penetration of teeth of the instrument may allow of the formation of tattoo marks in this membrane, where they are not wanted. The ink, rubbed up with water to a thin paste, is then placed upon the part of the cornea which it is designed to color, and pricked into the surface over the desired area with a fine needle, or with several needles fastened together. Too much should not be done at one time, lest irritation and circum-corneal injection should ensue if the operation is prolonged. Tattooing the marginal parts of a leucoma in colors, to imitate the tint of the healthy iris, has not been very successful, the coloring matter being readily reabsorbed or eliminated. If the eye is very sensitive, etherization greatly facilitates the operation.

Scores of applications for promoting absorption of corneal opacities, most of them of a more or less stimulating effect, have been advised. Among these are the insufflation of calomel or other powders, the introduction of various mercurial ointments beneath the lids, the use of stimulating or astringent or supposed solvent collyria. Most of these are not otherwise harmful than from the temporary irritation and pain which they excite; but it is doubtful if any of them are of service in removing permanent opacities. If used in young subjects and soon after the healing of ulcers, improvement often follows; but this gain follows rather than is in consequence of their application. Such irritating means, long continued and frequently applied, are very annoying, especially to young patients, and it is better to assist the absorption which is to be expected from natural processes, by soothing applications; assuring the friends that as much can be gained by these milder remedies as by any more active and painful treatment, and that they must probably expect only a slow, and in some cases but a partial, restoration of transparency.

Among cicatricial conditions of the cornea may be mentioned the slight irregularities of surface in the form of nearly or quite transparent facettes or depressions, which are sometimes sequelæ of ulceration. They impair vision by causing irregular refraction in different points of their wavy surface; and the correction of these refractive errors by means of glasses is very imperfect. In extreme cases of this class, as also in some conditions of corneal opacity, vision for near objects is improved by looking through a stenopæic slit in a disc of hard rubber or horn, which may be worn like spectacles, half an inch in front of the eye.

TUMORS OF THE CORNEA.

Tumors of the cornea are of infrequent occurrence. When superficial and of dermoid nature they may be carefully separated from the underlying tissue. If they extend deeper, and manifest an epithelial character and a disposition to increase, which only very exceptionally occurs, it may be necessary to remove with the diseased growth a part of the cornea itself or the anterior third of the globe; uniting the edges of the elliptical wound with fine sutures.

CHAPTER VII.

AFFECTIONS OF THE IRIS.

ANATOMY OF THE IRIS.

THE iris forms a disc-like diaphragm, with a hole or pupil a little to the inner side of the centre; it is attached to the cornea and ciliary body at its periphery, and hangs suspended in the aqueous humor, with the pupillary margin resting on the anterior capsule of the crystalline lens.

The tissue of the iris consists chiefly of a fine net-work of blood-vessels, which are bound together by a loose connective tissue frame-work; the inner surface is covered with a thick layer of pigment cells continuous with those lining the ciliary body, and in the posterior layers of the iris are found the delicate muscular fibres and nerves.

The vessels of the iris come from the circulus iridis major, a ring of anastomosing vessels lying in the anterior portion of the ciliary body. From this ring they pass in a radial direction through the iris to the pupillary border, where they form a smaller capillary circle, from which the veins return beneath the arteries to empty their contents finally into the venæ vorticosæ.

In the posterior portions of the iris the unstriped fibres of the sphincter muscle form a ring about the pupil one mm. wide, and connected with this are the fibres of the dilator muscle, which radiate from the pupil to the periphery. These two muscles control the size of the pupil and regulate the amount of light which passes into the eye. The sphincter receives its nerve supply from the third pair; consequently paralysis of these nerves usually causes dilation of the pupil. The dilator receives its supply from the sympathetic. In addition to these the iris has some branches from the sensitive nerves.

The anterior surface of the iris is covered with a thin layer of endothelial cells, a direct continuation of those which line the inner surface of the cornea, and scattered through its stroma are numerous pigmented cells, on whose number depends the color of the iris. In hot countries the pigment is abundant and the irides are dark; in temperate climates we more often find a gray or blue; and in albinos the pigment is entirely wanting. In babies' eyes the irides are always blue, owing to lack of pigmentation.

The iris divides that portion of the eye which is filled with aqueous into an anterior and posterior chamber; the first lying between the iris and the cornea, the other between the iris and lens, the two being connected by the opening of the pupil; but in case the pupil becomes closed by disease, and the aqueous, which is principally secreted in the posterior chamber, can no longer pass forward through the pupil, the iris is bulged forward, and grave changes may result in the eye, unless this condition is relieved by operative interference.

COLOBOMA OF THE IRIS.

A congenital fissure, almost always situated in the lower part of the iris, forming a pear or balloon shaped addition to the natural pupil from its margin to the ciliary border of the iris, is occasionally seen, and is almost always accompanied by a similar deficiency of substance in the choroid at that part of the fundus which is posterior to the coloboma iridis. These defects are due to a want of perfect development in the two halves of the uveal structures, and of course are incurable. Other faults of development sometimes coexist with these. One or both eyes may exhibit this anomaly, which if considerable in extent materially impairs vision.

Complete or nearly complete absence of the iris is still more rare, and is generally accompanied by other imperfections of the eye.

More than one pupil has been exceptionally met with.

IRITIS.

The iris, whose stroma consists principally of a fine net-work of blood-vessels, with delicate muscular fibres, nerves, and pigment, is one of the ocular tissues most frequently the seat of inflammatory processes. It is not only very subject to idiopathic attacks, depending on and influenced by certain diatheses of the general system, but, owing to its intimate connection with the ciliary body and the choroid on the one hand, and with the cornea on the other, it often shares in disturbances beginning in those parts, and is furthermore liable to become secondarily affected from the contact of foreign bodies or displaced fragments of the crystalline lens, or as a consequence of total obstruction of the pupil, resulting from former disease. On account of the important functions of the iris, its diseases constitute some of the gravest affections of the eye; while its position behind the transparent cornea gives an unequaled opportunity for closely watching and following the phenomena of inflammatory processes in all their various stages and degrees.

Authors differ as to the classification of iritis, some grouping in one description all the several forms of inflammation which are attended with plastic exudation, though recognizing various causes as modifying the symptoms and influencing the results. It seems desirable, practically, to discriminate between certain conditions which are almost constantly associated with each other, and have mutual dependence, and other groups of symptoms having a different ætiology. I shall therefore describe as distinct affections sundry varieties of iritis having a special origin, though in some cases their symptoms have a close resemblance to those of other forms.

RHEUMATIC IRITIS.

There seems to be no question as to the influence of the rheumatic diathesis in causing a form of plastic iritis which is marked by the severity of its course, and especially by its strong tendency to recurrence.

In a few cases, at the outset, the attack appears to be a mere conjunctivitis, of no great moment, these symptoms being succeeded in a few days by more characteristic phenomena. But in most instances, some, at least, of the symptoms of the deeper-seated disease are present from the beginning. If the eyes are examined separately, the movements of the pupil are found to have already become sluggish. The patient complains of slight soreness to the touch at some part of the eyeball, generally at the scleral insertion of one of the recti muscles, and of pain if this muscle is brought into exercise by turning the eye in that direction. A slight purplish or lake-colored injection of the epi-scleral vessels develops itself about the sensitive spot, or extends to the entire corneal zone; the straight filiform vessels radiating in an outward direction from the margin of the cornea, and growing fainter, till finally lost. This injection is in marked contrast with the scarlet net-work of vessels seen where the conjunctiva is inflamed. The degree of pain at this early stage is very variable. Sometimes it is of so little account that the patient neglects to give attention to his eye; more frequently it is severe and aching in its character, differing entirely from the smarting or itching accompanying conjunctivitis. If the iris is carefully inspected it will be seen to be congested, perhaps evidently thickened, as lymph is extravasated. Vision may continue normal, or nearly so, for a time, or even, in some instances, during the whole course of an attack. As the disease increases, the circum-corneal injection becomes much greater in amount, and is readily distinguishable by its color and the course of its vessels from the secondary conjunctival injection which overlies it, and which has a scarlet tint. The iris looks puffy, loses its lustre and its normal striated aspect, and its color is changed, a blue or gray iris becoming greenish, and a brown iris taking a dark-reddish hue, in consequence of infiltration of yellowish lymph into its tissue, which blends with and alters its natural tint. Vessels are sometimes visible upon its surface. The pain is often very excruciating, with a feeling of distention of the globe; and extends to and along the supra-orbital and other branches of the fifth pair, and perhaps over the entire half of the cranium; causing sometimes so much tenderness of the scalp that the hair cannot be combed without suffering. Frequently scarcely felt during the day, the pain comes on in the evening or during the night, to be followed by remissions on subsequent days. Photophobia is generally present in greater or less degree. There is copious lachrymation, but little or no muco-purulent secretion. Effusion of plastic lymph, mingled with pigment cells, is liable to occur from the iris, especially at its pupillary border, and, if overlooked or neglected, causes permanent adhesions between the margin of the pupil and the capsule of the crystalline lens, or even fills with deposits the whole area of the pupil. Turbidity of the transparent media often greatly diminishes or even temporarily abolishes vision, and at the same time prevents a view of the fundus of the eye with the ophthalmoscope, though no visible effusion may have taken place. These conditions do not necessarily involve any permanent lessening of visual power, as, if uncomplicated by actual deposits in the field of the pupil, the turbidity disappears as the disease subsides. Sometimes, though very rarely in this form of the affection, hypopion may be formed, by a deposit of effused lymph at the bottom of the anterior chamber; but this is usually reabsorbed, in these cases, without a resort to paracentesis of the cornea. Œdema of the lids is occasionally seen, but in some few cases may be due to the continuous use of atropia.

If, as is not seldom the case, the patient has suffered from previous attacks, sequelæ of these may be evident in the form of old adhesions of the edge of the pupil, or of spots or rings of organized lymph and pigment on the surface of the anterior capsule of the lens. These can usually be distinguished by a practiced eye from recent effusions.

Atropia sulphate gives us great advantages in the diagnosis and prognosis as well as in the treatment of iritis. A solution of two grains to the ounce of water is usually sufficiently strong for all purposes, though it needs to be repeated oftener in the severest cases ; in some of these a four-grain solution may be required. In fifteen or twenty minutes after instillation of a drop or two into the eye, the pupil should begin to enlarge, and if no adhesions have formed dilates with regularity. If slight exudation and adhesion has already taken place the pupil will expand in some parts of its border, while remaining fixed at other points more or less numerous, giving to its edge a scalloped appearance. Some or all of these adhesions may be torn away, while recent, by the continued use of atropia, restoring to the pupil a partially or completely normal circular outline. If the exudation has been very abundant, or has been neglected, or if previous attacks have already established extensive adhesions, the pupil may scarcely yield at all to the action of atropia, even when used oftener and in greater strength ; and the danger that the existing attack may cause still further permanent damage becomes very serious. We are greatly aided, in estimating the actual condition of the parts, by oblique illumination, which renders even minute changes distinctly visible ; and they may be still more clearly defined by the aid of a magnifying glass while thus illuminated.

It should be borne in mind that the intolerance of light gives rise to strong contraction of the pupil, the edge of which then lies in contact with the crystalline. From this contact and the subsequent effusion of lymph arises the principal danger attending the disease ; and the prognosis depends largely on whether the area of the pupil continues clear and its border free from adhesions. *Per se*, this form of iritis seems to be self-limited, with a tendency towards complete recovery at the end of varying periods, provided no complications are allowed to form. If the attack is but light, and the eye free from sequelæ of former invasions of the disease, and especially if the patient, perhaps forewarned by previous experience, is treated early and skillfully, the symptoms may pass off in two or three days, without leaving any trace. If the invasion is violent the attack cannot always be thus cut short, and the recovery, under the same circumstances of intelligent treatment, may be delayed two or three weeks, which is the usual term, or even longer; but the restoration will be equally perfect, though the symptoms may have great severity for some days at least.

But such fortunate results are not always attainable if the case is mistaken or neglected at the outset, or if the pupil is prematurely allowed to contract, or if, on account of former adhesions, only partial dilatation can now be obtained. More or less extensive deposits and adhesions are then likely to be formed, or prëexisting adhesions largely or even fatally increased. Should these cause complete occlusion of the pupil and subsequent bulging forward of the iris, iridectomy must be done at once, to reopen communication between the posterior and anterior chambers, before fatal irido-choroiditis is developed by the increased intra-ocular pressure caused by retention of the aqueous in the posterior chamber.

Some authorities have regarded synechiæ between the iris and the lens capsule as predisposing causes of recurrent iritis, and therefore advised the performance of iridectomy, or the detaching of adhesions from the capsule, as a prophylactic means to prevent such recurrence. I have for years made careful observations relating to this question, and have not been able to satisfy myself that rheumatic iritis, returning as it often does again and again, occurs any more frequently in eyes where there are extensive organized adhesions than in the other eye of the same individual where no such adhesions exist. Others of high authority corroborate my experience, and doubt the influence of synechiæ as excitants of subsequent iritis. Iridectomy should therefore be reserved for cases where it is urgently required to relieve actual threatening conditions, and never resorted to as a preventive measure. Detachment of adhesions, in Passavant's method, by seizing the iris near the point which has become adherent with a pair of fine non-toothed forceps introduced through a small incision in the cornea, and making gentle traction, is also unnecessary in most cases, and where it might be useful it is impracticable. If the adhesions are few and slight they are comparatively unimportant, and surgical interference is unjustifiable. If they are extensive it is nearly impossible, without repeated operations, or even if these are done, to accomplish permanent separation ; because so little can be safely done at one time that the pupil cannot be dilated by mydriatics, and the iris, kept in contact with the capsule by the remaining attachments and slightly irritated in the performance of the operation, renews the connections which had just been sundered. But we should never forget that the prevention of the formation of such adhesions, which, though they may not excite an attack, certainly enhance its dangers when it does occur, should be the prime object of treatment.

Various forms of plastic iritis have occasionally a close resemblance to the rheumatic affection, yet their distinctive features are generally sufficiently well marked. To ascribe all cases of iritis to constitutional syphilis, as is done by some authors, is to do manifest injustice. Many of the subjects of iritis had their first attack before they had cohabited, or even before puberty ; and, without ever having afterwards any impure connection or any syphilitic symptoms, they have repeatedly suffered from iritis, for which the only explanation is found in a strongly rheumatic constitution. Where the predisposition is present, the exciting causes of attacks are such as give rise to rheumatic manifestations in other parts of the body: cold, damp, exposure to draughts of air when heated, and sudden changes of temperature. As these may act at any time of the year, we find cases occurring at all seasons, but especially at those when other rheumatic affections prevail. Men are more subject to iritis than women, because they are more exposed to vicissitudes of weather. Attacks during youth are rare, and, after having perhaps recurred often during adult life, they become less frequent after fifty years of age. Simultaneous attacks in the two eyes are rare, but occasionally the second eye is affected soon after the recovery of the first. Complications with keratitis or choroiditis, except where the pupil has been occluded, are fortunately infrequent.

We owe to Schmidt, of Vienna, no longer ago than the beginning of this century, the first clear description of iritis as a distinct form of disease. Its gravity was so strongly insisted on, and so well recognized by the profession, that for a long period they did not venture to depart from the specific treatment enjoined; inasmuch as it was averred, that unless the system was placed as quickly as possible fully under the influence of mercury the golden opportunity would pass, and the eye could not be saved. In fact, so strong was the belief in the efficacy of this treatment that it came to be a proverb in medicine that some remedies were as much a specific in certain diseases as mercury was in iritis, where, it was said, we could witness within the eye the absorption of coagulable lymph. Unfortunately, if, while ptyalism was actually present, the use of belladonna was neglected, the lymph remained in great part unabsorbed, and the pupil was often closed by deposits; but if during the administration of mercurials mydriatics were also employed, the pupil was kept free from obstruction or adhesion, and the disease, at about the time when the constitutional effects of the mercury declared themselves, began to diminish by its own limitation, and went on to recovery.

Having observed these facts, I began, twenty-five years since, to treat various phases of iritis, and especially the rheumatic form, without the use of mercury. The results in more than sixty of these cases were communicated to the Boston Society for Medical Observation, and were published in 1856, the diagnosis in more than forty instances having been confirmed by other physicians with whom I saw the patients. I was first led to dispense with mercurials and antiphlogistics by having a number of patients whose general condition contra-indicated the use of such means, and the success, with these, of a plan which included only mydriatics and tonics, and other alteratives than mercurials, was so complete that I ventured to extend its application to other more sthenic cases. Subsequent and very extensive experience has proved the value of this innovation thus made, and we must regard it as a great boon to the numerous victims of this severe affection if they can safely be spared the added and prolonged discomfort which so often attended and followed the use of mercurial alteratives. Incidentally, we may also esteem it a benefit to mankind that the profession has been led to make a new inquiry and estimate as to the alleged resolvent powers of mercury in other maladies, and as to its effect upon the biliary and other secretions.

Happily, we no longer find mercury advised as the *sine qua non* in iritis. Even those authorities who are unwilling to lay it wholly aside qualify and limit its use, and we see mydriatics taking their deserved place, as essentials to successful treatment. To quote the expressive words of Zehender: "Only one great fault can be committed in the treatment of iritis: — the neglect of the timely use of atropia."

The extracts or infusions of belladonna and stramonium were formerly employed for obtaining and keeping up dilatation of the pupil, and are efficient for this purpose. But we have at command the more convenient atropia sulphate, which is readily soluble in water. A strength of two grains to the ounce of water is generally sufficient for our purposes, and is more manageable than solutions of higher strength. No acid should be added to effect a prompt solution, as this renders it more irritating to the conjunctiva. Four or more grains to the ounce of water may exceptionally be used, where it is important to make immediate and strong traction upon adhesions which threaten to become permanent; but if these do not cause symptoms of poisoning, as occasionally happens with feeble persons, they increase the uncomfortable dryness of the fauces. Usually we gain the effect of the stronger solutions, with less discomfort, by oftener repeated use of the weaker drops, and when we wish to lay aside the remedy its effects are sooner recovered from. In a healthy eye a single drop of even a much weaker than two-grain solution will dilate the pupil in fifteen minutes or so; but where the iris is turgid with the products of plastic inflammation, or its sluggish movement is yet further impeded by actual adhesions, it may be necessary to repeat the application more than once, or even several times, to obtain the desired enlargement. It is only necessary to put a drop or two inside the lower lid, from a teaspoon or drop tube, to insure its being absorbed.

If adhesions are already formed, of if the intumescence of the iris makes it difficult to maintain sufficient dilatation, the atropia should be used hourly, if necessary to keep up its full influence. After dilatation is accomplished, the atropia drops may be used once, twice, or thrice daily, or every hour or two, according to the tractability of the iris and the urgency of the symptoms; the rule being to apply it often enough to keep the pupil widely open, thus preventing contact of the swollen iris with the lens, and obviating the danger of the formation of adhesions, until the symptoms abate and the congestion lessens, when it will be found that a much less frequent use of the solution will suffice for keeping up its influence. We should err, if at all, on the side of too frequent use of this means, as no harm beyond slight and temporary inconvenience arises from this, while much mischief might follow the contrary course.

If the practitioner does not have atropia at his command, the extract, infusion, or fresh juice of belladonna or stramonium may be used. Recent adhesions will often give way as the disease subsides, if the use of atropia is continued, and we should therefore not too readily despair of obtaining this result. But if there are already large old adhesions, we must often be content if we are able to prevent an increase of these; and even this is not always possible, because the existing deposits hinder our obtaining free dilatation, and the plastic material is then liable to limit yet further the area which it is so vitally important to preserve. It is not impossible that old adhesions may be stretched or sundered during a fresh attack, when they seem to become softened, by the use of atropia, though this occurs but seldom to any important extent.

The atropia should be gradually discontinued during convalescence. The patient may be directed to use it less frequently, but to watch that the pupil does not become small. When at length we find that the effect of one instillation continues for a day or two, we may feel that the congestion and irritation of the iris has been relieved, and the mydriatic is no longer necessary. It is well, however, to use it once more, after a few days, to make sure that no adhesions are being formed. The power of accommodation being paralyzed during the use of atropia, vision for small objects is imperfect until its effect has passed off. If adhesions persistingly resist the traction made upon them by the atropia, it is generally useless to continue the dilatation very long after the disappearance of active symptoms; but the patient should be cautioned as to the necessity of prompt attention to the earliest manifestations of any new attack, so as, if possible, to avert any increase of the synechiæ.

Beyond the skillful use of mydriatics we have few resources in the way of local application. All recent authors agree as to the necessity of avoiding stimulants and astringents; which hold so useful a place in the treatment of conjunctivitis. In iritis they do positive harm, irritating the external membranes, and thus adding to the congestion of the eye, while they have no favorable influence upon the principal disease. The secondary conjunctivitis which accompanies iritis is to be regarded as a mere complication, which will subside with the original disease, and as not requiring treatment like a positive inflammation of that membrane. But though lotions and mild collyria have little positive effect upon the iritis, their use may be permitted if found grateful and desirable. Tepid infusions of poppy capsules or of opium, of rose leaves or tea, may be used as fomentations; or if the patient or his friends have a prejudice in favor of mucilaginous infusions of quince seeds, sassafras pith, or marshmallow root, even these are allowable, though the gummy feeling about the lids after they have been used makes them less eligible. Infusions of camomile flowers, dear to the heart of many a good-wife, should only be used after being filtered through blotting-paper, as fragments of the silicious spines will pass through a sieve or a muslin filter. Bathing with tepid water or milk and water sometimes gives relief, while cold applications are rarely acceptable in rheumatic iritis. As a rule, however, little if anything is gained by the use of such means, and the eye is often the better for being left to itself instead of being too much fomented. Such applications, therefore, are scarcely to be recommended, though they may be allowed if a person desires to try them.

General anodynes play an important part in the treatment of iritis, and next to mydriatics are the most essential means to be employed. The severe intra-ocular and circum-orbital pain is not only agonizing to the patient, but seems to increase the congestion and the tendency to exudation. The intensity of pain is often so great that it is controllable only by considerable or even very large doses of the more powerful narcotics. Potass. bromide, and remedies of this class, do not suffice, but we must employ preparations of opium or morphia, chloral hydrate or croton chloral; the selection being determined by the indications in each case, or sometimes by idiosyncrasies of the patient. They should be repeated till relief is obtained; and the amount required for this effect is sometimes very large. Anodynes may usually be withheld during the day, when the pain is but moderate, and kept in reserve for the nightly exacerbations. Hot pediluvia at bed-time are often useful auxiliaries.

General depletion is not required; nor is Heurteloupe's artificial leech or other apparatus for the local abstraction of blood. Three or four leeches may sometimes be applied to the temple with apparent benefit, or at least with relief to the pain, in the early stages of the disease. Later, they are of doubtful utility. They should be placed at a part of the temple not above the level of the eye, and not too near it; as otherwise infiltration of the cellular tissue and œdema of the lids may ensue. After the leeches have filled, the bites may be fomented with warm water, if the patient is vigorous, to favor further bleeding. When this has continued long enough, it can be stopped by applying a little dry lint, absorbent cotton, or cobweb, and if necessary making slight pressure, with or without a compress and bandage. The evening is the best time for this local depletion. Potassium iodide or bromide, sodium iodide, colchicum, salicylic acid, and other anti-rheumatic remedies, and sometimes quinia sulphate, lupulin, or other tonics, are serviceable in modifying the general condition. Purgatives or milder laxatives may be prescribed if required. Counter irritation near the eye is worse than useless. Paracentesis of the cornea is only indicated when hypopion has formed in the anterior chamber, or in a few cases of extreme pain and much turbidity of the aqueous, and should be resorted to only cautiously in acute cases, lest any exacerbation of symptoms should be attributed to its having been employed.

A cheerful prognosis is an important means of encouraging those who have become depressed by the suffering and the continued dimness of vision; and this may be given with confidence if no harm is already done in the field of the pupil; the vision rapidly improving as the attack subsides.

The earliest symptoms, of tenderness or soreness on motion, are readily recognized by those who have suffered from several attacks. If, when these are perceived, atropia is at once applied, it is sometimes effectual as an abortive means; the pain and sensitiveness being removed almost at once, probably by relief of the iridal congestion from alteration of the conditions of its fibres and vessels. Patients living at a distance or traveling should be supplied with atropia, to be used at the outset of an attack until they can have skilled advice. No harm is done, at all events, by employing it; and if, as often happens, the disease has taken too firm a hold to be thus dislodged, the prompt resort to this remedy will at least secure such immediate dilatation of the pupil as is so important to the favorable after-course of the disease. Opium should not be given as a preventive, as it has no value in this respect; and it disposes the patient to subsequently fly to it too willingly upon the slightest suspicion of an attack, and thus in some cases to become addicted to its use.

Tinted glasses should be worn as a precaution by those subject to rheumatic iritis, when exposed to cold or damp winds or strong light.

Unfortunately, we meet with too many cases where iritis has been mistaken at the outset for some far less serious affection; its real nature being discovered only when grave and permanent changes have taken place in the iris and pupil.

SYPHILITIC IRITIS.

This form of plastic inflammation does not always present features so absolutely characteristic that we can decide as to its nature from the local conditions alone, without inquiry as to the antecedents of the patient and as to the presence of general symptoms of specific disease.

The injection and the general aspect of the iris, in mild cases, are similar to the appearances in other acute forms of the disease; but as the cases become more severe the puffy and discolored aspect of the iris is more marked, indicating parenchymatous inflammation, and the tendency to infiltration of the stroma and to exudation more evident; often showing itself in the form of globular masses, gummy tubercles, which frequently soften and discharge, forming hypopion in the anterior chamber, or uniting the inner surface of the iris with the lens. By thus keeping the parts in contact they mechanically obstruct the dilatation of the pupil. These masses, if not too large, are sometimes reabsorbed without causing structural lesions. Such round tubercles may very rarely be seen in non-specific forms of iritis, but their presence is always a suspicious symptom; and, moreover, they render the prognosis less favorable, since they tend to destroy the stroma of the iris when they are of any great magnitude. The color of the iris is more changed, but the pain is often less severe, than in rheumatic iritis, and is sometimes so slight in proportion to the other symptoms that the patient scarcely has warning of the mischief which is happen-ing until considerable pupillary obstruction has taken place. Attacks of syphilitic iritis are more dangerous, while present, than the rheumatic form ; but once recovered from, the patient is generally safe from recurrence. A not unfrequent complication occurs in the form of interstitial inflammation of the cornea.

Syphilitic eruptions are a usual concomitant of this affection. Alopecia, ulcerations of the throat, and other evidences of syphilitic cachexia are also not uncommon. The frequency of these complications, though not justifying the proverb, " *Ubi iritis ibi syphilis*," should lead the physician to satisfy himself as to the existence of any specific diathesis in every suspicious-looking case. If direct evidence is not at the time perceptible, indirect questioning will generally afford the desired information without compromising domestic felicity in delicate circumstances. Iritis may show itself in the primary or the later periods of lues, usually, however, in the secondary or tertiary stages or in inherited forms.

Even more pains must be taken in iritis syphilitica than in other forms of iritis to preserve the pupil intact. Early and continued dilatation is of the first importance, because the deposition of organizable lymph is usually greatest about the pupillary margin. Constitutional treatment for the relief of the general cachexia naturally suggests itself, but this need not necessarily be mercurial. Potassium iodide is often very efficient and prompt in its action ; relieving the symptoms *tuto*, *cito et jucunde*. The internal use of small doses of mercury iodide and inunction with mercurial ointment are serviceable methods of administration, if the practitioner deems such alteratives necessary ; but if otherwise, he may safely venture to dispense with them, notwithstanding old traditions in their favor.

Sedatives are of great value if pain is present, and should be used *pro re nata*. Depletion is generally contra-indicated. Counter irritation is in this, as in other ocular affections, according to Stellwag von Carion, " a relic of barbarism."

HERNIA OF THE IRIS

is of so frequent occurrence, as a result of wounds, or of perforating ulcer of the cornea, and requires in many cases such prompt and skillful treatment, that it deserves special mention. If the hernia is very recent, it is possible, though not probable, that it may be drawn back into the eye by mydriatics, if the prolapsus is central; by myotics if it is marginal; or that it may be reduced by careful pressure with a small probe. These means may therefore be tried if it is deemed expedient. But if these endeavors fail, as they usually do, because of the aqueous pressure distending the pouch, it is best to at once excise the protruding portion by a single clip with fine curved scissors, the convex surface of the blades being held toward the cornea; since delay only increases the prolapsus iridis. This excision may be done without anæsthesia, if the patient can keep the eye turned in the proper direction and the operator has a steady hand. The little projecting mass must not be taken hold of with forceps, as any attempt thus to raise it would on the slightest movement of the globe draw a larger portion of iris from the eye; and the entire iris might be torn out if the patient should make a sudden turn of the eyeball. If a ragged mass of iris is strangulated in a wound it may be occasionally best to etherize the patient, so that it may be more cleanly removed. Quiet, especially of the eye, and sometimes keeping the patient on his back in a partially darkened room, with cold compresses over the eye, are the proper treatment after excision; atropia or pilocarpine being employed if indicated.

SEROUS IRITIS.

The designation scrofulous iritis, of the older writers, was not without its appropriateness as applied to this disease, inasmuch as it is oftenest met with in those of strumous diathesis. Usually the symptoms have a much less acute character than in the more plastic forms of inflammation. There is less circum-corneal and conjunctival injection, less pain, and less evident infiltration of the iris tissue. Instead of the abundant exudation of organizable lymph, we have here an increased aqueous secretion, slightly turbid from holding small particles of lymph in solution. These particles are deposited upon the lens capsule, the membrane of Descemet, and the inner surface of the cornea, especially in its lower hemisphere ; giving to all these parts and to the iris a hazy aspect. On account of these conditions the disease is sometimes termed aquo-capsulitis. The anterior chamber is increased in depth. The pupil is sluggish, often somewhat dilated, but shows little tendency to the exudation and adhesion along its border which marks the other forms of iritis. Serous iritis has, however, its own special dangers, from increase of intra-ocular tension, and from a disposition to involve the ciliary body and the choroid in destructive inflammation of a low type, as well as to extend to the cornea. In fact, it is deemed by some authors a form of cyclitis rather than iritis.

In this relatively very infrequent affection, atropia is by no means to be regarded as the treatment *par excellence*, to be used early and often, which it has been shown to be in the plastic forms of iritis; but, on the contrary, is sometimes to be avoided, on account of its increasing the photophobia, and perhaps the intra-ocular tension. At times myotics may be indicated; but the pupil should be closely watched, and mydriatics are to be occasionally resorted to, if any disposition to the formation of synechiæ should declare itself.

Paracentesis of the cornea is indicated where the tension continues higher than normal and the anterior chamber or the inner surface of the cornea is clouded by minute specks of lymph. General treatment should be directed to the improvement of the constitution and the lymphatic system.

This affection is most common in young girls and in feeble or badly nourished persons ; and in these the prognosis is favorable, but recovery slow.

INFANTILE SYPHILITIC IRITIS.

This usually appears within a few months after birth, frequently accompanied by syphilitic ulcerations about the lips and face and on the nates, with specific eruptions on the skin, and a marked inherited cachexia of the system. The disease affects the whole parenchyma of the iris, with tendency to copious exudation. The pupil is often occluded and the ciliary region involved, with subsequent choroiditis and atrophy of the entire globe. Tonic general measures, to secure the best possible nutrition, and the early local application of atropia afford the best chance of preserving vision. Specific remedies and tonics are to be used in moderation. Many of the subjects of this affection are so puny, from their inherited ailments, that fatal results cannot be averted. Of those who survive, and recover from the earlier eye symptoms, a certain number become subjects of specific inherited keratitis at or after the time of the second dentition, which is elsewhere described.

IRIDO-CHOROIDITIS.

The iris, ciliary body, and choroid include much of the vascular and nervous supply of the globe. Being intimately connected with each other, they frequently become involved, by contiguity as well as by continuity, in affections which primarily involved only one of the parts; although, on the other hand, either of them, as we have seen in regard to iritis, may be and may remain the sole seat of disease. When these structures are secondarily implicated, they may be so in very different degrees, and it is at times difficult to isolate the morbid processes which belong to each.

Irido-choroiditis may occur as a secondary result of traumatic injury in the eye itself; or from sympathetic influence after injury of the other eye; or from pressure, or other pathological change, which alters the relative conditions of the internal parts of the globe. One of its most frequent exciting causes is the complete occlusion of the pupil resulting from neglected iritis. Here, the aqueous secreted in the posterior chamber no longer finds its way through the pupil, to pass gradually through the cornea by endosmosis, and be replaced by fresh secretion. It accumulates behind the iris, and, unless this abnormal condition is at once relieved by an operation for artificial pupil, we soon have an accession of entirely new and destructive phenomena. The iris, which is now firmly fastened at its pupillary margin, as well as at its ciliary border, begins to bulge forward, its fibres become thin from distention, and it gradually forms a prominent ring of discolored and disorganized tissue, which nearly obliterates the anterior chamber, and comes to lie in contact with the cornea. The pressure also acts backward upon the ciliary body and processes, and the suspensory ligament and capsule of the lens, causing a slow form of inflammation with plastic deposits in these parts. The lymph and uveal pigment, which at first formed a mere annular union between the edge of the pupil and the lens capsule, is expanded as a continuous layer behind the whole extent of the iris, and closely cements together the adjacent surfaces. so that at this stage a successful iridectomy is nearly impossible. If this operation is attempted, and a portion of the underlying false membrane as well as of the iris is removed, the vitreous is often found to have been replaced by a yellow serous fluid. Ophthalmoscopic examination of the deeper parts of the eye is of course impossible; but the gradual diminution of light perception indicates the progress of morbid changes in the retina and choroid. This perception fades more and more, and, with the lessened tension of the globe, marks the progress of yet further disorganization of the internal membranes and of atrophy.

When irido-choroiditis has originated in the choroid or the ciliary region from irritation excited by the presence of a foreign body, by a cretaceous or displaced lens, or by a separated retina, the iris does not form a bulging mass, depressed at its centre, where its pupillary border is fastened to the lens, but is everywhere crowded forward with and by the disorganized structures behind it. This is perhaps the best distinguishing mark, indicating a choroidal rather than iridal origin of the disease. These phenomena were formerly not unfrequently a sequel of the operation for cataract by displacement into the vitreous space. Practically, the question of origin is not without importance, as the prognosis could be favorable only when the iris rather than the choroid had been the primary seat of the inflammation, as would be indicated with reasonable probability when the light perception continues good.

If, where there is good light perception, iridectomy can be performed, and an artificial pupil substituted for the closed central opening before the occlusion has continued long enough to cause destructive changes, some vision at least may be regained. In proportion to the duration of obstruction of the pupil and the complication with subsequent morbid conditions, the chances of success grow less and less, until at length no operative interference is desirable, the globe having become disorganized. Iridectomy is justifiable, even where a firm curtain of exudation behind the iris requires a second operation for its division or excision, if the field of vision is still everywhere cognizant of light, and the evidences of extreme or atrophic alterations are not present.

Extensive but not universal adhesions of the margin of the pupil have been believed by some authors to be capable of developing irido-choroiditis, but it is doubtful if the disease is ever induced by less than an absolute occlusion, with the resulting abnormal pressure. Iridectomy, therefore, is not indicated as a preventive means where only adhesions, even though considerable, are present. It should only be done when the area of the pupil is so far obscured by the amount of deposit that vision is greatly impaired, or where recurrent attacks of iritis are of such frequency and severity as to threaten the closure of the remaining free space during some fresh attack. In such case, especially if the patient cannot remain under supervision, timely iridectomy would be preferable to delay, because the prognosis of the operation is more favorable when it is done at a time when no actual inflammation is present.

SYMPATHETIC OPHTHALMIA.

When one eye has suffered certain kinds of traumatic injury, there is a peculiar liability to sympathetic affection of the opposite eye, which may declare itself within a brief period of a few days, or may be delayed many months, or even years. This tendency is also very likely to show itself where the globe has been penetrated by a bit of steel, gun cap, shot, or other missile, which has remained in the eye. Such a foreign body may continue dormant for a long time, even, as I have seen, for twenty-two years, when, in consequence of some change of place, or of the absorption of lymph by which it had been enveloped, it becomes a source of irritation of the surrounding parts. Displacement of some part of the eye, as, for instance, separation of the retina from the choroid, or dislocation of the crystalline from its normal situation, may cause like effects, as may also cretaceous transformation of the lens. Punctured, contused, or lacerated wounds, or the scars of these, if they involve the ciliary region, are frequent causes of sympathetic disease; whereas large incisions limited to the cornea, or operations where a large portion of iris is removed, are not attended by any such subsequent risks. But incisions for the extraction of cataract, if made so near the ciliary region that this becomes involved in the scar or drawn towards it, are dangerous; a very large number of cases having been already reported where linear extraction, with the incision at or beyond the border of the cornea, has been followed by sympathetic inflammation and loss of the other eye. The wearing of an artificial eye over a disorganized globe where the ciliary region continued irritable has been known to cause sympathetic symptoms.

The approach of sympathetic ophthalmia is often insidious, the patient not being warned by severe symptoms of the danger which threatens him. Those who have had any lesion of one eye, which may possibly in the near or remote future become a source of risk to the other, should therefore be cautioned not to disregard even slight manifestations of irritation in the injured or diseased eye; for if he delays till the sound eye begins to be affected, it is often too late to avert a sad result, even by a resort to the most energetic treatment.

Children are peculiarly susceptible to this affection; and, as they are not likely to complain of the slight early symptoms, they cannot be too closely watched after one eye has been injured.

Mere sympathetic irritation may appear in a few cases, and subside, if early recognized and properly treated, without going on to the more fatal form of inflammation, which almost invariably destroys the eye. The symptoms of this irritation resemble those of serous iritis, — a moderate degree of circum-corneal injection, sluggishness of action of the pupil, turbidity of the aqueous, and lessened vision, — and the sympathetic origin of this condition is denoted by the existence of prior or actual tenderness on pressure, increased lachrymation, and possibly pain, in the injured or diseased eyeball, which may have been previously for a long time quiescent. The presence of these symptoms, or any of them, in the sound eye indicates the treatment, which consists in the removal of their exciting cause as disclosed in the injured eye, before the other becomes more seriously involved.

Unfortunately a manifestation of the more serious inflammation is the rule, without prodromata of irritation. Suspicious conditions having perhaps lingered a longer or shorter time in the injured eye, there is noticed a dimness of vision in the other eye, especially at twilight, or a slight sluggishness or discoloration of the iris, or photophobia and lachrymation, or circum-corneal injection. In children, as above remarked, these slightly marked symptoms will not be complained of; they must be watched for.

If vision is slightly hazy before other symptoms appear, this may possibly announce a primary implication of the choroid and retina, or it may be but the earliest sign of iridocyclitis, the lessened sight being due to congestion and loss of accommodation in these parts, with a yet scarcely appreciable turbidity of the transparent media.

The marked and dangerous feature of sympathetic iridocyclitis is the rapid and often nearly painless development of plastic inflammation. The parenchyma of the iris, the part most open to observation, speedily becomes puffy and infiltrated, and the pupil, notwithstanding the use of atropia, is soon blocked by exudations, which extend over the whole posterior surface of the iris, and to the ciliary body and processes, precluding much hope of restoration by surgical procedures. As the cyclitis goes on the choroid and vitreous are implicated. There is usually much injection of the ciliary region, and it is more or less sensitive to pressure. The amount of pain varies greatly in different cases. As a final result the tension of the globe lessens, and it is gradually atrophied, generally with flattening in the positions of the four recti muscles.

Sympathetic ophthalmia seems to be usually a reflex phenomenon, extending from the ciliary nerves of the injured to those of the fellow eye. But very rare cases have been observed where the optic nerves seemed to be the medium of transmission, though the apparent inflammation in these might have arisen by contiguity, from a neighboring ciliary branch.

After sympathetic ophthalmia has once begun in an eye the prognosis is most unfavorable. Except when it is seen and arrested in the stage of irritation, loss of vision is the usual sequence. The questions as to when an injured or disorganized eye is to be regarded as threatening the safety of the other, and when a healthy eye is to be considered as imminently in danger, are therefore of the utmost importance. No mere limit of time insures safety. If the injured eye is very much shrunken the chances of its being troublesome are less, because the ciliary region in these cases, as in those where the whole contents of the globe have been removed by suppuration, seems generally to lose its susceptibility to irritation, the nervous filaments having probably shared in the general atrophy. But if this region remains sensitive to the touch, though the eye may be free from other symptoms, it should be closely watched. If an injured eye continues to be intolerant of light, or painful, or much injected, after the time when in the ordinary course of things these symptoms should subside; or if, after recovery from these, there are recurrences of the morbid phenomena, such an eye should be viewed with suspicion. And we should remember that prevention of sympathetic inflammation, and not its cure, is within our power, and that even the sacrifice of an already useless and oftentimes deformed eyeball is not to weigh in comparison with the safety of its fellow.

Some have insisted that an eye regarded as hopelessly lost from injury should be at once removed after the accident. There are many objections to so extreme a course. The injury may not prove so fatal as is supposed; or should it be so, the patient and his friends are often quite incredulous as to this fact, and may object to the enucleation, or may unjustly blame the surgeon for having performed it, when, as they believe, the eye might have recovered. Of course this consideration should not influence the practitioner, when he is certain that the patient's welfare demands prompt action; but, in fact, many gravely injured or destroyed eyes never afterwards cause disquieting symptoms, and there is virtually no risk in at least a few days' delay, until the parties interested can convince themselves that the case is probably hopeless as regards the preservation of sight. If, after a short time, everything wears a promising aspect, and especially if the patient is intelligent, or if he can remain under the supervision of the physician, further delay may be accorded. But if the injured person is not to be relied on, or must go to a distance, where he could not have skillful advice, it may be judicious to avoid risk by immediately resorting to surgical interference. Even when we are sure that a foreign body is buried in the eye, it may often be left undisturbed; and when lodged at the fundus it is frequently eliminated by a slow process of suppuration around it, by which it is brought to the anterior surface and thrown off without exciting sympathetic phenomena.

Enucleation of a totally blind eye, when it continues or becomes irritable, has, until a recent period, been regarded as affording the only absolute assurance of protection to the other eye from the chance of sympathetic inflammation; and, in the solicitude of surgeons to avert this danger, it seems to have been sometimes forgotten that an eyeball, even when incapable of sight, and shorn in a measure of its fair aspects and proportions, is yet in many cases a valuable possession, especially to the poor, who cannot afford artificial substitutes. Patients are far more comfortable if even a shrunken but painless globe remains in the orbit than they are without it, as the lids are better supported, and the secretions conveyed to the lachrymal passages instead of flowing out to irritate the cheek. Moreover, cases are seen where an injured eye, after having excited sympathetic inflammation and loss of the other eye, has itself been left in such a condition that we are able to restore useful vision by iridectomy.

Happily, there appears to be no doubt that at least a partial substitute for this measure of last resort has been found; in enervation, by section of the optic and the ciliary nerves. The posterior ciliary nerves, which seem to be the usual if they are not the invariable channel for conveyance of morbid sympathetic influences, are grouped about the optic nerve in such a manner that they may all be divided at one operation. Their tortuous course among the loose cellular tissues of the orbit, which is necessary to the free movements of the globe, offers great security against the possibility of any reunion of the severed ends of these filaments. By this neurotomy we are able to avoid a mutilation, in the loss of the eyeball, which, if not imperatively required, is often, as above stated, a serious misfortune to the patient, whether rich or poor.

Enervation was first done by Boucheron, at Paris, in 1876. It is as yet too soon to allow us to say with certainty that this operation may be substituted in all cases for enucleation, but there appears to be every reason for believing that it may replace the graver operation in a large number of the cases, at least, where enucleation has been performed as a preventive measure, before the second eye has become affected. Its results thus far give reason to hope, that, as experience makes the operation and the conditions adapted for it still better understood, it will be the means of preserving many otherwise doomed eyeballs. It will doubtless fail in some cases from imperfect performance, or because undertaken after the other eye had already been hopelessly affected; but in these latter circumstances even enucleation is not more successful. The anatomical relations of the ciliary nerves with the parts which are the chief seat of origin and development of sympathetic symptoms, and the fact that after section of these nerves the threatening symptoms subside in the injured eye, and signs of irritation which had begun to manifest themselves in the opposite eyeball disappear as quickly as after enucleation, afford strong confirmation of the hopes which are entertained as to the future of this new procedure.

The required instruments for the operation are a pair of strong scissors, much curved upon the flat, so as to be adapted to the outline of the globe, fixation and fine-toothed forceps, a strabismus hook, a needle armed with thread, and an elevator for the lid. After anæsthesia has been obtained the conjunctiva over the insertion of the internal rectus is raised with the forceps, and divided by a vertical incision with the scissors. Tenon's capsule is opened and the internal rectus drawn forward with the hook, and its tendon divided, a suture having been previously carried vertically through it. The globe is then seized with the fixation forceps, and drawn outward and a little forward, so as to render the optic nerve slightly tense. The closed scissors are now to be introduced along the posterior wall of the globe till the optic nerve is felt; and being then drawn back a little, the blades are opened so widely as to include the ciliary nerves with the opticus, and all these are then severed at a single stroke, or more than one if needed. A bit of ice of lengthened form may be passed along the course of the wound to check hæmorrhage. The globe being thus freed in its mobility, it is taken hold of with the forceps and turned outwards, until the severed end of the optic nerve can be seen, and the operator assures himself that none of the ciliary branches which are grouped around its entrance into the sclera have escaped division. The eyeball is then returned to its position, and the rectus internus may be reunited to the conjunctiva near the cornea by a suture, to avoid strabismus; though this is often unnecessary. The central artery and vein of the retina and some of the ciliary vessels are cut in making the nerve section; and this creates an instant and frequently considerable flow of blood, which may perhaps be checked by using a long bit of ice. Most of this does not find its way through the external wound, but, on account of the retraction of the divided vessels, is diffused into the orbital cellular tissue, and causes a sudden and considerable protrusion of the eyeball. This extravasation of blood is lessened by the use of Warlomont's scissors, which crush as well as divide the vessels; and it is reabsorbed within a few days; but a portion of it often finds its way forward into the loose cellular tissue of the lids, giving rise to a temporary ecchymosis. Cold compresses are to be laid over the lids for a day or two, but no compressive bandage should be applied; the globe itself, retained as it is by Tenon's capsule and the ocular muscles, affording sufficient compression to arrest further effusion from the vessels. More pressure than is thus obtained is dangerous to the globe, and might give rise to suppurative inflammation, or, if the cornea is intact, to ulceration of this part.

Notwithstanding some feeling of distention from the retro-ocular hæmorrhage, the patient generally experiences immediate relief from the deep-seated and circum-orbital pain which had existed in more or less severity previous to the operation.

The subsequent nutrition of the eye has been found not to be affected, its vitality being probably maintained by the anterior ciliary system of vessels. The sensibility of the cornea is abolished by the operation, and it no longer feels a touch with a probe or a wisp of paper; and it may sometimes require to be protected by glasses from injury by foreign substances, of the contact of which it is unconscious, or from cold winds, to which the eye is now very susceptible. Should there be continuance of pain and of corneal sensibility, it may be suspected that some branches of the posterior ciliary nerves escaped division, and that the operation was not quite complete. Should these symptoms persist to any threatening extent, a further section may be performed with little inconvenience to the patient, no considerable hæmorrhage being likely to occur at this repetition. The possibility of a reunion of the divided ends of the ciliary nerves, probably generally far separated from each other in the cellular tissue, is a theoretical rather than a practical idea; and should the divided opticus reunite, as is asserted to have occurred in a single instance, this would not necessarily be a source of danger; the ciliary nerves being the channel through which sympathetic inflammation extends. It is not shown that, even should the ciliary nerves be subsequently reunited, a return of the symptoms of irritation would occur, after these had been once quieted.

Enucleation may still be done, as a last resort, in case of the continuance of urgent symptoms. There was ample justification for a resort to this extreme measure while it was looked upon as the sole security against sympathetic ophthalmia and the blindness which was its sure consequence; but should experience prove that it may in the future be held in reserve, and that we have in enervation even a partial substitute, we shall have gained another of the great advances of modern surgery.

But if we even admit the supposition of an insufficiency of effect, or of a relapse, in certain exceptional cases, there can be no question that a larger number of eyes would be saved by the substitution of a less formidable for the severer operation of enucleation. An injured eye oftentimes shows but slight defect so far as appearance goes, though its vision is virtually lost, and though a scar in the ciliary region may be like the impending sword of Damocles, a perpetual threat of danger. The patient, especially if the eye has for a long time been quiet, will not consent to part with it, and thus destroy his good looks; and his medical adviser hesitates to urge enucleation, or perhaps does not know the danger of delaying it. And even when other warning symptoms supervene, these seem so trivial to the unskilled observation of patients and their friends that the golden opportunity passes, disease insidiously begins in the other eye, and enucleation, if done, is then too late to avert destruction. But let it be once understood that a far less serious operation offers probably equal or nearly equal security against reflex excitation of sympathetic disease, the surgeon will feel it proper in many instances to advise its performance, so as to avoid any possible risk, and to relieve the patient from the suspense and anxiety which must always attend the presence of an eye which may at any time become a source of danger. The patient is then often willing to consent to surgical intervention.

The question sometimes arises whether any operation should be done upon an injured or degenerated eyeball, after symptoms of sympathetic ophthalmia have already become evident in the previously healthy eye. Yes, if the morbid processes have not advanced too far. If, however, plastic exudation is already extensive in the second eye, the prognosis for this eye is so almost uniformly unfavorable that the surgeon may sometimes act wisely in abstaining from useless enucleation of the other, and avoiding the possible risk of septicæmia. The lesser operation of enervation would be justifiable, as involving no danger of harm, and none of the subsequent annoyances caused by an empty orbit.

But, if some vision or good light perception remains in the eye, even this operation should not be performed if there is no hope of advantage to the other eye; as there is a chance of restoration of at least some vision in the injured eye, by iridectomy, after the acuter processes have subsided.

Iridectomy should never be done in the eye secondarily affected, during the active stages of the inflammation; and is permissible only after the subsidence of the active symptoms, and in the few very exceptional instances where the uveal tract has not become utterly disorganized, and where the qualitative perception of light is good.

CYSTS OF THE IRIS.

Of very rare occurrence, cysts occasionally form in the iris near its ciliary border, and now and then from the ciliary processes. Their walls are generally thin, and they are semi-transparent; but they may be firmer and have more opaque contents. Most frequently they have a dermoid structure, covered anteriorly by a few iris fibres. They may arise without known antecedents, though punctured wounds of the iris have sometimes appeared to be their exciting cause. They are usually of slow growth, show no disposition to spontaneous cure, and may increase so as ultimately to destroy vision, or even disorganize the entire contents of the globe.

Extirpation rather than puncture is to be advised, as, like other dermoid sacs, they refill, unless all, or at least a large part, of the cyst wall is removed. To insure a definite cure it is desirable to excise a portion of the iris at the place of attachment. An incision is made in the cornea with a narrow cataract knife or a bent iridectomy knife, in such a position as to allow of the cyst being seized with delicate forceps and drawn out, with a part of the iris if desired, and it is then excised with fine scissors. The prognosis is reasonably favorable, but should not be too positively so, as the operation has been sometimes followed by inflammatory reaction, and even with loss of the eye.

MALIGNANT TUMORS OF THE IRIS.

Melanotic, sarcomatous, or other solid growths very rarely originate in the iris. When, however, the diagnosis is made clear by the dark color or the rapid and steady growth of such masses, with increased tension of the globe, removal of the eyeball is the only proper course.

DISCOLORATIONS OF THE IRIS.

One or more spots, usually of a rust color, may be visible in the iris, or a segment of the membrane may be totally different in color from the remainder. These are merely peculiarities of pigment distribution, and not pathological conditions.

MYDRIASIS.

Abnormal dilatation of the pupil may result from several causes, and may appear in one or both eyes. In the latter case, especially, it is sometimes of pathognomonic importance as a symptom of disease of other parts of the system. The enlargement varies greatly in degree, from a moderate dilatation, seemingly dependent on a merely partial loss of power in the ciliary branch of the oculo motorius, to the widest expansion, so that the iris tissue becomes almost invisible, where irritation of the sympathetic appears to be conjoined with complete paralysis of the third pair.

When widely dilated by paralysis or mydriatics the pupil changes very little, if at all, when suddenly exposed to strong light. The retina, no longer able to protect itself by exciting reflex contraction of the iris, is dazzled by the excess of light and by the circles of diffusion formed by the numerous lateral pencils of rays which fall upon it. If, as is usually the case, the nervous branches supplied to the ciliary muscle are also affected, accommodation is suspended, and vision for small objects is in most eyes much impaired. If the person is hypermetropic he cannot see even large objects distinctly. This imperfection, however, may be distinguished from the loss of sight in amaurotic eyes where mydriasis is also present, by testing the person with convex glasses, or by having him look through a pin hole in a card held close to the eye, when vision is found to be perfect. The grayish appearance of the pupil, caused by the unusual reflection of light from the deeper parts of the eye, should not be mistaken for commencing cataract, nor for the discoloration occurring in advanced glaucoma.

Mydriasis often follows concussions of sudden blows on the eye, as from a cork flying from a champagne bottle. Though there may have been no other injury, the function of the ciliary nerve is sometimes never restored, and the pupil remains permanently enlarged. It will, however, contract temporarily under the influence of myotics, and in some cases these may be used to advantage from day to day, generally in solutions of one or two grains to the ounce, to restore the normal aspect of the pupil and relieve the dazzling and other inconveniences of mydriasis. Pilocarpine or eserine should be at once applied, if the case is seen soon after the injury, in the hope that by promptly exciting action in the iris through this means its functions may be reëstablished.

A very frequent cause of mydriasis in one eye is the more or less complete paralysis of the third pair of nerves, in consequence of exposure of one side of the head to cold draughts. If the ciliary branch alone is affected, the symptoms will be as already described; but the other branches of the third nerve are often also implicated, so that we have the globe turned outward by the unopposed action of the rectus externus, and the upper lid drooping from loss of power in the levator palpebræ. This condition admits of a favorable prognosis. Recovery will be gradual, and sometimes very slow, requiring weeks or months; but it is nearly always complete. Myotics may be used to mitigate the inconveniences of the situation, and efforts should be made to hasten the cure by the use of stimulating lotions about the forehead, temples, and lids. Spirits of rosemary, pure or combined with one fourth or more of sulphuric ether, is an example of such remedies. Tonics are often serviceable.

Very active treatment is only required where there are special indications, as, from the nature of the lesion, rapid improvement is not to be expected. Laxative remedies are sometimes useful.

Mydriatics, when accidentally or intentionally put into the eye, or used as therapeutic means, produce confusion of vision, photophobia, and loss of accommodation, as temporary phenomena. This constitutes a grave objection to the now too common employment of atropia or other mydriatics in the treatment of phlyctenular, catarrhal, and other forms of conjunctivitis; as well as in many corneal affections where this class of remedies is not needed, and where they often increase the already existing intolerance of light. They should be mostly reserved for affections of the iris, in the treatment of which they are indispensable; to avert the dangers of perforation in some conditions of the cornea; and in special circumstances when indicated; but by no means as agents to be indiscriminately used in eye disease.

If atropia or other mydriatic has accidentally been instilled into the eye while being used for some other person, the subject of the mishap, alarmed at his confused and dazzled sight, often comes for advice. He can be assured of the only temporary duration of his disturbance of vision, and the effect may be neutralized or abbreviated in a measure by pilocarpine, if thought advisable. The action of even a two-grain solution of atropia sulphate may continue from one to three or four days, and possibly longer in very susceptible eyes. If it is desired to produce artificial mydriasis, with suspension of the accommodation for the purpose of measuring the refractive power of an eye, a four-grain solution must be used.

Malingerers often use mydriatics to simulate amaurosis, hoping thus to escape conscription for the army or some disagreeable duty. They have also been occasionally employed by hysterical individuals for purposes of deception.

Binocular mydriasis may occur as a symptom of hydrocephalus, meningitis, or any source of pressure upon the region of origin of the third pair. It may also result from a loss of perception in the two retinæ. Syphilitic intra-cranial lesions may give rise to this symptom, more or less permanent, in one or both eyes. Mydriasis may also be excited, as a reflex phenomenon, by the irritation caused by intestinal worms. In all these cases the indications for treatment are based on the general condition of the patient.

MYOSIS.

Contraction of the pupil beyond its usual average limits is found as a normal condition in advanced age. It may be induced in younger subjects by constant close application of the eyes to fine work, or occur spasmodically from overaction of the ciliary branch of the third nerve upon the sphincter iridis. A similar action, affecting also the muscles of accommodation, can be excited temporarily by solutions of pilocarpine or of eserine. Such spasmodic action can be antagonized, when required, by atropia.

When seen as a symptom of tabes of the cervical portion of the spinal cord, the prognosis can only be unfavorable.

IRREGULAR MOVEMENTS OF THE IRIS.

Miners who, as not unfrequently happens, are subjects of nystagmus, as well as those persons in whom this peculiarity is congenital, usually have also irregular action of the sphincter iridis. I have seen the spasmodic affection also associated with tremulousness of the iris and dislocation of the crystalline in both eyes; possibly a result of the desultory movements of the globe. Tremulous movements of the iris are a usual consequence of the want of support of this membrane, resulting from dislocations of the crystalline lens, or its removal by absorption or by extraction, or of such a relaxation of the suspensory ligament of the lens as permits of its occasional luxation even into the anterior chamber. In some instances softening of the vitreous may cause a similar tremulousness from lack of the normal support. Vision may still be tolerably good, or may be found much lessened, according to the nature of the causes or complications of this condition.

OPERATIONS ON THE IRIS.

Of all the operations on the iris, iridectomy is the most important, and is applicable in a great variety of circumstances. It may be done to displace the pupil, or to reopen or form an artificial substitute for it; to relieve intra-ocular pressure, or arrest intra-ocular inflammation; and to facilitate operations for extraction of cataract. Special reference will be made to the operation as a means of relief in glaucoma, and as an auxiliary in some cataract extractions, in other chapters.

Iridectomy may be done to improve or restore the sight, in numerous cases where the central pupil no longer serves for visual purposes, or where this has been closed as a consequence of inflammation or injury.

When the centre of the cornea has become densely and extensively clouded, as a result of deep and large ulceration, or where there is central opacity of the crystalline lens, vision may be very imperfect, although the pupil may be normal. In some cases atropia, used alone or combined with glasses, affords relief. In other instances, the opposite eye, if perfect, may singly better answer all required purposes than if we attempt to aid it by forming an artificial pupil in an eye which even then will have defective vision. But in cases where both eyes are destitute of useful sight, much may often be gained by the formation of a new opening, in one or in the two irides, for the passage of light. The lower or lower and inner part of the iris is the place of election for the operation, unless opacity of the cornea in front of this part forbids its being chosen. An artificial pupil in this situation affords greatest assistance in vision, because most of the objects we look at are seen below rather than above the equator of the eye; whereas, if made upward and outward, it is sometimes useful only when there is little or no vision in the other eye, and but serves to confuse the opposite eye, if this retains its sight.

The instruments required for iridectomy are a spring or other elevator for the lids, fixation forceps, fine curved toothed forceps, a bent triangular iridectomy knife or narrow cataract knife, fine straight scissors, and fine scissors curved on the flat. Anæsthesia is desirable. If the right eye is to be operated on, the lids are kept open by the elevator, and the surgeon, standing behind the head of the reclining patient, fixes the globe with the forceps, while he enters the iridectomy knife close to the border of the cornea, or through the sclera just beyond the corneal margin, according to the proposed form and size of the new pupil. As soon as the point of the knife is within the anterior chamber the blade should be directed considerably in front of the plane of the iris, so as not to wound the capsule of the lens, and pushed steadily onward, till the incision is of the proper extent. It is then withdrawn, the handle of the knife being depressed, so as to keep the point close to the inner surface of the cornea. A slow withdrawal has been supposed to lessen the probability of an intra-ocular effusion in consequence of a sudden change of tension; but there is a greater danger of wounding the capsule of the lens, after the escape of the aqueous has allowed of collapse of the anterior chamber, by a too slow withdrawal. The fixation forceps are now given over to an assistant, and the operator introduces the curved iris forceps, closed, and with the convexity toward the iris, till they nearly reach the border of the pupil. The iris is seized at this point, and gently drawn out at the wound, forming a triangular flap. If it is desired to make but a narrow, key-hole-like pupil, not extending to the ciliary margin, the wedge-shaped bit of iris, drawn out to a less extent, is cut across with curved scissors, at a little distance from the cornea, the convexity of the curve being towards the eye. If the conditions of the case require a larger loss of substance, one edge of the flap of iris is cut with the scissors close to one extremity of the wound; the iris is then gently drawn toward the other angle of the wound, separating it to that extent from its ciliary attachments, and then cut away close to the cornea. A segment of iris of the desired size being thus removed, care should be taken to see that the iris retracts within the globe, and that no bit of it remains between the edges of the wound at either extremity.

If the pupil has become closed, as the effect of disease or accident, while the cornea continues clear, the operation should be similar as to the point selected and the different steps of its performance. If the cornea has at the same time been rendered more or less opaque, it may be necessary to make the artificial opening at a part of the iris corresponding to a transparent portion of the cornea; and where this clear space is limited, it is important to make the corneal wound through a part which is opaque, so as not to further reduce the transparent area by the scar.

Apart from its application in glaucoma, iridectomy may, exceptionally, be done in epi-scleritis, or other disease threatening by its extension to impair the integrity of the pupil. In these cases, unless for special reasons, the operation should be done at the upper instead of at the lower part of the iris, so that the artificial addition to the natural pupil may be covered by the upper lid, to conceal the slight defect, and to avoid dazzling. When iridectomy is performed to reopen a pupil which has become closed by plastic deposits, the operation is often made more difficult by the rotten state of the iris fibres, or their close adhesion to a layer of organized lymph which has extended behind the entire iris. Here the iridectomy should be large, and should include the whole segment to the ciliary border, so as to lessen the danger of reclosure of the artificial opening. It is of great importance, if an eye is seen soon after such closure of the pupil, to operate at once, before the iris has become lined by plastic deposits, and the posterior structures of the eye have been disorganized by the disturbance of balance of the intra-ocular pressure which occurs when the pupil remains thus occluded for more than a brief period.

Iridotomy, or incision of the iris, is done in some instances where adhesion has formed between the iris and the cornea (anterior synechia), or where, after removal of the crystalline by accident or by an operation, the pupil has become closed by deposits. In these cases the incision should be made in the part of the iris rendered tense by the adhesion, or at the point most favorable for vision. The iris may be incised by means of a very minute knife, no larger than a cataract needle, and made with a slightly conical shaft, so that it shall fill the opening made in puncturing the cornea, and thus prevent the escape of aqueous and relaxation of the iris before the incision can be made. The operator himself fixes the eye with forceps held in one hand, while he introduces the knife and cuts the iris with the other. He is thus better able to adapt the position of the eye and facilitate the division of the iris fibres. If the iris had previously been upon the stretch the incision gapes sufficiently to form a pupil of suitable size. When the iris is thickened and made inelastic by false membranes it may be necessary to use Wecker's iridectomy scissors, which are introduced closed through a small incision in the cornea, then opened and one blade pushed through the iris, which is then cut with one stroke of the scissors; or two incisions may be combined in V-form, to allow of more separation of the divided parts.

Iriddesis, or the drawing out of a portion of the iris, with canula forceps, through a puncture made with a broad needle in the sclera just beyond the corneal margin, and leaving the iris strangulated in the wound, was highly thought of at one time as a means of displacing the pupil without loss of substance in the iris. But further experience proved that this operation was occasionally followed by cyclitis, with sympathetic loss of the other eye. It has therefore been nearly abandoned. Its advantages without its dangers can be obtained by a narrow iridectomy.

CHAPTER VIII.

AFFECTIONS OF THE CHOROID.

ANATOMY OF THE CHOROID AND CILIARY BODY.

THE choroid is the vascular coat of the eye. In connection with the ciliary body, which is a direct continuation of the choroid, it lines the whole surface of the sclera, and is firmly united to it at the entrance of the optic nerve and at the sclero-corneal junction.

The surface of the choroid next the sclera is covered with a thin endothelium, which lines the lymph space between them. This space is crossed in all directions by a loose connective tissue net-work and by numerous arteries and veins, which serve to bind the two membranes together.

The parenchyma of the choroid consists of a light framework of connective tissue, holding in its meshes the numerous blood-vessels, pigment cells, and nerves which make up the bulk of its substance. The inner layers are filled with a net-work of fine vessels; in the other parts the vessels are larger, and in the outer layers we find that the veins converge from all directions toward four or six great trunks, the venæ vorticosæ, which are situated in the equatorial region, and, piercing the sclera in a very oblique direction, return the blood from the eye to the ophthalmic vein.

The short ciliary arteries, forming some ten or twenty branches, enter the sclera near the optic nerve, and passing forward through the choroid furnish it with an abundant blood supply. Near the optic nerve they sometimes have anastomoses with the vessels of the nerve or its sheath.

The two long ciliary arteries enter the sclera in front of those last mentioned, and pass forward on opposite sides of the eyeball to the ciliary body, where they each divide into two principal branches, which pass in opposite directions through the anterior portion of the ciliary body, and uniting with those of the opposite side form the circulus iridis major, from which circle the vessels supplying the iris, ciliary body, and cornea take their origin.

The anterior ciliary arteries follow the course of the recti muscles to their tendinous insertion, then penetrate the sclera and connect with the circulus major. This ring also sends a few small branches back along the ciliary processes to join the choroidal system.

Between the vessels of the choroid are found large numbers of densely pigmented cells, which give the tissue its dark color; and where the layer of pigment epithelium between the choroid and retina is thinned or wanting, the ophthalmoscope shows the choroidal vessels as lighter streaks on a dark background, the pigment causing the spaces between the vessels to appear darker colored.

In albinos, where the pigment is wanting, the vessels appear dark red on a lighter background.

The nerves of the choroid are branches of the long and short ciliary nerves. They generally follow the course of the vessels, and are quite numerous. Numbers of branched ganglionic cells are also found scattered through the stroma or collected in groups.

The inner surface of the choroid is covered with a thin homogeneous layer, lamina vitrea, upon which rests the pigment epithelium, which is now considered to belong to the retina rather than to the choroid.

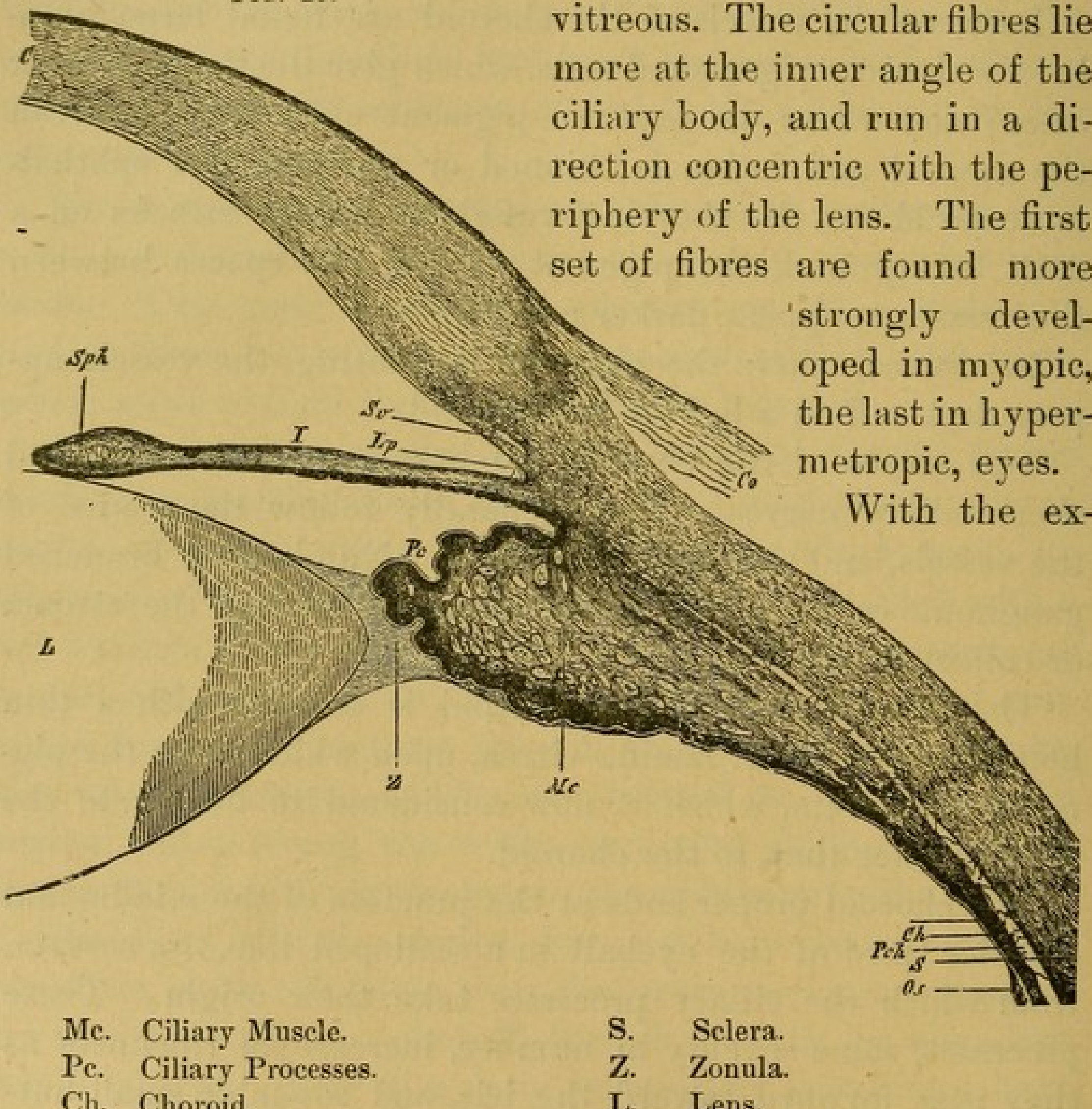
The choroid proper ends at the junction of the middle and anterior third of the eyeball in a scalloped line, ora serrata, from which the ciliary processes take their origin. These processes, some seventy in number, increase in thickness as they pass forward toward the iris, and resemble small buttresses, which soon coalesce to form the ciliary body.

This ciliary body, on cross-section, has a triangular shape, the outer angle being firmly attached to the sclera near the sclero-corneal junction and to the iris, the inner corner giving rise to the zonula, which holds the crystalline lens in place, and the posterior angle being united to the choroid.

It forms a ring about the crystalline lens, and by means of the ciliary muscle, which is imbedded in it, and the zonula, it is able to change the shape of the lens, and thus control the accommodation of the eye.

The ciliary muscle forms the principal part of the ciliary body, and consists of organic muscular tissue. The longitudinal fibres run from the point of attachment to the sclera, back toward the choroid and vitreous. The circular fibres lie more at the inner angle of the ciliary body, and run in a direction concentric with the periphery of the lens. The first set of fibres are found more strongly developed in myopic, the last in hypermetropic, eyes. With the ex-

Fig. 20.



Mc.	Ciliary Muscle.	S.	Sclera.
Pc.	Ciliary Processes.	Z.	Zonula.
Ch.	Choroid.	L.	Lens.
I.	Iris.	C.	Cornea.
Sph.	Sphincter Iridis.	Co.	Conjunctiva.
Pch.	Peri Choroideal Space.	Sv.	Sinus Venosus.
Os.	Ora Serrata of Retina.	Lp.	Ligamentum Pectinatum.

ception of the muscular tissue the parenchyma of the ciliary body resembles that of the choroid, but the layer of uveal pigment which lines its inner surface is much thickened, and in the neighborhood of the zonula is thrown into deep folds.

The choroid being composed of similar tissues and arranged in somewhat the same manner as in the iris, the inflammatory processes which go on there resemble in many respects those of the iris. In what is supposed to be hyperæmia, and in serous choroiditis, the layer of pigment which lies between the retina and choroid often prevents one from seeing the difference in the fullness of the choroidal circulation; but in the other forms of inflammation, plastic, fibrinous, purulent, or atrophic, we are enabled, by means of the ophthalmoscope, to follow clinically the course of the destructive changes in the choroid, and, by observing the varied appearances to which they give rise, to form a prognosis as to the ultimate result.

SUPPURATIVE CHOROIDITIS.

Monocular suppurative choroiditis is met with as a result of the presence of foreign bodies in or near the choroid, and may even declare itself in eyes where such substances have remained many years *in situ* without causing irritation. Sooner or later, however, their displacement, or perhaps absorption of protective layers of lymph which surrounded them, leads to inflammation in the contiguous parts, followed by purulent accumulations. This process need not involve the whole of the posterior contents of the globe, but the offending substance may be gradually conveyed with the pus toward the anterior part of the eye. In its passage forward it makes its way through the iris, exciting sluggish plastic inflammation there, and at last it reaches and perforates the cornea; being then at length expelled, if it is not removed by extraction. The attending symptoms are seldom severe, there being only moderate injection or pain; and it is important to note that there is here by no means the same danger of sympathetic inflammation of the other eye as exists in cases of wounds of the ciliary region, or the lodgment there of a foreign body. Considerable atrophy of the globe ensues upon this process of elimination, but this is not so complete as where its entire contents have been disorganized.

But where in such cases active symptoms are present, and the history of the case affords probable evidence of the continued presence of a foreign substance within the globe, — which evidence is made conclusive where we have a corneal scar, with a hole in the iris behind the cicatrix of the cornea, — it is safer to divide at once the optic and ciliary nerves than to take the chance of an irido-cyclitis and possible sympathetic affection of the other eye; such enervation being substituted for the more serious operation of enucleation, and being advisable where the surgeon is in doubt whether the expulsion of the foreign body will be accomplished by natural processes without danger.

Suppurative changes, apparently beginning in the choroid, but quickly involving the retina, vitreous, and all the internal parts of the globe, and becoming a true ophthalmitis, may follow chemical or other destructive injuries of the anterior parts, metastatic or embolic puerperal inflammation, and even operations. If the transparent media remain clear the pus may be seen causing a yellowish reflex at the fundus. The rapid formation of purulent matter and increase of tension causes great suffering, and may even induce cerebral symptoms. The sub-conjunctival, palpebral, and orbital cellular tissue becomes infiltrated, giving rise to serous or phlegmonous chemosis, which overlaps the cornea and impedes by its volume the movements of the eye. Left to itself, the matter of this intra-ocular abscess generally makes its way through the sclera, between the insertions of two of the recti, or through the cornea.

As soon as the surgeon can satisfy himself of the actual formation of pus within the globe, it should be at once evacuated, to shorten the duration of suffering. If its presence is only suspected, delay and the use of anodynes is prudent;

for the friends or the patient are often slow to believe the loss of sight inevitable, and if the operation is prematurely done may ascribe the subsequent blindness to the surgical interference, whereas they cannot but be satisfied of its necessity when the eyeball is filled with purulent fluid. Should the contents of the globe be found to be in a semi-plastic, sloughy condition, the spontaneous breaking down and discharge of this mass should not be waited for, but everything contained within the eyeball should be at once removed by means of a scoop or a lid elevator through an incision of requisite size. This procedure gives immediate relief, lessens the risk of septicæmic infection of the system, and hastens the cure. The abscess may be opened through the cornea, or at any part of the sclera where pointing of matter is observable. The after-treatment is by warm fomentations, and the infiltrated tissues of the eye and the orbit soon recover.

PUERPERAL OPHTHALMITIS: POST-FEBRILE OPHTHALMITIS.

In puerperal fever, perhaps from metastasis, or more probably from embolism, and occasionally after exhausting diseases, a plastic choroiditis, frequently changing to a suppurative ophthalmitis, is now and then observed. Loss of sight is often the first symptom which calls attention to the eye. I have been able to detect with the ophthalmoscope a limited amount of exudation in a puerperal patient who was in a low condition, and to predict its increase and transformation to a purulent deposit if the life of the patient continued: a prognosis which was verified shortly after at the autopsy; purulent matter, surrounded by an extensive effusion, being found between the choroid and retina. One eye only is usually affected. As the exudation increases, it may force its way into the anterior chamber. This deposit is now and then absorbed without the occurrence of panophthalmitis and suppuration of the whole contents of the globe; resulting in such case in partial atrophy of the eye, not greatly injuring its appearance.

In the later stages of severe cerebro-spinal meningitis, which may or may not terminate fatally, symptoms of injection lead to an examination of the eyes, which perhaps had not been complained of by the unconscious patient. A yellowish reflex is perceived at the fundus, sometimes even without the aid of the ophthalmoscope, indicating the formation of exudation by an extension of inflammation along the optic nerve, or by actual percolation of matter, between the layers of the nerve-sheath, from the cerebral membranes to the eyeball. This may augment in quantity and change in consistence, sometimes flowing through the pupil into the anterior chamber, but occasionally being reabsorbed, even when of considerable amount, without causing complete intra-ocular destruction. If the patient is sufficiently conscious, he complains of pain, proportioned to the degree and the rapidity of the morbid change. Both eyes generally share in the disease. These forms of suppurative choroiditis are fatal to vision in the affected eye, and result in more or less atrophy of the globe; but they do not leave behind them a disposition to subsequent reflex inflammation of the other eye if this has not been implicated in the disease.

DISSEMINATED CHOROIDITIS.

Various alterations of the choroid, of a less aggressive and more chronic nature than the suppurative forms, may be observed with the ophthalmoscope. These appear as small white spots, scattered over a greater or less amount of surface; or as patches of paler color than the surrounding choroid with perhaps an irregular margin of more inflammatory aspect or with masses of accumulated pigment at some part of their extent, the whole fundus resembling in its mottled aspect the skin of a leopard; or as large marked white spaces of atrophy, surrounded by black borders of pigment, which has been crowded into this position by exudations of fibrinous material, and left there when these became absorbed; or as masses of organized connective tissue, taking the place of the choroid. These changes may be confined to a small area or implicate a large portion of the choroid, and they may be limited to its structure, or perforate its anterior layer and involve the retina. The smaller spots are of rounded form, the larger often very irregular. Sometimes they are peripheral only, or few in number, and scarcely affect vision; in other cases they occupy the region of the macula, and, even if of small size, seriously impair the sight. The more recent patches are usually less clearly defined; those of longer standing much more distinctly outlined, because of the atrophy which has occurred in the choroid. The retinal vessels are often seen unaltered, passing over the surface of the diseased choroid. Where the retina overlies the spaces of exudation it is perhaps more or less compressed between the choroid and the vitreous, and its perceptive power, for the time at least, is lessened. When the choroidal changes are extensive, confluent, and of considerable duration, perfect vision may never be restored, because of a loss of proper nutrition of the retina and the destruction of the layer of pigment epithelium from which the retinal purple is renewed, though the exudations should after a while be absorbed. Unfortunately, the region of the macula is a favorite seat of areolar changes, and central vision is then much impaired, dark spots appearing in the field of view. One eye being attacked, there is much reason to fear that the other will participate, though this does not always happen; and if occurring, there is often a marked difference of degree in the two eyes. Fixed or floating opacities of the vitreous frequently accompany or supervene upon these forms of choroiditis, sometimes to such an extent as to obscure the fundus. The ophthalmoscopic appearances are shown in plate at the end of the work.

Disseminated choroiditis may continue for months, with perhaps intervals of improvement and of relapse, and exhibit consecutively or simultaneously the phenomena of all the various phases of the disease; resulting in more or less marked permanent changes of structure.

Authors agree in regarding this affection as being frequently of syphilitic origin, and the possibility of this complication should be borne in mind when investigating a case; but there can be no doubt that it also appears where no such diathesis exists.

The prognosis depends partly on the presence or absence of any constitutional cachexia, and in part on the degree in which important portions of the retina have suffered from changes in the underlying choroid. If even considerable structural alterations have occurred at the periphery, the patient may be found to have some lateral part of the field of vision obscured by scotomata, and yet be unconscious of any defect in his sight; but where far less changes have taken place in the neighborhood of the macula lutea, grave disturbance of visual perception ensues.

Cobalt blue or neutral-tinted glasses should be worn when the eyes are exposed to strong light. The eyes must be used but sparingly, and such physical exertion as might increase the ocular congestion should also be avoided. The digestive functions are to be kept in good condition. Internal remedies must be relied on, rather than collyria or other local means. These should be selected according to the condition or diathesis of the patient. A combination of potassium iodide and bromide, or soda iodide if the former combination does not agree with the patient, is often useful. I cannot say that I have seen benefit from the application of leeches or of Heurteloupe's instrument to the temples, the depletion being too indirect. Pilocarpine nitrate in the form of the subcutaneous injection of from ten to twenty-five drops of a one or a two per cent. solution, twice or thrice a week, is worthy of trial in this disease.

HÆMORRHAGE IN THE CHOROID

may occur in consequence of a blow on the eye, or, in those disposed to cerebral or ocular congestion, from strain in lifting, or from too violent exercise in running or otherwise. It may also happen in glaucoma, from obstruction of the intra-ocular circulation.

If the effusion is central, the patient is conscious of a sudden loss of sight; if elsewhere, the fact of its having taken place may be only afterwards discovered. The extravasation may be situated in the stroma of the choroid, or between it and the retina or the sclera, and forms one large effusion or several usually roundish spots, having the color of venous blood. Choroidal are readily distinguishable from retinal hæmorrhages, which are more flame-like in form and are generally contiguous to vessels.

Reabsorption of the effused blood gradually takes place, the spot becoming paler, and finally, if the hæmorrhage is but small, scarcely noticeable. If large, a border of pigment usually remains, marking the area which had been covered by the effusion, and atrophy of the choroid over the same space often leaves the sclera exposed as a white spot in the red fundus.

Vision may be partially restored, even when the effusions have been considerable, but the patient generally perceives one or more scotomata, which interfere with vision according to the nearness of affected spots to the region of the macula.

Those once subjects of this hæmorrhage should be careful to avoid in future all predisposing causes.

OSSEOUS FORMATION IN CHOROID.

Deposits of bone are occasionally formed in the choroid, in eyes which have undergone extensive degenerative changes. These may be either in small plates, or they may form a bony cup of nearly or quite the full size of the choroid. If, at length, the eye becomes sensitive to the presence of this transformed structure, and reflex sympathetic inflammation of the other eye appears to be threatened, the removal of the source of irritation is imperatively required. The practice has been to enucleate the eye, but I have in my possession a completely ossified choroid, which I unexpectedly encountered in operating for the removal of the anterior part of a staphylomatous globe, and which I extracted with forceps, bringing the cut edges of the sclera together with fine sutures. The case made an excellent and prompt recovery, and the resulting stump gave good support to an artificial eye. In any similar case enervation of the globe, by section of the optic and ciliary nerves, would be worthy of trial instead of enucleation; and, if this appeared to be insufficient to relieve the symptoms, extraction of the ossified choroid, as above described, through the anterior parietes, would be preferable to complete removal of the globe.

TUMORS OF THE CHOROID.

Sarcoma, and more rarely melanotic or medullary disease, may originate in the choroid. The appearances these present to the ophthalmoscope do not always suffice for a differential diagnosis as to the nature of the growth, but this is of less importance, as the treatment must be identical.

Most of these tumors arise from the posterior part of the eye, more seldom from the ciliary region. If seen while of small size, and before the transparency of the media has been affected, they appear as masses of rounded outline, whitish in color, and having vessels of bright tint and active circulation; distinguishable in these respects from separations of the retina, which have a more pearly color and vessels containing a darker and sluggish current. Even at an early stage, however, these growths are often complicated with separation, the retina being more or less pushed up by the tumor, rendering the outline of the latter less definable and the diagnosis more difficult. Malignant glioma of the retina shows a yellower appearance at the fundus.

As the disease advances, the vitreous grows cloudy and perhaps softened, the lens becomes opaque and pressed forward, and glaucomatous symptoms, with increase of tension and severe intra-ocular and supra-orbital pain, may be manifested. As the tumor approaches the anterior structures, the globe becomes irregular and bulging, as in staphyloma of the ciliary region, and at last the cornea gives way, with sometimes temporary relief to the suffering, but with subsequent rapid development of the growth. In other cases, the destructive changes in the cornea are followed by ophthalmitis, and the globe is diminished by suppuration; but, contrary to what is observed after shrinkage of the eyeball in suppurative inflammation from other causes, the stump continues painful and sensitive, and a fresh and oftentimes rapid development of the tumor is soon evident.

Extension of the morbid growth beyond the limits of the globe may occur from perforation of the sclera, or from the beginning of similar pathological changes beyond it, without apparent connection between the two formations, or from extension of disease along the optic nerve. The rapidity of development varies greatly in different cases. Choroidal tumors do not appear, as does malignant disease of the retina, in very early life.

The prognosis as to return of the disease after removal, at its original seat, or by metastasis in other parts of the body, depends on the nature of the growth, and whether or not it is confined within the limits of the eyeball. The alpha and omega of treatment consists in enucleation of the diseased eyeball as soon as the diagnosis is distinctly made out. Care should be taken, however, not to mistake separation of the retina, which may usually be left to itself, at least till it excites irritation, for intra-ocular tumor. The differential appearances are described in the chapter on retinal separation.

Tubercles of the choroid, usually associated with acute tuberculosis of other organs, are occasionally observed with the ophthalmoscope, in the form of small, round pink or whitish elevations, most frequent in the neighborhood of the optic disc or of the macula lutea. Their recognition may now and then aid in the diagnosis of tubercular disease.

ENUCLEATION OF THE EYEBALL.

After anæsthesia has been induced, the lids are to be separated by a spring elevator. The other instruments required are fixation forceps, fine toothed forceps, fine scissors, a strabismus hook, large scissors curved on the flat, a curved needle armed with thread. A fold of conjunctiva is to be raised with forceps, and divided with the scissors close to the cornea; the division is then finished by passing the scissors completely around the cornea to separate the conjunctiva and sub-conjunctival tissue from the globe, and preserve as much as possible of these. The recti muscles are then in turn drawn forward by the hook, and their tendons cut close to the globe. The capsule of Tenon, and its auxiliary attachments to the muscles, may be kept nearly intact, thus subsequently affording better support and motion to an artificial eye. The globe is then strongly rotated outward with fixation forceps, and the curved scissors are carried behind the globe, from the inner angle, to sever the optic and ciliary nerves and vessels. If there is a suspicion of possible extension of any morbid growth along the optic nerve this should be divided far back. The eyeball can then be drawn out of the orbit, and the oblique muscles cut close to the sclera. If the optic nerve has a diseased look, its cut end should be sought for with the finger, seized with forceps, and excised as deeply in the orbit as possible. Any masses in the orbital cellular tissue, which look or feel as if diseased, should be carefully extirpated. If the changes are more extensive, all the intra-orbital tissues must, if necessary, be removed, and chloride of zinc paste applied to the periosteum, in case this seems to be implicated.

The optic nerve may be severed and the globe drawn forward after section of but one or two of the recti, leaving the others to be cut after evulsion of the globe; but previous section of the four recti is to be preferred.

If the surrounding parts are healthy, and the globe only is removed, the conjunctiva may be brought together at its margin by a circular suture, drawing it up like the mouth of a reticule. This helps to prevent continued hæmorrhage, by exerting a certain amount of compression, and favors prompt healing and preservation of the greatest possible amount of the orbital contents; and it also tends to prevent the springing up of fungous growths at the bottom of the orbit. Should this closure be unadvisable, or the exsection of the parts too great to admit of it, a bit of sponge enveloped in a piece of linen rag may be pressed into the orbit, beneath the lids, to compress the vessels; and retained in place for a few hours by a bandage. The rag is folded around the sponge to make its extraction easier. Cold applications are laid over the lids, and pressure by a sponge and compress externally may be used if needed. The pressure may generally be removed after a short time, and only cold compresses continued. Should hæmorrhage recur, which seldom happens, it can be arrested by introducing a bit of ice into the orbit, or, if necessary, a sponge to serve as a plug; or even by folded compresses over the lids, and a bandage, if rightly applied. As a rule, the hæmorrhage is but slight. From three days to a week are sufficient for recovery from the operation. When there is reason to suppose that the contents of the orbit must be largely excised, as in cases of orbital tumors, the lids may be divided at the outer commissure to facilitate the operation. This incision readily closes, without causing deformity. An artificial eye cannot be properly selected before at least some weeks subsequent to the operation, and not until the parts in the orbit have assumed their permanent condition; as, if chosen while yet more shrinkage is to take place, the eye will not fit after this process is completed.

COLOBOMA OF THE CHOROID.

This congenital defect of development is found associated with a similar imperfection of the iris, generally implicating the lower part of both these membranes. It is seen ophthalmoscopically as a broad fissure, laying bare the white sclera, and extending perhaps from near the edge of the optic disc to the ciliary processes. The retina is usually also more or less deficient, and vision is therefore imperfect over a corresponding extent of the field.

ABSENCE OF CHOROIDAL PIGMENT.

In albinos the pigment is wanting over the whole uveal tract, in the choroid as well as in the iris. The vasa vorticosa and other choroidal vessels are clearly seen with the ophthalmoscope, and the iris can be seen with the naked eye, or especially with oblique illumination, to be destitute of its pigment lining. This state of things deprives the eyes of their normal protection against strong light, and renders them extremely sensitive, since reflex contraction of the pupil no longer prevents dazzling. These persons therefore shun bright lights, and see best in a moderate illumination. The condition is congenital and sometimes hereditary.

SCLERO-CHOROIDITIS POSTERIOR.

This term is sometimes used to designate chronic alterations in the form of the posterior part of the globe unattended with acute inflammatory symptoms. These changes, more often spoken of as posterior staphyloma, are very frequently associated with myopia, so that they may almost be regarded as one of the peculiar features of this affection, though they are occasionally found in other refractive conditions.

As there exists in numerous cases an hereditary tendency to myopia, this is probably accompanied by a congenital thinness of the sclera about the posterior extremity of the axis of the globe, predisposing to the giving way which forms the essential feature of posterior staphyloma. This disposition is favored, and the ectasia increased, by gradual elongation of the axis from lateral pressure of the recti muscles during over-use of the eyes upon small objects, especially during the period of childhood and youth. Furthermore, the convergence of the eyes kept up during study, and the continuous slight traction thus made on the optic nerve, explains why we find the beginning of staphyloma at the temporal side of the optic disc. Accompanying the yielding of the posterior sclera atrophic changes occur over a greater or less space in this region of the choroid.

Viewed with the ophthalmoscope, only thinning of the choroid, with lessening of the amount of pigment, is observable, at the outer side of the disc, in the early stages; but this is succeeded by a white crescent of atrophy, its outer border toward the macula, its inner edge close to and often blending with the side of the disc, thus giving to this an oval form, so that it is only by careful inspection that its border can be defined. As the disease progresses the glaring white crescent extends in irregular outlines, perhaps varied by pigment masses in its area or along its edge, toward, and even so far as to include, the macula, while it also sometimes completely encircles the disc with a narrow band of atrophy. (See Plate at end of work.) When these changes are considerable, extensive though shallow excavation can be clearly seen with the ophthalmoscope. Floating opacities in the vitreous often indicate softening of its mass, and effusions in the region of the macula, and separation of the retina, are also not infrequent concomitants of posterior staphyloma. If, subsequently to this retinal separation, the crystalline becomes opaque, as is often the case, no operation for the removal of cataract could have a favorable result. But if the disorganizing process affects the ciliary body as well as the crystalline lens, so much irritation may ensue as to call for operative interference, by enervation or enucleation of the globe, to prevent sympathetic inflammation of the other eye.

Visual power may still be in good measure retained when the atrophy of the choroid is considerable, provided the region of the macula lutea is not involved; but it is often lessened in acuteness, from the stretching of the retina accompanying the elongation at the posterior half of the globe, which reduces, as it were, the number of percipient elements in a given space, and also because the atrophy of the pigment layer of the choroid and of its vessels affects the nutrition of the retina. Since the partial yielding of the tunics of the eye renders them thinner and less able to resist further change, it follows that staphyloma posticum is a most serious affection, on account of this disposition to progressive deterioration. That such a progressive change is going on is indicated by appearances of thinning beyond the outline of the crescent, instead of its having a well-defined border.

The preventive means which alone are of service will be indicated in the chapter on myopia.

CHAPTER IX.

GLAUCOMA.

THIS disease, which seems especially to affect the parts of the eye included within the uveal tract, is marked by a notable increase of intra-ocular pressure, which appears to form the first link in the chain of symptoms and the most characteristic early feature of the affection.

The cause of this initial condition is still a mooted point. Professor Donders regarded it as a result of irritation of the ciliary nerves which preside over the vascular supply and the secretion of vitreous, in consequence of which irritation the volume of vitreous became increased. Others believe it to depend on obstruction of the circulation in the ciliary body and obliteration of Schlemm's canal, by which the equilibrium of secretion and excretion in the eye is disturbed, and excretion impeded. If such be the case, how can we explain the complete remissions which often occur in the symptoms? Perhaps the theory of Professor Donders affords an explanation of both these conditions: the hypersecretion caused by neurosis, creating pressure upon the efferent vessels and displacing the lens and iris forward, thus developing the subsequent changes in the ciliary body and obliteration of the canal of Schlemm; which, in their turn, by hindering excretion, further augment the intra-ocular tension.

Efforts have been made to devise tonometers for determining the exact degree of tension of the eyeball; but these have not as yet equalled the accuracy of touch with the educated finger. In estimating this tension the lids should be closed, and pressure alternately made and relaxed on the centre of the globe with the forefinger, comparison being made, if desired, with the finger of the other hand on the opposite eye; or the forefinger of one hand may be placed upon the lid to steady the globe, while counter pressure is made at another point with the finger of the other hand, as in determining fluctuation. A little careful practice will give the *tactus eruditus*, so important in deciding questions of such delicacy.

Mr. Bowman, of London, has proposed a scale of tension, now everywhere adopted, as follows: —

T n, normal tension.

T 1 ?, tension perhaps increased?

T 1, tension increased.

T 2, tension much increased.

T 3, tension very much increased.

The plus sign (+) may be either prefixed or omitted in expressing augmented tension.

—T 1 ?, tension perhaps diminished?

—T 1, tension diminished.

—T 2, tension much lessened.

—T 3, tension very much reduced, so that the globe dimples under pressure of the finger.

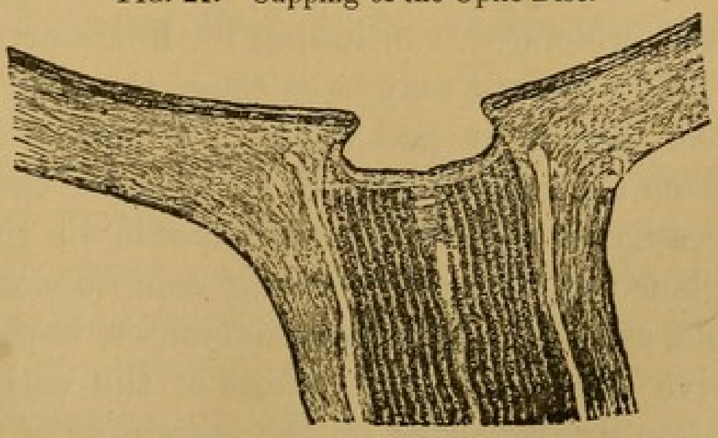
The minus sign (—) should always be used in designating reduced tension.

Glaucoma manifests itself in a variety of ways, as regards its obvious symptoms: sometimes with great suddenness and severity, sometimes without any phenomena which are sufficient to call attention to its existence until a late period of the disease. These dissimilar forms might almost be classed as distinct diseases, were it not for the presence in all of one pathological state, increased tension of the globe.

Glaucoma is rarely seen in its earlier stages, except where the other eye had previously been attacked, because of the absence of all active phenomena. Limitation of the field of vision at the periphery is not at first observed, on account of the good degree of central vision which is still retained; and it is only when central vision begins to fail that the patient comes for advice. The condition is then much as follows: The patient finds his way with difficulty, perhaps not at all in a strange place, though in some instances he may still be able to read if the book is held in a certain position. The field is limited, and he perceives objects held up before him (the other eye being covered) only when they are brought nearly in front of his eye. If seen at all when held laterally it is generally toward the outer side, while at the nasal side they are invisible. This peripheral loss of function has been explained by the greater fineness and more superficial distribution of the nerve fibres in the marginal portion of the retina, and perhaps by compression of the nerve fibres at the edge of the cupped disc. The anterior and exterior parts of the eye are often at this time nearly or quite free from abnormal appearances. The pupil is probably sluggish and perhaps somewhat dilated; the iris a little in advance of its usual plane, but appearing otherwise normal; the anterior chamber somewhat shallow. The T is moderately increased. The patient complains of a gradual loss of sight, greater on some days than others. Rainbow colors have perhaps been noticed as a halo around the lamp flame in the evening. There has been no pain in or about the eye.

On ophthalmoscopic examination, the transparent media are free from cloudiness, and ordinarily at only one point of the fundus, the optic disc, are morbid changes to be seen. But there the change is characteristic: the disc is cupped, or, as it were, excavated, instead of being nearly on a plane with the retina; the nerve fibres and the lamina cribrosa offering less resistance to the increased intra-ocular pressure than the surface of the firm fibrous sclera. As the retinal vessels reach the margin of the cupped disc they are suddenly bent from their course, and follow the line of its depression; sometimes wholly

FIG. 21. Cupping of the Optic Disc.



disappearing as they pass the sharp border of the excavation, to reappear at its bottom. Pulsation of the retinal arteries may be perceived, or may be excited by pressure with a finger upon the globe. There is marked congestion of the retinal veins. A narrow, yellowish-white ring may surround the disc, which at first view gives to it an apparent increase of size; the choroid having been somewhat crowded back from its attachment to the optic sheath, leaving the sclera exposed to view. The color of the disc is often grayish or greenish, and it sometimes has a glistening atrophied look. These appearances (see Plate at end of work) will be more or less marked according to the duration of the affection, and are readily distinguishable from the shallower depression accompanying atrophy of the optic nerve; where this is simply retracted, not crowded upon from within. If the convex object-glass of the ophthalmoscope, in examination of the inverted image, is slightly moved laterally, the glaucomatous excavation seems to have motion, the deeper part more than the edge. These phenomena must not be confounded with physiological excavation, where the vessels are not suddenly deviated at the margin of the papilla, but pass to some distance within its border, though not as far as usual toward the centre, before they turn backward to enter the optic nerve. Here there is no semblance of atrophy of the disc, but merely grayish spots in the slight funnel-shaped depression, marking the lamina cribrosa.

Central vision is at length affected, and objects are obscured for periods, which gradually become more frequent and prolonged, continuing for hours or days.

The patient may have some time previously observed that the glasses he had worn soon became insufficient, and have been obliged frequently to increase their power. This necessity is one of the prodromata in the different forms of glaucoma, the commencing compression of the ciliary muscle, as the ocular tension increases, impairing its accommodative function. Like others of the earlier symptoms, this is often not regarded by the patient as of any moment, and its having existed is only subsequently brought to light by inquiry.

In glaucoma simplex, the pathological processes are not only more gradual, but also less extreme, than in the acuter forms, the + T not attaining the stony hardness observed in some other cases. The disease may go on in this more sluggish way to complete blindness, or, after some time, there may be an outbreak of severe symptoms; the general rule being a slow deterioration of vision, unhindered by such operative measures as are so brilliantly successful in more violent acute attacks. If, however, the loss of sight has been rapid, and the tension is considerable, iridectomy may be justifiable, in the hope of preserving for the patient his actual amount of vision. But even this hope is seldom realized in these indolent forms of the affection, and the operation is, occasionally, immediately followed by a still further depreciation. The use of pilocarpine and eserine has been highly recommended by Laqueur and others, but further trial has not confirmed their seemingly favorable results. Atropia should be avoided, as, according to some authorities, it appears to increase intra-ocular tension to such a degree as even to induce an outbreak of glaucoma in an eye predisposed to the disease. The patient should be directed to avoid any fatiguing use of the eyes, anxieties of business, mental excitement or grief, and violent or long-continued exertion. Any indications relating to his general health should be attended to. Under such a regimen, the chances of retaining as much and as long-continued vision as possible are generally greater than by active operative interference.

ACUTE GLAUCOMA.

Premonitory symptoms are seldom wanting, but these usually pass unnoticed by the patient, although he remembers having had them, when questioned by his physician after the actual attack has supervened. But if one eye has already suffered, the patient is thenceforward on the *qui vive* as to any unusual phenomena in this or the other eye, and even slight symptoms attract his attention. Being generally past middle life, the patient perhaps observes that his glasses no longer give him the accustomed aid in reading, and if these are changed their insufficiency is soon again felt. Next, he has periods of dim vision, continuing for minutes, hours, or days; most frequently recurring at some part of the day, and especially toward evening. During these intervals, objects appear as if seen through a cloud or thick mist. At night, a lamp flame seems to be surrounded by an iridescent halo. These disturbances of vision are often followed by intermissions, with apparently perfect recovery of sight; but if the T is examined, it is, perhaps, even during this intermission, found to be a little more than the normal, though the ophthalmoscope may as yet detect no cupping of the disc or other morbid change. The field of vision may or may not be slightly contracted. Thus far no pain has been experienced.

These conditions, which may or may not be observed by patient or physician, continue a longer or shorter time; to be succeeded, often with great suddenness, by an invasion of violent symptoms. The hardness of the globe becomes greatly increased; agonizing pain is felt, extending to and along the circum-orbital branches of the fifth pair of nerves. Vision is at once nearly extinguished, or, if still partially retained, the field is concentrically narrowed. The cornea loses its lustre, and the transparent media may be so hazy that the fundus cannot be clearly seen, if at all, with the ophthalmoscope. The crystalline lens is crowded forward, causing dilatation and fixedness of the pupil and shallowness of the anterior chamber. The anterior ciliary vessels, in their course outside the sclera, are congested and tortuous. The sensibility of the cornea is lessened, and it may be touched with a probe or bit of paper almost without exciting consciousness. If the media remain so clear as to permit a view of the fundus, the retinal veins are seen to be enlarged, congested, and sinuous, and the arteries perhaps show pulsation, although the cupping of the disc may not yet have acquired any great depth. Sometimes spots of retinal or choroidal extravasation are visible; and, as also in some cases of the more chronic glaucoma simplex, scattered hæmorrhages may occur at a later period, though wanting in the early stages. When present, they make the prognosis as to the results of treatment more doubtful.

Nausea and bilious vomiting often accompany the intense pain about the eye and side of the head, and this complication constantly gives rise to sad mistakes in diagnosis. Those who have never before seen this somewhat rare disease are liable to be misled by the violence of the general symptoms, and to overlook the eye affection, which is their sole exciting cause, until it is too late for the relief which might have been given by the timely performance of iridectomy.

After continuing a longer or shorter time, these urgent symptoms may, in a few cases, temporarily subside before permanent loss of structure or function has resulted, though more or less cupping of the disc and limitation of the field of vision persists. An interval of remission ensues, to be followed by a renewed attack. More than one such suspension of the disease may exceptionally occur. Most commonly, there is no real abatement of severity; but if not arrested by treatment, the pathological sequences go on until the globe is quite disorganized. The cornea grows more and more insensitive, has a dull, irregular surface, as if steamed, and is sometimes ulcerated, or vesications form in its epithelial layer. The conjunctiva is more or less injected. The anterior chamber is nearly or quite obliterated, or occasionally is partly filled with extravasated blood. The crystalline lens becomes opaque, has often a sea-green color, which gave its Greek name to the disease, and is sometimes crowded so far forward that it lies in contact with the cornea. The pupil is widely expanded, only a narrow rim of discolored and atrophied iris being visible at the ciliary border. The anterior ciliary veins are varicose. The globe is of stony hardness. Perception of light is absolutely lost. Dull or even severe pain may still be felt, after the completion of these ultimate changes; or it may entirely cease, the eye habituating itself to its altered tension, or the sensitive capacity of the ciliary nerves being perhaps extinguished.

To this hopeless state we apply the term absolute glaucoma.

GLAUCOMA FULMINANS.

In some rare instances, acute glaucoma attacks its subject instantaneously, in the street, in a picture gallery, or elsewhere. Intense pain, followed by almost immediate loss of sight, comes without warning. All the characteristic symptoms, and even great pathological alterations, may be developed within a few hours. Fortunately, this violence of outbreak does not preclude relief by suitable treatment, provided this is promptly applied.

CAUSES AND TREATMENT OF GLAUCOMA.

Glaucoma is a disease of the middle and later periods of life, probably because the sclera has become more unyielding than in youth; and is more common in hyperopic eyes. Its directly exciting causes, except the very rare hereditary transmission, are not always discoverable, but a large number of cases occur after mental excitement coupled with fatigue; as, for example, after long anxiety and watching with sick friends, and grief at their loss. In men it may follow excessive business cares. A larger proportion of women than of men are attacked, generally at or after the critical period. It may declare itself as a complication in the course of other ocular diseases, rendering the prognosis less favorable, and sometimes requiring immediate operative treatment for the removal of a dislocated lens or other exciting cause.

The successful application of iridectomy by Von Graefe to the relief of previously incurable glaucoma was one of the greatest triumphs of modern surgery. Since his great discovery that extreme ocular tension could thus be put an end to, various attempts have been made to substitute other operative measures having the same object. The effect of the operation was empirically known, but its *modus operandi* was not scientifically explained, and it was hoped that the same result might be attained by other methods. Among those proposed, but now regarded as only partially or temporarily effective, were repeated evacuation of the aqueous by paracentesis corneæ, division of the ciliary muscle, drainage of the posterior hemisphere of the eye by the insertion of a loop of fine gold wire through the sclera, and, since the broaching of the theory that obstruction of the circulation in the anterior part of the uveal tract and Schlemm's canal might be the initial cause of glaucomatous tension, division of the sclera, near or including this canal (sclerotomy). The value of this last procedure is scarcely as yet determined; probably it may have some useful place, at least as a tentative operation in cases where, if found insufficient, iridectomy may be subsequently employed, or as a palliative, for the removal of secondary symptoms.

Where we have an urgent case of acute glaucoma, which admits of no delay, iridectomy is undoubtedly the expedient on which we can most certainly rely. It cannot be too forcibly insisted on that glaucoma is never relieved except by operation; and, moreover, that if this is to be a means of restoration it must, in most cases, be immediately done. It is difficult for a practitioner who has not before seen the disease and become informed as to its nature and prognosis, when he finds a person prostrated with agonizing pain and severe bilious vomiting, to believe, that a slight operation on an eye which is apparently little concerned in the symptoms will cause all these to disappear as if by magic; and to convince himself that if this operation is not promptly done no resources of our art can afterward restore the patient's sight. If, in such a case, he cannot take the responsibility of immediately performing iridectomy, which alone can arrest the disease, he should either ask the aid of a skillful confrère, or, after rendering the patient comfortable by anodynes, should at once send him to a competent adviser; without vainly waiting for any remission of the severe symptoms.

Delay in these circumstances is the death warrant for the eye.

That iridectomy may be completely successful, it must be done before the glaucoma has continued too long, or caused too great alterations of structure. Great differences are found in this respect. The insidious development and progress of chronic glaucoma, glaucoma simplex, extinguishes the retinal perceptive power with a slow and sure fatality, which, as has already been said, leaves little hope of relief from surgical or other aid. On the other hand, acute attacks may be intensely violent, but if at once abridged may leave behind no record of their existence. In other instances the acute disease may continue much longer, but cause less structural change than its apparent severity would lead us to expect; and an operation, delayed even for months after the beginning of the attack, may be followed by complete success. I once had a case of this nature so remarkable as to deserve mention. The acute glaucoma had continued for four months, with little mitigation, and when I first saw the patient, a middle-aged lady, at the end of this time, perception of light was lost, the eyes were extremely hard, and the prognosis most unfavorable. Iridectomy was advised for the relief of the still continuing pain; but the lady was told by her physician and myself that we could not promise restoration of vision, on account of the long duration of the symptoms and her complete blindness, though her sole possible hope lay in the operation. The only circumstance which gave any encouragement as to improvement of vision was the greater transparency of the media and less cupping of the disc than would have been expected from the + 3 tension. I was nearly as much surprised as her family physician, when he wrote to me the next day from the town to which she had returned after the iridectomy: "It seems to me a miracle; the lady has not had a moment's pain since the operation, and to-day can see every wrinkle in my forehead." This lady is still, after the lapse of more than twelve years, a living and seeing monument to Graefe's memory. Such an instance as this, though quite exceptional, justifies an operation where the conditions are less promising than could be wished; provided always that the evidences of actual disorganization are not conclusive against interference. But, as a rule, every day's postponement of the operation, in acute cases, increases the danger of failure, and recoveries are exceedingly rare after the attack has continued longer than two or three weeks. Even as many days' duration may be sufficient to destroy an eye, where the accession of the disease has been violent. No delay is therefore justifiable, after the diagnosis is clearly established. The features of glaucoma are generally so clearly marked, that, once recognized, the practitioner is usually able to point them out distinctly to the patient and friends, and to obtain their consent to the necessary operation; though, if not enlightened by such an explanation, the friends cannot believe the case so serious. If, unfortunately, the patient is not seen until the internal parts of the eye have become too completely disorganized to admit of a chance of restoration of vision, iridectomy may still be done for the relief of persistent pain; and if, in some cases of hæmorrhagic glaucoma, this operation should not accomplish the desired result, enervation of the globe should be performed. But when absolute glaucoma is established, with stony hardness and total disorganization of the eyes, but with no pain to warrant interference, iridectomy should be abstained from; as it is very difficult to bring away portions of the rotten iris, and it may excite inflammation, and even suppurative processes. Should pain persist in such disorganized eyes, enervation is to be preferred to enucleation of the globe, and is advisable, not only for promoting the present comfort of the patient, but as a security against possible sympathetic inflammation of the other eye.

In certain instances where the operation has been delayed in acute cases, but where there has been but a limited amount of apparent pathological change, an ultimately favorable result is obtained, but with a very slow recovery; six months sometimes elapsing before vision is reëstablished. It is best, in such conditions, not to make too sanguine promises to the patient as to the effect of iridectomy, as frequently only a moderate gain in sight, or an arrest of further impairment, or even merely relief from pain, is all which can be obtained or hoped for from our best efforts, in cases which undoubtedly might have been fully restored if seen earlier.

The physician has another most important duty to fulfill. Where one eye has been attacked, whether the issue is favorable or otherwise, there is probability, amounting nearly to certainty, that glaucoma will at some future time declare itself in the other eye. This may occur at various periods, from days to years, most frequently at the end of a few months. The friends, but, if possible, not the patient, should be informed of this danger; for, since grief and anxiety are strongly predisposing causes, the mere knowledge of a probable liability to it might induce an attack in the second eye. The physician should therefore speak cheerfully to his patient, as to the sufficiency of the remaining eye for all visual purposes, etc, but should find occasion to warn some one of the family or friends to be on the watch for any premonitory signs, which should be carefully explained to them, in order that they lose no time before applying for advice, so that aid may be given at once when it becomes necessary.

If an eye which has manifested signs of an incipient glaucoma is seen during a remission of acute symptoms, we can generally find evidence of the nature of the disease in a slight concentric limitation of the field of vision or loss of perception towards the nasal side, increased tension, and excavation of the disc. If this is the first eye attacked it may be expedient to postpone operating, but such a patient must be closely watched, in order that iridectomy may be instantly done when the disease makes its almost certain reappearance. If the person cannot be thus under observation and within easy reach of professional aid, immediate iridectomy should be advised, notwithstanding the absence of urgent symptoms at the time. When the other eye has previously suffered from a glaucomatous attack, the necessity of a prompt operation upon his second eye is usually recognized by the patient when proposed by the surgeon, after characteristic symptoms have declared themselves. Although the operation of iridectomy is described in another chapter, I again refer to it in this connection, on account of its extreme importance in glaucoma.

Ether should be administered to obtain anæsthesia, not so much on account of the pain of the operation, which is only momentary, but because the eye is then rendered passive. Advantages are thus gained; not only in making the incision of the cornea with less risk of wounding the capsule of the lens, — which in glaucoma is often pressed forward toward the cornea; and in being able to excise the required portion of iris without danger that some quick movement of the eye may tear it away to an extent which was not intended; but also in the greater security thus obtained against retinal or choroidal hæmorrhage, resulting from involuntary pressure of the recti muscles upon the globe during the operation while the intra-ocular pressure at the same time is suddenly diminished.

If the surgeon has no reliable assistant, the spring elevator must be used to open the lids, care being taken that it does not press upon the globe. The surgeon, standing behind the patient, may fix the eye with forceps with one hand, while with the other he makes the corneal incision with the bent triangular iridectomy knife, or with a Graefe's narrow cataract knife. The latter has some advantages where the anterior chamber has become very shallow and the lens much crowded forward. If the bent knife is used, its point is passed through the sclera, just beyond the corneal margin, until it enters the anterior chamber; it is then to be pushed onward, its point being kept close to the cornea, so as not to wound the lens, until the incision is sufficient. If this is done with steadiness there will be no escape of aqueous till the beginning of withdrawal of the knife. If the narrow cataract knife is employed, it is to be passed across from point to point of the scleral margin, as in linear extraction of cataract, so as to make a wound of the requisite size, the knife being kept close to the ciliary margin of cornea and iris. The gradual withdrawal of the knife is much insisted on by some, but its effect as to the suddenness of evacuation of the aqueous can only be most insignificant, while there is more danger of wounding the lens capsule, after the aqueous escapes, during slow withdrawal. There is, moreover, a certain advantage in the quick outflow, as the iris is often drawn out with the aqueous, and can be taken hold of with the forceps without introducing this into the eye.

Iridectomy in glaucoma should be made upward. The large artificial space added to the natural pupil is then in great part covered by the upper lid, and the resulting deformity is concealed, while at the same time the refractive conditions are better and the eye is less dazzled than when the operation is done elsewhere in the iris; the important function of the normal pupil in regulating the amount of light and preventing circles of dispersion on the retina being in a great measure preserved.

The incision being completed, the surgeon exchanges the knife and the fixation forceps for the fine curved iris forceps and straight scissors. Should fixation forceps still be needed to keep the globe in a favorable position, they should be confided to an assistant. The iris is then seized with the forceps, not far from its pupillary margin, drawn out at the wound, and the edge of the triangular flap divided, from its free toward its ciliary border, at one extremity of the wound, by a slight cut with the scissors; the forceps, with the retained iris, is then carried gently toward the opposite end of the incision, tearing the membrane from this part of its ciliary attachments, and the piece of iris is excised close to the eyeball by another stroke of the scissors. Usually the iris contracts, and no portion remains strangulated in the wound; but the operator should take care that this is the case, and that the incision is left free from inclusion of any bits of iris tissue.

In many cases the anterior chamber is at once filled with blood from the torn iris vessels. Much or all of this hæmorrhage may often be at once evacuated by gentle pressure on the outer lip of the wound with a curette or probe, but it is not necessary to insist on the complete removal of the effusion, since it will be quickly reabsorbed. A moderate iridectomy, if carried to the ciliary border, seems sufficient to insure success.

Instant relief from all or nearly all pain often follows the operation. The eyes need not be covered with a bandage, if the patient is tractable; otherwise a light bandage is to be applied; but the room should be darkened, the lids closed as if in sleep, and the eyes kept very quiet. Cold wet compresses may be applied for some hours. Compressive bandages should never be used after this or any other operation on the eye. The wound generally closes promptly, and the blood disappears from the anterior chamber in a few days, after which, in some cases, there is a perceptible improvement in vision; in other patients this gain is only gradual, and the full benefit of the operation is not obtained till much later. In a few instances firm cicatrization is not at once completed, perhaps because the abnormal intra-ocular pressure continues to some extent; and a bulging cystoid scar is formed, which consolidates only after a considerable time. A minute fistulous opening sometimes persists in the sclera after the epithelial conjunctival layer has healed, and this aperture occasionally allows of escape of the accumulated aqueous, which infiltrates between the conjunctiva and the sclera, causing slight chemosis, which disappears by absorption in a few days. Each time the anterior chamber is thus partially emptied there is a temporary lessening of visual power, from want of proper refraction. It is best not to close too soon such a minute fistula, as it may be a safety valve; but should it continue after the eye has evidently recovered, the aperture can be closed by exciting slight irritation of its walls by punctures with a cataract needle, so as to cause a formation of coagulable lymph in the fistulous passage.

An acquired hyperopia or increased presbyopia sometimes needs correction, after recovery, by stronger glasses than were worn previous to the operation. Tinted glasses are useful when the patient first exposes the eyes to much light. The cupped form of the disc continues, although the pressure which created it has been relieved.

Cases where the second eye is attacked soon after an operation on the first are to be regarded as coincidences, and not as consequences, except in so far as the mental agitation following the announcement of the gravity of the disease and the need of an immediate operation may have a causative influence. The outbreak often occurs with similar suddenness where no operation has been done. Certainly the iridectomy is not to be regarded as exercising an unfavorable influence on the other eye, but quite the contrary. Should such an invasion of glaucoma occur, the second eye must be at once operated on, if the indications are clear; and I have never seen other than good results from such a course, which, it is true, requires courage on the part of the surgeon.

If, after iridectomy, any disposition to a renewal of glaucomatous processes should ever appear, the use of myotics, pilocarpine and eserine, has been recommended as a means of lessening intra-ocular tension. Their value in this respect has not as yet been fully demonstrated. It is only very rarely that a second iridectomy has been found desirable. The application of atropia to the eye for purposes of diagnosis or treatment has been believed to sometimes excite a glaucomatous attack. Such an attack may have been a merely accidental coincidence; but it is prudent to dispense with atropia where any glaucomatous tendency is suspected.

Recently, Laqueur and others have advised the use of myotics as a preventive treatment in threatened or incipient glaucoma, as well as for the purpose of preventing relapses, but this affection is so variable and uncertain in its phases that it is difficult to form a judgment, except after long trial, as to the worth of such remedies. At present their value seems doubtful.

SCLEROTOMY.

Section of the sclera has been recently proposed, instead of the division of the ciliary muscle, which was at one time strenuously advocated as a substitute for iridectomy, for the relief of excessive intra-ocular tension. It seems to be conceded, however, that, though sclerotomy offers a fair chance of success, iridectomy is most to be relied on for a certain and permanent curative effect in glaucoma. Sclerotomy is perhaps sometimes useful for the relief of persistent pain in cases of absolute glaucoma where vision is hopelessly lost.

Myotics may be applied to the eye before the operation, to contract the pupil and keep the iris from falling in front of the knife during the incision. The patient being etherized, Graefe's narrow cataract knife, or a broader two-edged sclerotome, is passed through the sclera from the temporal side, at about one mm. from the corneal margin, and brought out at the opposite point, near the cornea, as if a flap of two mm. in height were to be formed. But instead of continuing the incision to complete formation of the flap, a narrow bridge of sclera is left uncut to prevent prolapse of the iris, and the knife is withdrawn. This incision may be made with more facility near the lower than near the upper margin of the cornea. The after-treatment consists of rest and cold applications, as in iridectomy.

Prolapsus iridis, at least to an extent to cause adhesions to the inner surface of the wound, is not infrequent after sclerotomy, and may impair its effect.

CHAPTER X.

AFFECTIONS OF THE RETINA.

ANATOMY OF THE RETINA AND OPTIC NERVE.

As the optic nerve emerges from its bony foramen at the back of the orbit, it is surrounded by three sheaths derived from the cerebral membranes.

The dural sheath, which forms the dense outer covering, is attached to the periosteum at the foramen, and at its anterior end it unites with the sclera and merges its fibres in that membrane.

The inner or pial sheath closely surrounds the nerve, and from it numerous bands of connective tissue pass in between the fibres of the optic nerve, separating them into distinct bundles.

Between these two enveloping membranes is the ill-defined arachnoidal sheath, more closely adherent to the dural membrane; and between it and the inner pial sheath is the large sub-arachnoidal space, through which fluid may pass directly from the cranial cavity to the sclera, and even to the neighborhood of the lamina cribrosa.

At from fifteen to twenty millimeters from the sclera the central artery of the retina, a branch of the ophthalmic artery, perforates the sheath of the optic nerve and runs forward in the middle of the nerve fibres, surrounded by a slight connective tissue net-work, to the inner surface of the eyeball, where it branches on the inner surface of the retina to furnish the blood supply of that delicate structure. Smaller branches are also given off to the optic nerve, and as the nerve passes through the opening in the choroid fine anastomoses are sometimes made with its blood-vessels.

The optic nerve fibres pass through the openings in the lamina cribrosa, at which point they lose their white medullary sheath, and go on as transparent axis cylinders to the level of the retina, over which they spread out in all directions to form its inner layer.

The entrance of the optic nerve is called the optic disc, and, as seen with the ophthalmoscope, is easily recognized as a circle of lighter color than the rest of the fundus. From it the vessels radiate in all directions, the main trunks passing out above and below, and, branching dichotomously, send their principal supply toward the macula region, although just in the macula no vessels are seen.

The retina extends from the entrance of the optic nerve to the ora serrata.

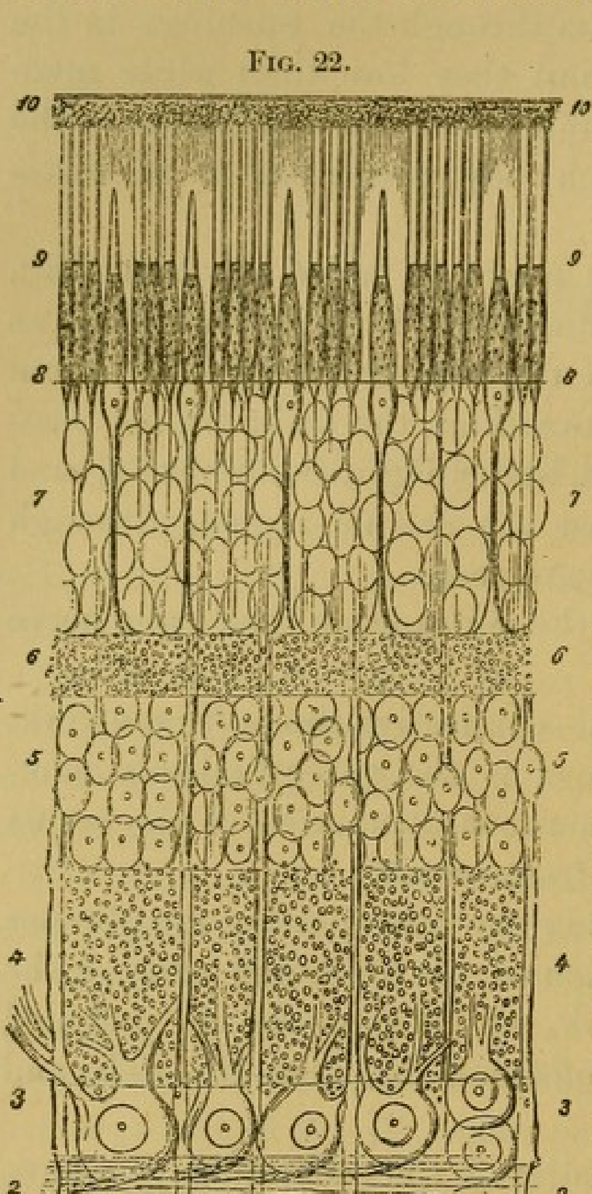
It is composed of a light connective tissue frame-work, which stretches from the inner to the outer limiting membrane, and of the delicate nervous structures of the retina which are supported by this frame-work.

It is still a question whether the two limiting membranes are not merely a condensation of the enlarged ends of the connective tissue frame-work, which supports the included layers and also sends fine offshoots between the rods and cones.

The anatomical characteristics of the different layers have been carefully studied. But their functions are not yet known. It appears, however, that the layer of rods and cones is the percipient layer of the retina from which the sensation of sight is carried to the nerve fibre layer, and thus to the optic nerve and brain.

The ends of the rods and cones are imbedded in the layer of pigment epithelium, made up of large hexagonal and densely pigmented cells, and from this layer is reproduced the visual purple which is found in the rods, and has the peculiar property of being bleached by strong light, so that by proper manipulation a photograph or optogramme of an object, such as a window with cross-bars, may be demonstrated on the retina even after its removal from the eye.

FIG. 22.



The retina has been divided into ten distinct layers, which, beginning at the vitreous, are as follows : —

1. Membrana limitans interna.
2. Optic nerve fibre layer.
3. Ganglion cell layer.
4. Inner granular layer.
5. Inner nuclear layer.
6. Outer granular layer.
7. Outer nuclear layer.
8. Membrana limitans externa.
9. Layer of rods and cones.
10. Pigment epithelium.

At the macula region, which comes just in the line of direct sight and sharpest vision, the layer of nerve fibres is lacking as a distinct stratum, and at the fovea centralis, which forms a small depression at the centre of the macula region, the rods are wanting and the inner layers of the retina become much thinner, so that the rays of light fall upon the enlarged cones after passing through less of the retinal substance than at other parts of the fundus.

HYPERÆMIA OF THE RETINA.

Arterial hyperæmia is recognized with the ophthalmoscope in evident congestion of the optic disc and larger vessels; and is attended by increased sensitiveness to light and sometimes by dull pain. In some very rare cases, after traumatic injury of one eye, it seems to show itself in the other as an early symptom of sympathetic irritation. Venous hyperæmia is easily distinguishable, being marked by increase in size and tortuousness and a deeper color of the veins. If resulting from heart disease or other disturbance of the general circulation, it slowly subsides, if the general conditions improve. Not seldom it is a mechanical symptom of obstruction of the circulation within the eye, as in glaucoma; or of pressure from behind upon the vessels by intra-cranial or intra-orbital effusions or growths, or of infiltration between the outer and inner sheath of the optic nerve, with choked disc and puffy infiltration and redness of the papilla.

When discovered its treatment must be adapted to the removal of the apparent exciting cause.

RETINAL APOPLEXY

occurs from pressure on vessels within the cranium, as from tumors, causing rupture of the retinal vessels; or results from obstruction to the circulation within the eye, as in some cases of glaucoma. The effusions are irregularly distributed over all parts, and may occupy different layers of the retina in the form of small clots varying in size and shades of color. The flame-shaped hæmorrhages along the course of the vessels, in the layer of nerve fibres, are usually associated with other diseases of the general system, as, for instance, Bright's disease, and will be elsewhere referred to. In these latter conditions the rupture, allowing the effusion, is due to degeneration of the walls of the vessels, or to morbid conditions of the blood, as in scurvy, purpura, malaria, and pernicious anæmia.

Considerable peripheral effusion may exist without much disturbance of vision; but the sight becomes greatly impaired if the region of the macula is involved, which, because of the delicacy of its vessels, is unfortunately too often the case. When the hæmorrhage happens in those layers which serve to convey rather than to receive impressions, the prognosis is more favorable than when the rods and cones have been displaced or compressed; more or less recovery of function being possible in the affected part after reabsorption of the effused blood. In septicæmia the round spots of effusion often occupy the deeper parts of the retina.

Copious extravasation may occur, especially in aged persons, where degeneration of the arterial coats has taken place in consequence of a sudden removal of pressure, in such operations as those for extraction of cataract. During, or soon after, the operation, the globe may be instantly filled with blood from rupture of a vessel, at once destroying all hope of vision. Fortunately, these cases are exceedingly rare; but, as there are no previous indications of any such tendency, the mishap cannot be guarded against by any precautions.

The appearance of retinal apoplexy in one eye, particularly where the person is disposed to vascular fullness, or is the subject of abnormal conditions of the circulatory system, such as hypertrophy of the left ventricle, should be considered as a warning, and excessive use of the eyes, violent exercise, long continued stooping, or excitements, must be scrupulously avoided.

In rare instances this condition, accompanied by greatly lessened vision, and by symptoms of cerebral congestion, may be observed, in one or both eyes of clergymen, or others devoted to literary and intellectual labors. Absolute rest from fatiguing brain work, tonics, with potassium bromide and iodide, with ergot, and, if possible, quiet traveling for at least a year, should be advised. I have seen these means accomplish complete recovery, even where useful vision had previously been nearly lost; but, in two patients, a return to exacting duties was followed, a few years later, by a partial renewal of the grave symptoms. These were again subdued, and have since been avoided by constant vigilance and self control in regard to both mental and physical exertion.

EMBOLISM OF THE CENTRAL ARTERY OF THE RETINA.

In many cases of slow loss of vision from gradual formation of cataract in one eye, the patient does not discover the defect until he covers the other. Embolism, on the contrary, is marked by consciousness of an instantaneous loss of sight. No pain is felt, and often the person is not apparently the subject of any disease; though in other instances aneurism or some heart affection exists. The embolus generally obstructs the artery at its passage through the lamina cribrosa, and thus affects both its superior and inferior branches; but cases have been seen where only one branch has been plugged, at some point beyond the optic disc. Ophthalmoscopic examination shows abnormal paleness and haziness of outline of the optic disc, and a nearly empty condition of the arteries; while the veins, though also reduced in calibre, may be partly filled. The central part of the retina soon presents a broad halo of white exudation, densest about the macula and thinning toward the periphery. The macula itself appears as a bright red spot or circle in the centre of this white field; the infiltration occupying layers of the retina which do not extend over the macula lutea, and the color of the choroid, at the macula, being strongly contrasted with the surrounding changes. After a time the disc assumes the appearance of atrophy, and the vessels are obliterated, and only distinguishable as white threads. A gradual absorption of the infiltration and the establishment of a slight collateral circulation may take place, but so far as a restoration of vision is concerned the prognosis is absolutely unfavorable. Zehender has proposed the causing a sudden change of intra-ocular tension, by paracentesis or iridectomy, in the hope that the arterial clot might thus be displaced. Such a procedure would certainly be justifiable, but it could scarcely be expected to avail, if at all, unless done very soon — within a few hours at most — after the obstruction had occurred.

The same author mentions rupture of the arteria centralis within the optic nerve, marked by a similar collapse of the arterial branches, but without congestion of the veins.

HYPERÆSTHESIA OF THE RETINA.

This affection, which occurs mostly in young and delicate subjects, is marked by photophobia with accompanying ciliary neuralgia, by persistence of retinal impressions, and by the seeing of luminous spots of different colors. The ophthalmoscope discloses no changes of structure or of circulation, and vision is unimpaired, though the act of accommodation may be painful.

Tonics, and perhaps change of air, with the wearing of blue or neutral glasses, and avoidance of intense glare of light from snow or from the water, together with little use of the eyes, are often effectual; but in a few severe cases seclusion from light for a few days, and of course rest of the eyes during this period, have seemed to be necessary. Subsequently, the eyes should be only carefully used for some time, that a relapse may not be excited.

HYSTERICAL HYPERÆSTHESIA.

In young or middle-aged women, with or without menstrual difficulties, we now and then meet with cases of apparently intense photophobia, which has caused the patient to keep herself in nearly total darkness, perhaps for a long time. When seen at home, the room is entirely dark; if the patient comes for advice, all light is carefully excluded by thick dark screens and bandages, and she protests that she cannot bear a ray of light without torture, or any examination of her eyes. One lady whom I saw had remained in this condition for six years, going out of her darkened room only at night; and in several other cases the symptoms had continued for many months. With persuasion, such patients can be induced to allow of an inspection of the eyes by a very faint light, when these are found to show no abnormal appearance other than a sluggish action of the pupils, and a vacant, lifeless expression, which is not easy to describe, but is readily recognized as characteristic, after having been observed a few times. At the first visit it is best to content one's self with this partial inspection, telling the patient that remedies will be given which will in a few days enable her to bear more light and a more thorough examination. These should be of a mild nature. A teaspoonful of tinct. saponis et opii, or spirit. rosmarini, put into a wineglassful of boiling water, may be held near her open eyes in the dark room, so that the vapor may enter them for one, two, or three minutes, morning and evening. A ten-grain solution of borax in camphor water may be used as a collyrium, three times a day. The patient should also be advised to bear a little more light, for a short time at least, each day. At the next examination more light may be admitted, with the assurance that, though it may be painful for the moment, it will do no harm. Very soon, perhaps even in three or four days, an ophthalmoscopic examination, with but a dim light, can be obtained; and the physician, finding nothing wrong in the interior of the eyes, may then confidently assure the patient of complete and probably speedy relief. This positiveness of cheerful prognosis is an important element in the treatment. Increased exposure to light should now be directed, as an aid to recovery, but it need not be too suddenly enforced. Other mild means, as unirritating collyria or aromatic vapors, may be substituted for those first ordered, if thought advisable. The patient should have cheerful surroundings, if possible, change of scene being sometimes expedient after convalescence is established, to gain release from annoyances, if such should be discovered to exist at home. Good diet and tonics are valuable auxiliaries. I have never failed thus to speedily obtain the promised good result; even the worst cases having been enabled, within three or four weeks, to walk in full sunlight, without protection for the eyes. It is important to gain the full confidence of the patient, and it is generally best that the case should continue under supervision at least till the more urgent symptoms are removed. I have seen but two examples of this affection in men, both of which were severe cases; and I recall to mind only two instances of temporary relapse, one of them a male subject.

Another form of hysterical hyperæsthesia is occasionally seen in women, who complain of the persistence of images upon the retina, and great discomfort from light, though they have no positive photophobia. Though their eyes show no structural or refractive defects, they are unable to apply them much to fine work. Tonics, cheerful occupation, tinted glasses in a strong light, and moderate use of the eyes, are serviceable.

RETINITIS.

Several rare pathological conditions of the retina are worthy of mention, though they should rather be regarded as phases, stages, or complications of other disease. Serous retinitis, or œdema of the retina, is seldom found, unless as a temporary result of embolism of the arteria centralis, except as a precursor of separation, or as a symptom in syphilitic retinitis. It appears as a grayish infiltration around the optic disc, perhaps rendering its edges ill defined, and extending along the vessels. The veins are congested, and partially hidden by the effusion. No pain is complained of, the only symptom recognized by the patient being a degree of dimness of sight, which is greater on a bright day, probably because a bright light causes contraction of the pupil, and prevents a sufficient number of rays from falling upon the retina to form a clear image, where its perceptive power has thus become lessened. The prognosis is uncertain: if uncomplicated, the condition may be removed by absorption, with little or no alteration of visual power; but, as already said, the œdema is in most cases a secondary symptom rather than the essential morbid alteration, and is frequently but the forerunner of other changes.

Inflammation of the parenchyma of the retina most frequently affects the connective tissue and optic nerve fibres, and is marked by points and striæ of opacity and small hæmorrhagic effusions. Sometimes it seems limited to the vessels, the coats of which are thickened. In many cases the choroid is also, and possibly primarily, the seat of inflammation. As the acute symptoms subside, sclerosis of portions of the retina remains, showing itself in the form of whitish lines, with permanent impairment of sight. The white striæ radiating from the disc, which are sometimes seen as a congenital extension of the fibres of the optic nerve sheath into the retina, should not be mistaken for this sclerosis. If the vitreous participates in the morbid inflammatory processes fibrous opacities become visible there.

NEPHRITIC RETINITIS.

Among the benefits conferred by the ophthalmoscope, by no means the least in importance is the disclosure it has made of the relations which exist between certain striking alterations in the retina and chronic structural disease of the kidney. Cases of albuminuria do not invariably manifest these changes, but, on the other hand, they are often discovered in the eye, and determine the diagnosis of Bright's disease, before the patient or his physician had been aware of any other derangement of the health than the dimness of sight of which complaint began to be made. These changes are most frequently seen accompanying the granular form of kidney disease. The ophthalmoscopic appearances present one of two principal forms. The most common consists in a yellowish-white exudation in and around the swollen optic papilla, which soon appears merged in it. This extends irregularly, with a somewhat fringed border, beyond which portions of the retina sometimes have a faint white cloudiness from œdematous infiltration. The retinal veins are much enlarged, and more or less concealed, here and there in their course, in the surrounding infiltration. White spots, indicating a commencement of fatty degeneration, are frequently observed just beyond the margin of the principal extension of the deposit, and similar white dots are often grouped about the macula in concentric rings. Now and then these latter appear around the macula before characteristic changes form about the disc, and when thus seen they afford good reason for suspecting the presence of Bright's disease, and suggest further inquiry and an examination of the urine. Flame-like patches of hæmorrhage from the degenerated vessels are often distributed over the space occupied by the whitish or straw-colored deposits. They take this form on account of their position in the nerve fibre layer, and sometimes their point of origin from the vessel can be seen. (See Plate at end of work.)

Another less common change at the fundus of the eye is a great obscurity of outline of the disc and dilatation of the retinal veins, which are hidden from view at some parts by the exudation which overlies them. With this evident neuritis we have numerous small ecchymoses, but without much yellowish or white transformation of the retinal tissues. These appearances are less strikingly characteristic, but bear a certain resemblance to the changes seen in retinitis apoplecptica, or to the scattered hæmorrhages caused by pressure of an intra-cranial growth upon the opticus. Repeated testing of the urine is necessary to confirm or disprove the renal origin of the alterations disclosed by the ophthalmoscope, as otherwise it is sometimes difficult to distinguish this latter form from the neuritis due to intra-cranial disease.

The degree of amblyopia, or dimness of sight, does not always correspond with the visible changes in the retina, different layers of this membrane being affected in different cases. It is not uncommon, even, to have great temporary improvement of visual power, the patient becoming again able to read, etc., though the case may be still advancing toward a fatal termination. This gain in sight may be accompanied by material modifications of the changes previously revealed by the ophthalmoscope, the morbid deposits being partially absorbed during the period of remission. This may extend from a few days to many months, during which, perhaps, the general as well as the ocular symptoms are so far improved that fallacious hopes of recovery are raised. Now and then nearly total loss of sight temporarily occurs, apparently from uræmic poisoning.

The hæmorrhagic spots differ from those produced in the choroid from intra-ocular pressure; being splashed or streaked, as if applied with a brush, rather than rounded. Though not absolutely peculiar to this disease, yet in connection with the associated changes they are characteristic. They may be attributed to obstruction and degeneration of the walls of the vessels as the infiltrated retinal layers undergo fatty change, which causes them to give way under the increased action of the hypertrophied heart.

It is prudent to test the urine before giving an opinion, and this is usually found to be albuminous and often contains casts, though these may not be found at every examination.

Albuminuric retinitis may appear at other periods of life, but is most common at middle age. Men are more subject to this disease than women, and it often attacks those in good circumstances, but whose mental energies have been overtaxed by exacting business cares. Poverty and exposure are also regarded as frequent exciting causes.

The degree in which vision is affected varies greatly in different cases and at different stages of the disease, though there is sometimes no corresponding variation in the ophthalmoscopic appearances or the general symptoms. Some persons, as I have said, had not considered themselves ill, although the ophthalmoscopic examination reveals extensive characteristic changes in the retina; and they come for advice only because of dim vision. Others complain of nausea and vomiting, or headache, when first seen. These general symptoms persist, or subside for a time, to be finally succeeded in the later stages by convulsions, coma, severe pain, and other cerebral precursory signs of approaching death.

Local treatment, by blood-letting or otherwise, is ineffectual. Ferruginous tonics, diaphoretics, and milk diet are recommended. But permanent improvement is seldom to be looked for, though encouraging and prolonged remissions are occasionally seen, under various plans of treatment.

The sudden or gradual, and sometimes almost total, loss of sight, associated with albuminous urine, occurring during or after pregnancy, or after scarlatina, is generally a merely temporary suspension of functional power, without structural changes in the retina. Recovery from this condition may be immediate after parturition, or more slow, but the prognosis is usually favorable, the albumen also disappearing as vision improves. In a small proportion of cases more or less permanent diminution of sight results, generally unexplained by any obvious lesion of structure.

LEUCOCYTHÆMIC RETINITIS.

This condition, marked by paleness of color in the retinal vessels and pale yellow appearance of the fundus, has been described by Liebreich and others, but is very rarely seen. The veins are said to look broader than normal. It depends on the peculiar constitution of the blood, and requires general remedies.

SYPHILITIC RETINITIS.

The retina becomes occasionally affected in constitutional syphilis, though less often than the iris. Viewed with the ophthalmoscope, the outline of the disc is hazy, and the fundus shows a diffused grayish cloudiness, from serous infiltration, as if obscured by smoke. Here and there, principally as radiations from near the border of the papilla, marked striæ are perceptible, having fine terminations like the flashes of an aurora borealis. These may be accompanied by faint diffused hæmorrhages, but the congestion of the circulation is less marked and the contours of the vessels less veiled than in albuminuric retinitis. The conditions, so to speak, are of a more passive nature than in most other retinal affections. Occasionally, congested spots or effusions are seen in the macula lutea.

Syphilitic retinitis may be uncomplicated, but is often accompanied by choroiditis or irido-choroiditis, with the marked changes which result from these. Rarely, also, some degree of retinitis may coexist with syphilitic iritis.

Vision is often much impaired during this affection, but, if uncomplicated, the prospect of recovery is good; the structural changes being comparatively slight in a large proportion of cases. The sight, however, improves but slowly. Where grave lesions are present, vision is not perfectly regained; atrophy of the retinal tissues and optic disc ensuing, as a frequent sequel, after the absorption of the morbid effusions. Relapses now and then occur. Mild internal alterative treatment, by potassium iodide, with perhaps mercurial inunctions, are useful. Blue glasses should be worn during the active period, if the eyes are exposed to strong light.

RETINITIS PIGMENTOSA.

As observed with the ophthalmoscope, this chronic and progressive affection has two marked distinctive features: a peculiar infiltration of pigment in the retina, often following the course of the blood-vessels in the form of irregular branching sprays, which have much resemblance in shape to bone-corpuscles as seen under the microscope; and a subsequent special form of atrophy of the optic disc and the retinal vessels. These pigment spots or sprays are most numerous at the periphery of the fundus, and are seen there if this part of the retina is carefully explored, before they are to be found elsewhere. They gradually increase in number, and are developed more centrally, being situated by preference along the course of the retinal vessels, and being usually more abundant at the nasal than at the temporal side. As the disease advances, and the connective tissue of the retina becomes hypertrophied, the coats of the vessels are thickened, their calibre is lessened, the finer branches being even obliterated. This cutting off of the blood supply from the equatorial parts of the retina involves a gradual lessening of perceptive capacity at the periphery and a narrowing of the visual field.

No pain is felt, and attention is first called to this affection by the defective vision which is manifest whenever the light is dim, as at twilight, sometimes increasing at a later period to almost total blindness in the evening. The field of sight grows more and more contracted, until, as in glaucoma, the patient cannot see to find his way, although he may still be able to read when the book is held at a certain spot, the region of the macula lutea retaining for a while its perceptive power. Those much affected often have nystagmus, a half involuntary oscillation of the eyes so as to turn the optic axis into positions for seeing objects. Children frequently see so well for reading that those about them cannot understand why they are constantly stumbling over objects which are not directly in their line of vision, especially at night; until at last it is found that this is not from mere carelessness, and their condition, which grows gradually more and more helpless and hopeless, is recognized.

The disease is congenital, sometimes hereditary, perhaps affecting several children in one family, making its appearance in these as they reach nearly the same age. In about half the cases, the disease has seemed to be the result of consanguineous marriages. Considerable difficulty in seeing may be experienced as early as ten years of age, or the first urgent symptoms may appear in youth, or much later. Very exceptionally, the affection may only manifest itself, as I have recently seen, in a person seventy years of age, who is just now beginning to complain of dimness of vision in the evening, and has marked limitation of his visual field, the ophthalmoscope showing at the same time evident changes in the optic nerve and the retinal vessels, with pigmentary spots in the lateral equatorial regions. Generally, the affection, developing itself slightly in childhood or youth, goes on with more or less regularity and rapidity until it implicates the region of the macula, and results in total blindness at a time rarely later than fifty years of age. Though the pigmentary infiltration above described is an almost invariable feature of the disease we are considering, cases are now and then met with where the characteristic conditions of this form of atrophy of the retina and optic disc, with the gradual limitation of the visual field and progressive blindness, declare themselves, without the appearance of stellated pigment spots at any part of the fundus.

Complications with choroiditis, opacities of the vitreous, separation of the retina, or with the syphilitic dyscrasia have been observed ; but these seem to be coincident, rather than to have any direct relation to this singular affection.

Care in using the eyes, avoidance of such active exertion as might tend to congest the cerebral or ocular circulation, prudence as to exposure to strong light, good diet, and attention to the health may have a conservative influence ; but no therapeutic means have hitherto been found of any service in arresting this malady.

SEPARATION OF THE RETINA.

The retina may be separated from its choroidal connections, by disease or by injury. Of the former causes, myopia is the most frequent. Separation is, unfortunately, exceedingly common as one of the series of changes which attend progressive near-sightedness, and forms one of the gravest of the insidious dangers of this, as was formerly supposed, harmless affection. The retina seems to yield to only a certain degree, along with the sclera and choroid, during the formation of posterior staphyloma ; but at last, the limit of its extensibility being reached, or becoming affected by changes in the underlying choroid, it is more or less suddenly detached, instead of continuing to follow the ectasia of the other membranes.

Separation may happen as a result of hæmorrhage, or purulent formations, or serous effusions, from either the choroid or retina, where these have been congested or diseased, especially if these accidents occur at the posterior part of the globe ; or, also, in consequence of the development of a cysticercus or intra-ocular growth between the retina and choroid. It may also be produced by traction upon the retina, where considerable alterations have taken place in the vitreous.

Separation from traumatic agency may result from penetrating wounds of the sclera, from mere contusion or concussion of the eyeball without actual wound, or from the contraction of cicatrices following wounds, or cataract operations, involving the ciliary region.

When caused by injury, or by intra-ocular tumor, the separation is likely to occur near the affected part. When it takes place, as it were, spontaneously, as a result of more slowly effective causes, the separation, for some unknown reason, generally begins at the upper part of the fundus, where it is first to be detected. From this position, the serum forming the sub-retinal effusion generally soon infiltrates toward the lower portion of the globe.

Slight effusion may form beneath the retina in many circumstances of disease, and be reabsorbed without causing actual separation. When more considerable, it appears, on ophthalmoscopic inspection, as a thin grayish film slightly raising the retina. As this increases and positive separation begins, the surface is thrown into pearly folds, showing varied light and shade, over which the retinal vessels, much darker than usual on account of the sluggishness of the blood current, take their course, which is evidently nearer the eye of the observer than their normal position. This change is delineated in one of the plates at the end of the work. At a more advanced stage, the vitreous having become disorganized and fluid, these retinal folds float and roll, in wavy movements, with every motion of the eye. More or less of the fundus may still have nearly its normal aspect; the vessels can be traced from the healthy part of the retina to where they bend upon the separated portion, marking the outline of the displacement, and the optic disc may perhaps be still little, if at all, changed from its previous condition. Where constant movements of the underlying fluid gradually peel and lift the membrane more and more extensively from the choroid, the separation becomes complete. The retina then remains attached only at the optic nerve entrance and at the ora serrata, and forms a tunnel-shaped, movable veil, which divides the fluidified relics of the vitreous from the sub-retinal effusion. Where the cornea and crystalline lens are transparent, these appearances can be clearly seen, when the separation is very extensive, even without the aid of the ophthalmoscope, by using oblique illumination. The disturbing action of the completely displaced retina not seldom ultimately affects the nutrition of the lens, causing cataract, and thus preventing further inspection of the deeper parts. It may even excite irritation of the ciliary body, threatening, and at last causing, sympathethic inflammation of the other eye, unless this consequence is averted by operative interference in the form of optico-ciliary neurotomy or of enucleation.

Partial separation does not usually alter the tension of the globe; in total displacement tension is lessened; where it occurs as a concomitant of intra-ocular tumor, tension is increased. Where the separating fluid has transferred itself by infiltration from the upper to the lower half of the retina, the first detached portion may remain separated; or, if the displacement has not been too long continued, this part of the retina may resume nearly its original position, and possibly regain some degree of functional ability; or, though returned to its place, it may still remain opaque, and may be again disjoined by any increase of effusion.

Vision is lost over at least so much of the field as corresponds to the extent of the separation. Objects below the eye are still seen when the effusion has occurred at the lower part of the retina, things above the eye when it occupies the upper section. If a very slightly detached and folded portion still retains some perceptive power, things may appear metamorphosed, wavy, and distorted, on account of the oblique positions of the rods and cones in the part of the retina which is displaced. When entire separation has taken place total blindness follows, not even quantitative perception of light remaining.

None other than recent displacements afford even a slight hope of recovery of function. In a few instances absolute repose upon the back for several days directly subsequent to the separation has resulted in improvement in the position of the retina and in visual power. But relapse has nearly invariably followed a return to active life. Spontaneous rupture of the displaced fold having also been succeeded by some amelioration, Graefe and others advised laceration of the separated retina, to allow the retained fluid to escape into the vitreous space. The sclera was punctured with a broad needle, and the displaced membrane divided. In other methods the sub-retinal fluid was drawn off by tapping the sclera and choroid, or drainage was established by means of a fine gold wire inserted through these investing membranes. Though some few cases have shown a gain in vision, of very brief duration, the results of any of these operative methods have not been so good as to warrant their general adoption, especially when it is considered that, to be of any possible service, they must be resorted to in the very outset, before the separation has extended far or continued long. But in these circumstances the person often still enjoys a good degree of sight; and if, after the operative procedure, vision still diminishes, as is probable, or is rendered immediately worse, it is difficult to convince the patient that the cause of his misfortune is to be found in the progress of the original disease, and not in the operation.

The physician can render a great service to a person who is affected with separation of the retina in one eye by advising him as to the best means of preserving the other, through avoidance of possible exciting causes of displacement. Where the retinal detachment has been induced by injury, we need not expect any similar change in the opposite eye. But when it has resulted from some pathological process at the fundus of one eye, the separation must be regarded as a warning; inasmuch as the symmetrical construction of the two eyes often predisposes them to similar affections. This warning should especially be heeded by very near-sighted individuals in whom the opposite eye is already affected with large posterior staphyloma. Such persons must be constantly careful to avoid over-use of the remaining eye, continued stooping, or violent exercise, as some slight imprudence in these respects might lead to total blindness. Prevention is our only hope, remedies, as has been shown, affording little chance of success.

SUN-BLINDING AND SUNSTROKE.

Looking directly at the sun, or observing an eclipse through insufficiently smoked glass, is sometimes followed by immediate loss of central vision, probably from the effect of the heat rays upon the macula lutea. The prognosis is unpromising.

Insolation of the head may cause partial amaurosis; the prognosis depending on the degree in which the central nervous organs are affected, and recovery being slow.

RETINAL TUMORS.

At some stages of their growth intra-ocular tumors may easily be mistaken for separation of the retina. In fact, this often coexists as a result of their development, and renders the diagnosis yet more difficult. The morbid growth may usually be distinguished as being more regular in outline, and having a greater and brighter tinted vascularity; and if separation is present, this may be traced beyond the limits of the tumor by its looser aspect and the darker vessels which run over it. The greater hardness of an eyeball inclosing an enlarging tumor is also diagnostic.

Glioma, or, as it was formerly termed, encephaloid, is the only morbid growth which has its origin in the retina. It is emphatically a disease of early life, infants and very young children being its subjects. As one eye continues good, and there is at first no pain, the child, even if old enough to talk, makes no complaint, being unconscious of the loss of sight. Attention is probably first called to the disease by the parents noticing a bright appearance behind the pupil, which by this time is often dilated and sluggish. This glistening reflex from the tumor gave to the disease its ancient name of "cat's eye." The ophthalmoscope shows a yellowish-white, highly vascular mass, which may be rounded or lobulated in surface. This extends slowly, not only forward, crowding upon and finally bursting the anterior parts of the eye, but also along the optic nerve and to the orbital tissues. The intra-ocular tension is increased as the disease advances.

Enucleation of the eye, at the earliest moment, cutting the nerve as far back as possible, is the only proper treatment, and the only chance for the child's life. Should the disease be found to have advanced beyond the globe, every particle of suspected tissue should be carefully removed from the orbit. Where the operation is delayed, the malignant growth may extend along the nerve to within the cranial cavity, and recurrence of the disease is speedy. Even when detected and removed at a very early period there is a strong tendency to reproduction; but though this were certain, and fatal consequences quite inevitable, the removal of the cancerous growth is still advisable in these days when anæsthesia annuls the pain of operations, as it spares the child the great suffering attending distention and rupture of the eye and the subsequent growth of the tumor in and beyond the orbit, which may attain enormous dimensions before the exhausted little patient is relieved by death. If relapse occurs it is often in parts which are less intensely painful, or where the termination is not so long delayed.

NORMAL OPHTHALMOSCOPIC APPEARANCES OF THE OPTIC DISC.

A brief description of the normal appearances and variations of the optic disc, which is the termination of the optic nerve, should find place here; not only on account of the important pathological changes of which the disc is so often the seat, but because of the conspicuous part it plays in ophthalmoscopic examinations, as a starting-point from which the exploration may most advantageously begin. As a rule, the disc appears nearly circular; it may have a somewhat oval form; and, though actually round, it may appear oval in cases of astigmatism. When an eye is hyperopic the disc seems relatively larger, and when myopic it looks smaller, than the normal size. By always employing the same object-glass we are able to judge of these differences. Its color is a slightly pinkish-white; sometimes, and especially in what is termed physiological excavation, caused by a beginning of separation of the nerve fibres before they have reached the level of the retina, it is slightly bluish-gray at the centre. The pink tint is often more marked at the nasal side. In persons of dark complexion, and in negroes, the disc appears whiter, by contrast with the darkly pigmented choroid which surrounds it. The border of the disc is made by the edges of the sclera and choroid, through which the nerve fibres pass in reaching the retina; and the margins of these may sometimes be distinguished, even in health, the inner white ring being formed by the sclera, and the outer darker circle by the choroid. A deposit of pigment is rarely seen as a black crescent at the temporal side of the choroidal margin of the disc. The retinal artery emerges from the optic nerve rather to the nasal side of its centre, and has a superior and an inferior offshoot, which again subdivide at or near the margin of the disc, and, branching dichotomously, spread over the fundus oculi. These have a bright color, and show a still clearer line along the centre of the vessel. The veins correspond in direction, and are darker, larger, and often more sinuous. The appearance of the normal disc is well shown in the Plate affixed to this work, copied, as are some of the other plates, from Jaeger's Atlas. When physiological excavation exists, the retinal vessels, instead of continuing their course to near the centre of the disc, bend backward at a short distance within the margin, where the central part of the disc is depressed in funnel shape below the ordinary level. The lamina cribrosa is more visible than usual, appearing as a group of grayish dots where the nerve fibres traverse it. This deviation from the usual aspect is interesting, because where the depression occupies nearly the whole size of the disc it might possibly be regarded as an effect of atrophy, or as a cupping of the disc from glaucomatous intra-pressure.

CHAPTER XI.

AFFECTIONS OF THE OPTIC NERVE.

NEURITIS.

THE changes which can be seen with the ophthalmoscope, in cases of inflammation of the terminal end of the optic nerve and of the surrounding retina, range from a simple hyperæmia of the disc to the most intense congestion, with infiltration, hæmorrhage, and marked pathological changes.

The student should remember, however, that notable diversities of color may exist in the disc in different eyes, or at certain parts of the disc, without denoting any abnormal condition. Much practice with the ophthalmoscope upon healthy eyes is needed to familiarize the observer with these variations, so that they shall not be mistaken for morbid changes.

In the hyperæmic stage the disc has a deeper rosy color, corresponding very nearly with that of the surrounding parts of the fundus. The disc outline is indistinct, and, as has been termed, woolly. The veins are oftentimes enlarged and tortuous as compared with the arteries. Vision is sometimes only very slightly affected. The sensibility to light is rather lessened than increased. These appearances may be present in some cases of deranged menstruation or of heart disease, in acute mania, or after a severe blow upon the eye; but may disappear without leaving any trace of structural alteration or impairment of function. Potassium bromide, lupulin, ergot, and such other remedies as are indicated by conditions of the system are useful.

If the congestion continues and increases, a slight, or it may be a severe, inflammation develops in the nerve, denoted by greater haziness of outline and a steeply marked prominence of the disc, from swelling of the nerve fibres and exudation. As the turgid retinal vessels pass over its border, they are seen to bend forward, and they are often obscured here and there in their course by the effused lymph. The color of the swollen disc is grayish or woolly white, and striated hæmorrhages are visible on the papilla and the neighboring parts of the retina, to which the morbid appearances extend, or may even be observed at other parts of the fundus. Occasionally, small white spots, resembling those seen in albuminuric retinitis, are perceived near the disc or the macula. These changes are represented in the Plate at the end of the work, copied, with some others illustrating retinal disease, from Liebreich's superb Atlas.

These phenomena have been supposed to be caused, in some cases, by compression of the nerve by fluid descending from the arachnoidal along the sub-vaginal space between the nerve and its outer sheath, so that the optic nerve is strangled where it passes through the lamina cribrosa and the scleral ring; this strangulation increasing the turgescence of the retinal veins, and thus augmenting the constriction, giving rise to the condition termed choked disc, "stauungs papilla." But a more satisfactory explanation of neuritis is the probable actual extension of inflammatory processes from the brain or its meninges along the nerve, or pressure within the orbit, causing infiltration and œdema at the terminal extremity.

Tumor of the brain and inflammation of the meninges are the most frequent causes of optic neuritis. It may follow suppression of the menses or anæmia, or occur after some febrile diseases or lead poisoning, or in connection with albuminuria, or with syphilis.

If kept under observation, it will be seen that after some weeks, in cases where the grave nature of the original cause does not forbid any amelioration, the tumefaction of the disc begins to subside, the hæmorrhagic and other effusions are reabsorbed, the vessels gradually resume their normal calibre, and the border of the disc is again visible. If the inflammation has been too severe or protracted, the disc may take on the appearances of white atrophy, and the vessels never regain their normal size, the inflammatory products thrown out into the nerve becoming organized as connective tissue, thus compressing the nerve fibres and impairing their function. This affection may result from disease within the orbit, in which case it is monocular. If arising from hydrocephalus, tubercular meningitis, intra-cranial tumors, or other causes of pressure, it almost always involves both eyes. In one instance I was able to make the diagnosis of tumor within the cranium as being situated between the left eye and the optic chiasma, and implicating this eye only; which opinion was verified at the *post mortem*, a few weeks later, the morbid growth, as large as half the thumb, having rested upon, and at last made its way through, the roof of the orbit.

When the stauungs papilla is caused by an intra-cranial enlargement or growth, pain and other evidences of cerebral affection are likely soon to confirm the revelations of the ophthalmoscope. Pain may occur comparatively early, or be postponed till the final period of the disease, and varies greatly in severity. Failure of other senses often follows the loss of sight, as the lesions increase in chronic cases. In two instances, six years before death, I had been able to make a confident diagnosis of cerebral tumor, in which cases the patients gradually lost hearing, smell, and taste, as well as sight; the tumors within the brain, as found at the autopsy, having slowly attained a size larger than the fist. Where the neuritis arises from disease of the brain there is usually a defect of vision, either as a small scotoma, or involving a large portion of the field.

If the affection has been induced by less fatal agencies, the active symptoms may disappear, and if the congestion has been only temporary a good degree of sight is recovered. The prognosis is less favorable if the morbid conditions are protracted, but vision is not invariably totally lost. Where, however, the disc shows material changes, or where, as the disease subsides, the vision and the intra-ocular circulation become diminished, the prognosis is very grave.

The treatment must be directed to the removal of the causes, where this is possible; as, for instance, in syphilitic or malarial cases.

CHRONIC NEURITIS

is marked, at the outset, by a bright rosy color of the papilla and of the surrounding choroid, without the mossy indistinctness of the disc and serous or hæmorrhagic effusions in the contiguous parts of the retina which accompany the acüter forms. After this injection has existed for a while, the arteria centralis gradually lessens in size, and the abnormal redness begins to give place to white atrophy.

Hutchinson gave to one class of the cases exhibiting this series of phenomena the name " tobacco amaurosis," because, although sometimes a sequel of chronic brain lesions, it is often found in men who are strongly addicted to the use of tobacco. It is very seldom met with in women. Too free use of alcohol has been also regarded, by some authors, as a cause of this affection; but this is less certain.

Allbut considers " that chronic optic neuritis is best seen in the three kinds of sclerosis which are known clinically as general paralysis, locomotor ataxy, and palsy with tremor."

To be of service, treatment in tobacco amaurosis must be begun in the early stage, before the congestion has been succeeded by atrophy. Abstinence from tobacco is essential; improvement often following its disuse, if the changes in the nerve are not too far advanced. Lupulin and potassium iodide and bromide may be given with benefit.

Where the changes in the disc are but an indication and a sequel of grave alterations of the central nervous structures the prognosis is unfavorable.

ANÆMIA OF THE OPTIC DISC.

Anæmia of the disc has occasionally been mistaken for atrophy, and some cases of reputed successful treatment of amaurosis by strychnia, electricity, etc., have doubtless been instances of this affection. As a rule, in anæmia, the whole fundus of the eye, as well as the nerve itself, shows defective vascularity and nutrition ; but though the somewhat blanched aspect of the disc and the evident lessening in size of the arteries gives, at first sight, the impression that atrophy is in progress, yet the outline of the disc is neither so sharply defined nor so irregular as we find it in true atrophy.

Vision is enfeebled, sometimes nearly lost, for the time ; but slow recovery may be expected to follow tonic general treatment. Cheerful surroundings and good hygienic conditions are of great utility, as in other anæmic states of the general system.

ATROPHY OF THE OPTIC DISC.

Unfortunately, we but too often see in this condition a pathological result, rather than a process ; but it is none the less of great importance, not only as regards prognosis, but as showing in its somewhat varied phases the ultimate consequences of several widely different affections. It most frequently results from acute or chronic neuritis, oftentimes originating in basilar meningitis. It may accompany retinitis pigmentosa, or ensue after embolism, or glaucoma, or syphilis, or tobacco or lead poisoning, or may be occasioned by pressure on the nerve by tumors, by fractured bone, or by orbital abscess in facial erysipelas. It may also result from locomotor ataxia or general paralysis.

The slight deviation from the ordinary aspect of the disc, known as physiological excavation, which has been referred to in the description of the normal appearances of the papilla, should not be mistaken for atrophy, as it never extends to the whole area of the disc.

Two stages, marked by different appearances, are distinguishable with the ophthalmoscope, in the atrophy following either intra-cranial or terminal inflammation of the optic nerve. At first the disc loses its transparency and its faint pink tinge, and assumes a dirty grayish, or in some cases a slightly greenish or bluish, look. The margin is a little irregular and its level a little depressed, so that the retinal vessels seem to bend, as if running over a saucer-like surface; but they never appear to end abruptly in passing over its edge, as in the cupped disc of glaucoma. Slowly the disc becomes of a glaring tendinous white; its border is very sharply cut, sometimes slightly deformed, and it often appears to be retracted backward. The principal vessels may continue visible, though perhaps lessened in size; or they are partly or wholly obliterated, or contracted to mere threads; the degree of change of calibre not being always proportional to the atrophy. The pupil is sometimes, though not invariably, widely dilated. Marked atrophy of the disc and retinal vessels is shown in one of the colored plates.

Atrophy consecutive to retinitis pigmentosa is marked by great diminution in size of the disc and the retinal vessels, the retina becoming everywhere atrophied; but there is less depression of surface, and the color is less of a chalky white, than after neuritis which has followed basilar inflammations.

In cases of extreme progressive myopia, the disc is blended in outline and color with the contiguous posterior staphyloma.

In glaucoma, much excavation or cupping of the disc may be produced by the intra-ocular tension, without necessarily involving permanent loss of vision; but if this pressure is allowed to continue a certain time the nervous structures are hopelessly altered, and the disc at length becomes atrophied, without, however, losing its cupped depression of surface or its greenish color.

In advancing atrophy, vision is gradually lessened over portions of the field. Sometimes this occurs in spots, termed scotomata; sometimes uniformly or irregularly over a considerable space, especially at the periphery, or over one half the visual field, generally at the temporal side, as in hæmiopia. These limitations of the field may be accurately determined in a dark room by the aid of a feeble artificial light, or, as may also limitations in the perception of colors, by the assistance of Forster's or Carter's perimeter. Vision is generally worse on a cloudy day or by a dull light. Treatment of true atrophy is unavailing.

TUMORS OF THE OPTIC NERVE

are rare. They may be suspected when the eye is pushed outward and upward, without pain, and without loss of mobility of the eyeball; and there is rapid loss of vision, with no other ophthalmoscopic appearances than hyperæmia of the papilla. If allowed to increase they may attain a large size, causing much pain by their pressure, and even destroying the eye. These tumors may generally be removed, without enucleation of the globe, by making an incision through the conjunctiva at the outer or inner angle, dividing one or more of the recti muscles, as in the operation for enervation, and separating the tumor from its connections with the nerve; thus leaving the globe intact, though sightless as before.

CHAPTER XII.

AMAUROTIC AND AMBLYOPIC AFFECTIONS.

AMAUROSIS.

BEFORE the invention of the ophthalmoscope this term was indiscriminately applied to all conditions of blindness for which no efficient cause could be seen with the unassisted eye. Glioma of the retina, being often visible as a bright reflex at the fundus, was termed amaurotic cat's eye; cataract was named gutta opaca; while the word amaurosis — gutta serena — designated all those affections where vision was lost but the media retained transparency. As Milton expressed it, "So thick a drop serene hath quenched these orbs."

Since our enlightenment by the ophthalmoscope as to the various structural changes which may exist at the fundus, the name amaurosis is generally given only to those hopeless states where the optic nerve has become atrophied from cerebral or spinal lesion. It is not applied to glaucoma; to blindness resulting from embolism, from retinal separation, from retinitis pigmentosa, or from intra-ocular inflammation in any form; for in all these cases the ophthalmoscope has revealed to us definite alterations depending on known causes, and we are thus able to establish a more accurate classification and nomenclature than before.

Complete or total amaurosis exists when the person has no longer even quantitative perception of light. The term partial amaurosis applies to the gradually increasing blindness during the progressive stages of atrophy. This is to be distinguished from the perhaps equal degree of lessening of vision arising from various causes other than nerve atrophy; which is termed amblyopia.

Large losses of blood after parturition, or otherwise, are occasionally followed by sudden incurable blindness, with subsequent atrophy of the optic discs. Wounds or contusions of the supra-orbital branch of the fifth pair, from blows upon the orbital ridge, were supposed to cause the same result, by some unexplained reflex action; but it appears, from recent observations, that, in such cases, the actual lesion affecting the eye is fracture of the thin bony parietes near the optic foramen; thus wounding or compressing the nerve itself, and ultimately causing atrophy. Compression of the nerve and its vessels by deep-seated abscess within the orbit, as a consequence of severe erysipelas, leads to a sudden extinction of sight and subsequent atrophy. It also involves danger of infiltration of pus toward the brain.

In the early stages of cerebral or spinal amaurosis, the ophthalmoscope shows the preliminary, and later the ultimate, changes of the papilla, which have been described as atrophy of the disc on a previous page. Where the symptoms have a cerebral origin, the pupil is usually large after the changes are complete; whereas in spinal affections, or locomotor ataxia, we most frequently have contraction of the pupil, which, moreover, as first observed by Argyll Robertson, is not affected by the action of light, but contracts and expands during accommodation. If both eyes have absolute amaurosis, the pupils do not respond to the influence of light. Phosphenes, crescentic spots of light appearing in a normal eye when the eyeball is pressed upon, are generally wanting.

The aspect of a person hopelessly blind from amaurosis is peculiar. He walks with head erect or thrown back, lifting his feet high; and does not appear to be searching his way, as in blindness from cataract. In partial amaurosis vision is usually best on a clear day. In cataract it is the reverse.

Taken in connection with the degree of obvious change in the disc, the extent to which the field of vision is limited offers important indications for prognosis. If central vision is lessened, with no corresponding loss of power in the periphery of the retina, the chance of recovery is better than where the periphery is first affected, or where vision is irregularly as well as concentrically limited. Where one vertical half of each retina has lost its perceptive power, while the other half remains nearly normal, vision often continues the same for a long time, being better for reading when the left side of the field is affected, because the patient can see the words in advance. The prognosis is most favorable in acute cerebral affections, as in effusion followed by hemiplegia, or in syphilitic cases. It is least so where the enfeebling of sight has been slowly progressive, and the primary disease persists. In spinal affections amaurosis is usually a late symptom, and the prognosis grave.

Treatment in confirmed amaurosis is generally useless. The success attributed to subcutaneous injections of strychnia or to electricity seems, on careful scrutiny, to have been gained, mostly at least, in cases where a fortunate result could reasonably have been expected from a judicious general treatment, without the addition of these means. Amaurotic persons willingly persuade themselves that they are gaining under any new treatment which is confidently recommended to them. Relief of cerebral congestion is indicated where the symptoms denote a sudden effusion. Potassium iodide may be used with advantage for the removal of syphilitic lesions when these appear to have been the original source of the affection of the optic nerve. If tobacco or alcohol are supposed to have acted as exciting causes, the use of these should be given up. Stimulating or soothing applications, such as aconite, veratria, peppermint or clove oil or spirit, ether, or laudanum, may be applied to the brow or temples, for the relief of pain in or around the eye, if this is complained of.

AMBLYOPIA.

A lack of visual acuteness may exist congenitally, with or without evident structural defect. Dimness of vision may also depend on faults of refraction, on opacities of the transparent media, or on various congenital or acquired defects of the retina or choroid, such as coloboma, posterior staphyloma, etc., which do not tend to amaurosis. Enfeebled vision may also occur during convalescence from exhausting diseases, during or after pregnancy or lactation, or from uræmic and possibly from lead poisoning. Temporary loss of accommodative power after diphtheria, scarlatina, or measles causes amblyopia, particularly in hyperopic eyes.

The perceptive power in one eye is also diminished, and even nearly lost, by lack of consonant use with the other eye; as in cases of marked refractive differences in the two eyes, or where one eye is disused because of deviation of its visual axis, as in strabismus. In these cases the eye may be said to unconsciously give up attempts to take part in vision, and disregards images which do not fall upon a part of its retina which corresponds to the point where the image is formed in the better eye. No atrophy or other important structural change is discernible with the ophthalmoscope. But total disuse of an eye for years where rays do not reach the retina, as in cases of cataract, does not impair its visual power. I have myself restored good vision by extraction of cataract, in one case after thirty, in another after eighty-four, years of suspension of function. The patient last referred to had his eye struck by a stone at the age of ten years, and the resulting cataract continued to eclipse his sight until the age of ninety-four, when he consulted me for incurable neuritis of the other eye. He was again able to read with the first eye, notwithstanding its long disuse, after the removal of its cataract.

The prognosis and treatment of these forms of amblyopia varies according to their ætiology. If arising from defects of refraction, these may be corrected by glasses. If from opacities, vision will improve if these can be absorbed; or the place of the pupil can be changed, if need be, by operation. Complete convalescence often reëstablishes vision enfeebled by disease. The termination of gestation is generally, but not invariably, soon followed by recovery of sight, which for a time had been nearly totally lost. When amblyopia has only supervened during lactation, tonics are often useful, but weaning the child may become expedient.

HEMERALOPIA.

Defective vision at night has been already mentioned as a symptom of retinitis pigmentosa, resulting, in such cases, from gradually increasing atrophy of the retina.

In idiopathic hemeralopia, or night blindness, on the contrary, slight, if any, changes are discoverable by the ophthalmoscope, and no permanent alterations of structure take place; although, for the time, the visual power, especially at the periphery of the field, may be below the normal even in daylight, and nearly abolished at night.

The marked symptoms declare themselves at twilight, and as darkness increases the affected person cannot see to distinguish objects or to find his way. Nor can he see in the day-time, if the room is moderately darkened. With full daylight his sight returns. Many soldiers or others, living under the same influences, are sometimes simultaneously attacked, as by an epidemic. The exciting causes are exposure to strong glare, as in barracks, forts, or prisons with lime-washed walls, or in camps near the sea, or near beaches of white coral sand or to snow reflections. Long cruises on board ships in hot climates, excessive fatigue, insufficient or unsuitable food, are also causes which affect sailors and soldiers subjected to them. A combination of intensity of light with unhealthy lodgings and unvarying food rations frequently coöperates in creating this weakened sensibility of the retina.

Confinement in absolute darkness for several days has been proposed as a means of cure; but this is difficult of accomplishment, and has many inconveniences in military and other institutions; and, moreover, even if successful *pro tempore*, affords no security against relapse. Improvement in diet and hygienic surroundings, with the use of colored glasses to protect the eyes from dazzling, is often sufficient for the relief of this affection. It is more speedily and certainly put an end to by transferring those who are attacked to another situation, if this is possible.

Soldiers and sailors often simulate this disease, where they have had opportunity of watching genuine cases; in order to avoid duty. Often, also, they are unjustly suspected of simulation, when really victims of this affection; those about them being unfamiliar with the disease, and regarding the sudden loss and recovery of vision as suspicious.

SIMULATED BLINDNESS.

Tricky malingerers often endeavor to escape conscription for the army, or, being enrolled, try to shirk duty, by simulating blindness of the right eye. Such feigned amaurosis may be readily detected by holding a prism, with the base upward or downward, before either eye, both eyes being open, while the man is told to look at a spot on a wall a few feet distant. On being asked what he sees, he replies that he sees two spots, one above the other; which proves that he has binocular vision. The stereoscope may also be used, with such pictures upon the slide as require both eyes for producing a certain position of the figures. A still more easily applied method is to hold a pencil or pen-holder a few inches in front of the person, midway between his eyes and a book, which he is required to read. If he sees with both eyes, he reads with facility, the words hidden from one eye by the pencil being seen with the other eye; but if one eye is blind, or is closed or covered, he cannot read.

Dilatation of the pupil by mydriatics, to simulate the enlargement seen in amaurosis, can usually be detected by its excessive degree. In case of doubt, the person must be kept under surveillance till the artificial mydriasis has disappeared. Such dilatation, where no atrophic appearances are discoverable in the disc, should always be regarded with suspicion. The simulation most difficult to expose is the positive assertion of total blindness of both eyes, sometimes persisted in for weeks by hysterical women or other sharp malingerers. The ophthalmoscope shows nothing abnormal; the movements of the pupil respond naturally to the stimulus of light; there is no history of disease to account for the alleged sudden blindness. These facts render the fictitious character of the disease nearly certain; yet, when the part has been well studied, it is difficult to prove, at the moment, that a person who appears to be perfectly blind and helpless, and whose acts are never for a moment unguarded, is an impostor. Time and watching expose the fraud. Sometimes the bringing a sharp instrument quickly in front of the eye, as if about to make a thrust, will cause involuntary flinching; in other instances, even this has not found the patient unprepared. The physician can only keep his convictions to himself, and advise some expectant treatment, until the patient becomes weary of persistent deceit; or confide his suspicions to a trustworthy person, who can, unsuspected, watch for facts which betray the imposture which has been practiced.

I once saw a case of what might be termed reflex blindness, and a similar instance has lately been observed in England. The very intelligent parents of my patient, a girl of eight years, gave me the following history: Six weeks previously, she suddenly became, and still remained, totally deaf. Four weeks later, sight was also almost entirely lost. For an hour at a time she seemed to be absolutely blind; these periods being succeeded by intervals when she appeared to grope her way, as if aided by a slight perception of light. During these intervals, if the eyes of another person were brought directly into the line of her visual axis, she fixed her own upon them with a smile of delight. But if the lids of the other person — myself, for instance — were closed for an instant, or if I slightly moved my head, she lost perception, and her eyes began again to wander aimlessly in constant nystagmus. She seemed quite incapable of finding again the eyes she had just before seen, and it was only when my eyes were brought somewhat near and directly in front of her own that there was recognition and fixation. The trial was repeated many times, always with the same result. No other objects, however bright or wherever placed, were noticed. Her health was generally good, though she was a rather delicate, even puny, child. All the external and internal appearances of her eyes were absolutely normal, except a rather sluggish action of the pupils and very marked nystagmus. Suspecting parasitic intestinal irritation as a source of reflex disturbance, I gave this opinion, and then learned from the mother that the child had a short time before voided what I judged to have been a fragment of tapeworm. It appeared, also, that an opinion had already been given by the family physician to the same effect; and, returning to his care in the country, the little girl soon recovered sight and hearing, after expulsion of a large amount of tænia by the aid of anthelmintics.

CHAPTER XIII.

COLOR-BLINDNESS.

It has been proved, by testing many thousands of persons in Europe and in this country, that about four per cent. of males, in every condition of life, are virtually unable to distinguish red from green, while perhaps not one female in four thousand has this defect. Inability to discern violet from yellow is found in extremely rare instances, but this is not practically important.

Color-blindness is congenital and incurable, and is sometimes hereditary. It may exceptionally appear as a symptom following disease of the optic nerve or brain, injuries of the head, serious illness, or the abuse of tobacco or alcohol. It is not accompanied by any perceptible change of structure, and involves no other deficiency of the function of vision, the forms of objects being seen as clearly as by other persons; but red objects appear to those who are red-blind darker, while to those who are green-blind objects of green color seem darker; this being their only means of estimating the difference between the one and the other of these colors of the same depth of tint.

While this defect constitutes a merely inconvenient infirmity for artists and for salesmen, who have to do with selecting and matching colors, it is an absolute disability for such employments as require an accurate and instant perception of the red and green colors which are everywhere used as signals upon vessels at sea and on railways. Ships of all nations are obliged to show a green light at the starboard side and a red light at the port side; and, to avoid collisions, the lookout, pilot, or helmsman should be able to judge at once whether the light seen is the red or the green, and thus to know what is the course steered by an approaching vessel.

On railways, a green flag or lantern indicates possible danger, requiring caution; while a red signal is an order to the engineer to stop his train immediately. Since we know that four per cent. of those offering themselves as pilots, seamen, enginemen, etc., are, unconsciously, red-green blind, the necessity of a proper examination of employés to discover the existence of this defect (as well as to test the acuteness of sight and hearing), as being the only means for securing the safety of the traveling public, and for protecting the interests of transportation companies on land and sea, is too evident to need argument.

Holmgren, in Sweden, proposed tests which have been generally accepted in his own and other European countries as both entirely reliable and easily made, and Dr. Jeffries has been indefatigable in endeavoring to secure their adoption in the American States. Three large test skeins of worsted are employed: I. a light green of a pure tint; II. a rose or purple, a mixture of red and blue; and III. a pure red. A collection of skeins of worsted of various shades and colors is placed before the man to be examined, in a good daylight (no examination being possible by the yellow flame of artificial light). The test skein I. is then placed at a few feet from him, and he is told to choose from among the hanks of worsted such as match No. I. in color. A color-blind person invariably blunders in attempting to do this, selecting shades of gray, or brown, or drab, as resembling the green test skein.

As No. II. is composed of red and blue, the red-blind see it as blue, and match it with blue tints, whilst the green-blind choose greens.

The red hank, No. III., being used, the color-blind person selects to match it brown, sage, and green tints, while he rejects or hesitates about tints which actually correspond with it.

These ill-matching tints are called "confusion colors," and are nearly the same for a large number of persons tested.

Dr. William Thomson, of Philadelphia, has devised "an instrument for the detection of color-blindness," which is so simple an adaptation of Holmgren's method, and so admirably suited and convenient for its purpose, that I have obtained his permission to reproduce the photograph of the instrument, which was exhibited at the last meeting of the American Ophthalmological Society, and has since, after practical testing of its efficiency, been ordered by the Pennsylvania Railroad to be used in an examination which has been directed to be made of the thirty-five thousand men employed on its extended lines. It is approved by the Railroad Commissioners of Massachusetts. Its simplicity permits of the examination being intrusted to non-professional hands, with the certainty that no error can occur which will endanger the safety of the public, since it is sure to detect any existing color-blindness; while, on the other hand, if any employé, on account of his embarrassment at the unusual test he is undergoing, or his anxiety from knowing that his fitness for his post is in question, makes apparent errors, they will so far differ from those made by the color-blind that the examination may be revised at a glance by an expert, from the record which should be made of the numbers chosen; and, if necessary, may be repeated.

Each man should be examined by himself, without the presence of others, who might by look or sign give him hints as to the choice of colors.

It is to be hoped that a sense of duty as well as of interest will lead all companies engaged in transportation by land or water to adopt at once so efficient a means for public safety, and thus exclude the possible risks caused by imperfections of vision.

I append Dr. Thomson's own description of his instrument, from the Transactions of the American Ophthalmological Society for 1880: —

"It consists of two flat sticks, about two feet in length and one inch in width, fastened by a hinge at one end and connected by a button at the other. Between these, and concealed from view, are forty white buttons, having the figures from 1 to 40 clearly engraved on them, attached to the stick by small wire hooks, which permit of their easy removal and change of position. To the eyes of these buttons are attached forty skeins of colored wool.

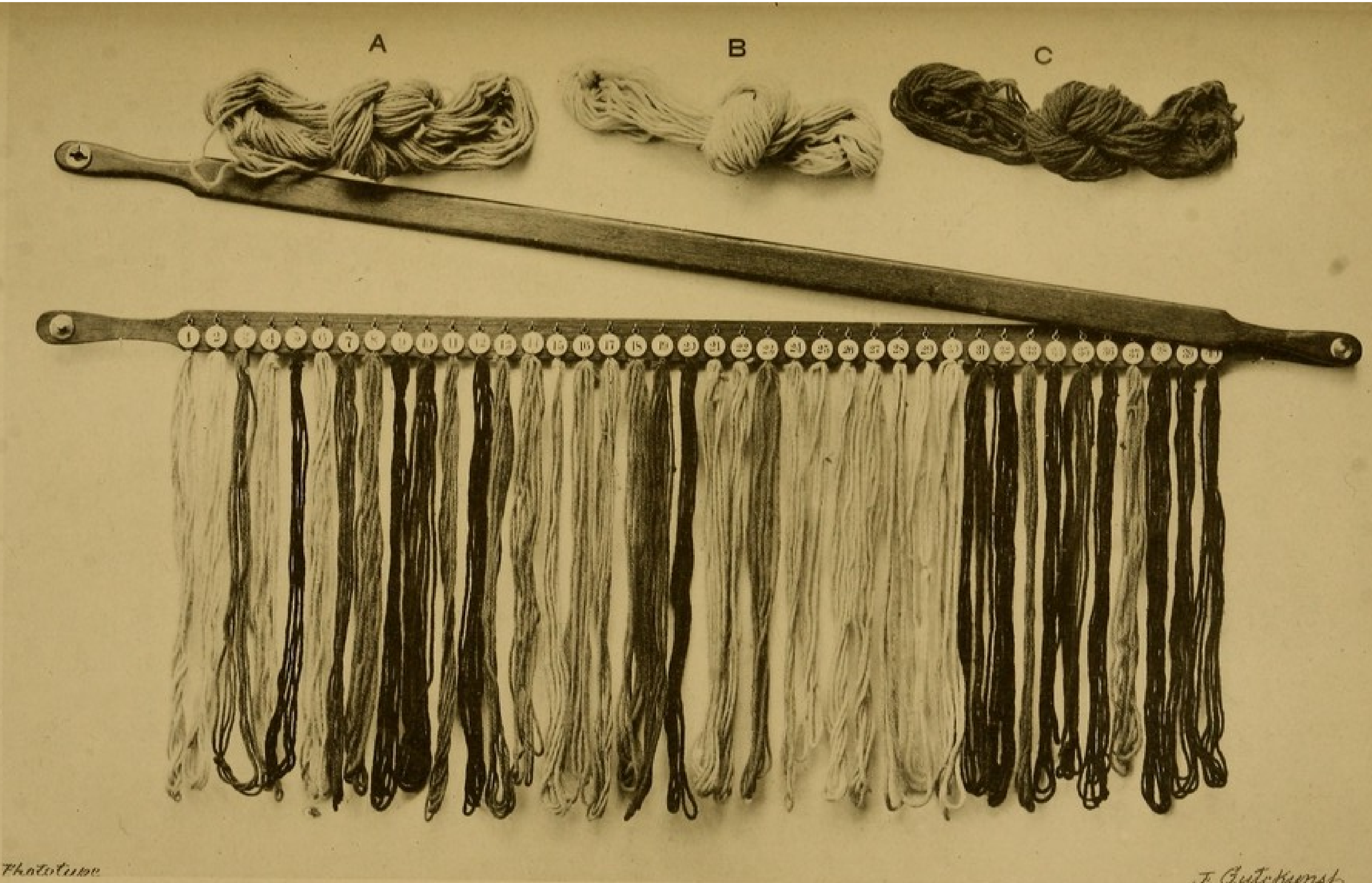
"In obedience to Holmgren the test skeins are three: I. light green; II. rose or purple; III. red. The persons examined are directed to select from the stick the colors which will match them.

"On the stick the colors are arranged alternately, — to match the tests, — and to be of those confusion tints which experience shows to be most commonly selected by the color-blind. The first twenty tints are green, and gray and tan-colored confusion tints; — and this part suffices for detecting any color-blindness.

"From 21 to 30 the tints are alternately rose and blue, and from 31 to 40 the tints are red, and its confusion colors brown or sage.

"When the examination is made, the instrument is closed to conceal the figures, and test green I. being shown, the person examined is directed to select from the stick ten tints to match this. When this is done the figures attached to the skeins are recorded by a clerk, and the selection thus made can be identified at any future time.

"It being arranged that the real tints are designated by the odd figures, commencing with 1, while the confusion tints are marked with the even figures — when the examination is concluded — in a case of normal sight and color perception — only odd figures should appear recorded on the register; whilst if a faulty selection has been made by a color-blind person, it will be revealed by even numbers. In the green test, the selection of Nos. beyond 20 would be more than suspicious; with the rose, any No. below 20 or above 30; and with the red any No. below 31. It will be seen that any superintendent or supervising expert could thus be sure of


A
B
C
Phototype
F. Gutekunst

the presence or absence of color-blindness by remembering the simple theory of the arrangement and scanning the blank on which the Nos. of the tints selected had been recorded.

"The first twenty are green and confusion tints, but the color-blind person has the whole forty to choose from, and frequently selects reds at the end of the series to match the green test I. Again, of these confusion tints, five are gray and five shades of brown; those green-blind will prefer the grays, and the red-blind select the browns.

"In the rose test, between 20 and 30, those green-blind frequently select greens of the first series, and thus show their defect."

Dr. Thomson's test may be procured from Queen & Co., Chestnut Street, Philadelphia, or Widdifield & Co., 38 West Street, Boston.

To avoid collusion, and to prevent any instruction of the men examined, by others, as to the arrangement of the colored skeins of worsted, the buttons, with their attached skeins, may be shifted at will from one part of the stick to another, the numbers of the buttons indicating, without chance of error, the selection made; whereas, if the arrangement continued always the same, the men might be told, by others who had passed the examination, how to choose the proper colors by their position, although quite unable to recognize them by their tint.

Of course, the examiner should be a person not only of intelligence, but of integrity and firmness, — one who can neither be biased by mercenary offers, nor by undue sympathy with the men whom it may be necessary to reject as disqualified for positions requiring them to distinguish color signals.

Tests as to acuteness of vision, though having no necessary relation to defective color perception, should be made at the same time, and are equally or even much more important.

Test types, like those appended to this work, may be obtained from its publishers.

CHAPTER XIV.

AFFECTIONS OF THE CRYSTALLINE.

ANOMALIES OF FORM AND DISPLACEMENTS OF THE CRYSTALLINE.

THE edge of the crystalline lens cannot be seen in a normal eye except in extreme dilatation of the pupil; but in certain instances after dilatation the border of the transparent lens can be distinguished as a bright crescentic line, like the outline of a drop of oil, or as a shaded crescent, if seen against the dark background of the fundus. In such cases the lenses are usually more convex as well as smaller than the normal, and often are displaced from the axis of the globe, either laterally towards one side of the iris, or diagonally, so that one edge projects into the pupil. Microphthalmos, a congenital smallness of size of all the constituents of the eyeball, or some other structural anomaly, may coexist with these variations in the lens. An imperfection of form, as if slightly shrunken, or irregular curvature of surface, constituting astigmatism of the lens, is occasionally combined with the other defects. Such deviations give rise to errors of refraction. Where no abnormal conditions had previously existed, the suspensory ligament is sometimes relaxed or detached to such an extent that the lens may be completely dislocated into the vitreous or into the anterior chamber. If dislocated backward, the iris has a tremulous movement, from lack of the support afforded by the lens. If completely displaced into the anterior chamber, the iris is crowded back, and the lens lies in front of it, looking like a drop of oil. These luxations frequently give rise to inflammatory processes. The traction of the heavy lens upon its suspensory ligament, as it sways to and fro with movements of the eye, causes irritation at its attachments, and, according to some authors, may excite hypersecretion and intra-ocular pressure, inducing glaucoma; or, acting as a foreign body, it may induce plastic inflammation in the iris or in the ciliary region, and give rise to irido-choroiditis.

If the lens is laterally displaced, so that it covers but half the field of the pupil, there will be double and confused vision in the affected eye, the refraction in one part being with the aid of the lens, and in the other without it. The power of accommodation will be wanting.

The lens may retain its transparency for a long time, even when largely separated from its suspensory attachments; its nutrition being perhaps kept up by imbibition through the capsule. After a while it may become cloudy. Fluidity of the vitreous often accompanies dislocation of the lens. These conditions are sometimes inherited.

Dislocation into the anterior chamber can often be reduced by placing the patient upon his back, when the lens will either spontaneously slip through the pupil, or does so if gentle friction and pressure is made with the upper lid upon the cornea. If not thus replaced, it will often pass through the pupil after this has been dilated by atropia. It may then be retained in position by keeping the pupil contracted by the use of myotics. If it cannot be reduced, and its presence in the anterior chamber causes threatening symptoms, it should be extracted through an incision of moderate size in the cornea, the lens being first transfixed with a fine needle, to prevent its slipping into the posterior chamber during the operation. I have known instantaneous restoration of vision from the accidental luxation of a cataractous lens into the vitreous by a blow upon the eye, though this is not to be recommended as an operative method.

Dislocation of the lens behind the iris places the eye in the same condition of aphakia as after an operation for cataract by couching. If it creates no irritation it should not be disturbed; but a convex glass may be given to compensate for the loss of its refractive aid.

CATARACT.

The crystalline being apparently destitute of nerves and nutrient vessels, its vitality is probably maintained by imbibition, through its capsule, from the surrounding transparent media. Except where traumatic injuries of the capsule have occurred, — which, unless very small, cause immediate opacities, — or where changes follow inflammatory or other lesions of contiguous parts, it is as yet impossible to determine in what way the nutrition of the lens is so far modified that it loses its transparency and forms cataract. In many families a disposition to opacity of the lens is hereditary; but this does not explain the *modus operandi* through which the effect is produced.

SENILE CATARACT.

Most of the various forms of cataract affect the lens substance, and it is only exceptionally that the capsule becomes opaque, unless as a secondary change after operation. Numerous terms were once used to designate as distinct varieties every trifling deviation from the usual appearances; but these have given place to the more useful and accurate division of senile cataract into two classes, cortical and nuclear cataract, and to the practical diagnosis of the various degrees of hardness proper to those two forms.

The detection of incipient cataract was formerly a matter of much difficulty. Where the sight was lost from deeper-seated disease, the amber tint acquired by the lens in advanced age often led to a diagnosis of cataract, where no opacity of the lens existed; and the catoptric test, by observing the upright reflections of a candle flame from the surfaces of the cornea and the anterior capsule, and noting the absence, in cases of cataract, of the inverted image reflected from the posterior capsule of the lens, was not very easy or certain of application by the inexperienced. This is now quite disused, for by means of the ophthalmoscope, and by oblique illumination, we can quickly assure ourselves if even a slight defect of transparency exists. Only the ophthalmoscope mirror, without the object-glass, is used. A faint illumination is best; and the observer readily perceives any slight lines or dots of commencing opacity of the cortical substance, or any diffused haziness of the nucleus. Thus viewed, these appear as dark spots upon the red background of the fundus, intercepting, as they do, a portion of the returning rays of light. Opacities in the vitreous are more deeply seated and have a quite different aspect, being more irregular, and movable. By oblique illumination through a convex glass of two inches' focus, these opacities are visible as grayish spots or lines, instead of being dark, as when seen by light reflected from the fundus; the lines being often evidently convex when in the anterior cortical substance of the lens, concave and deeper seated when in the posterior cortical layers. These lines of cortical opacity are usually to be found earliest at the lower part of the lens. They can be seen, if present, by having the patient turn the eye downward, without dilatation of the pupil by atropia; and its use can only possibly be required to render marginal opacities more visible, where for any reason it is important to make a diagnosis at a very early stage. In the advanced stages of cataract, both cortex and nucleus become involved. The characteristics of cloudiness of the outer and the central parts of the lens often coexist, and may be discerned with the eye alone, without artificial aid; the cortical opacity having the form of radiating lines segmenting the anterior superficial layers, with an opalescent haziness over the intervening space, which covers, without wholly concealing, the amber-colored nucleus. This senile form of cataract is hard or semi-hard, small or large, according as the nucleus or the cortical portions are most implicated, being hardest and smallest where the brownish nucleus is largest. Even nearly black cataracts are now and then seen.

Ripeness of cataract, or complete opacity throughout all its substance, was formerly regarded as essential to successful operation, but this entire transformation is now deemed of less importance in fixing the time for surgical intervention.

Those who have nuclear cataract, with but slight cortical changes, see best in a moderate light, and with the eyes shaded; and their vision can often be materially improved, for a time, by keeping the pupil dilated by atropia, thus allowing objects to be seen through the transparent border of the lens. Should this means be employed stronger glasses will be needed for seeing small objects, to compensate for the suspension of accommodation by the atropia. Those having only the opaque striæ of cortical cataract frequently see objects, the moon for instance, multiplied, several images being formed from pencils of rays passing between the radii. To persons affected with cataract, bright objects, such as the flame of a lamp, seem hazy, but much enlarged, as if surrounded by a halo; but this is a fog-like mistiness, without the iridescent rays seen in glaucoma when looking at a light.

Great differences exist as to the development of cataracts. In some cases their course is uniform and perhaps very slow; in others gradual but more rapid; in yet others a considerable period of slow change is terminated by a sudden increase of opacity, and the patient, who for months or years had experienced only an almost imperceptibly gradual failure of vision, becomes within a day or two so blind as only to distinguish light. Having appeared in one eye, cataract may be expected to eventually manifest itself in the other; but a long interval, even many years in exceptional instances, may elapse before the second eye shows traces of the disease. Nothing in the aspect of the first eye enables us to make an exact prognosis as to the time of development of cataract in the other. Distant objects generally are sooner indistinct than those near at hand. Sometimes there is an apparent myopia, owing to as yet undetermined changes in the lens, which increase its index of refraction, and concave glasses assist the eye in far vision. These changes may probably be due, in part at least, to an accession of cholesterine in the lens substance. Occasionally, those who for years have worn convex glasses can throw them aside, and read better without them by bringing the book nearer to the eyes. When this "second sight" is mentioned by a patient, cataract may be suspected to exist.

Plastic deposits resulting from iritis, causing more or less adhesion of the margin of the pupil, and partially covering the anterior capsule of the lens, are sometimes described as false cataract; but these are merely adventitious, and have no relation to changes in the lens itself, to which alone the term cataract should be applied. They are readily distinguishable from true lenticular opacities, as seen by oblique illumination or with the ophthalmoscope. The name cataract is, however, a merely arbitrary designation, a legacy from those days of imperfect knowledge when a drop of opaque humor — gutta opaca — was supposed to have obscured the pupil. Even at a later period cataract was believed to be a membrane formed in front of the lens, which could be depressed without disturbing the crystalline.

No other means of cure than the removal of the opaque lens from the field of the pupil has proved effectual. Many methods have been vaunted as successful, but none of them have stood the test of impartial trial. The most recent of these have been, frequent paracentesis of the cornea in order to obtain constant renewal of the aqueous, which, it was asserted, would effect a clearing up of the opaque portion of the lens, and the application of phosphorated oil, or of electricity, to the eye, with the same object. All of these means have totally failed to accomplish any good result.

When a case of cataract is seen at an early stage, before the fundus is hidden from inspection by the opacity, the internal parts of the eye should be carefully explored with the ophthalmoscope, to discover any complications, should such exist. Extreme myopic changes, alterations in the region of the macula lutea, separation of the retina, extensive posterior staphyloma, atrophy of the optic disc, disseminated choroiditis, and various other conditions of the important structures of the eye, rendering recovery of sight by the removal of the cataract unlikely or impossible, can thus be detected, and both patient and surgeon spared the anxieties and disappointments of a useless operation. By painstaking, a sufficiently good view of the fundus may often be had, even when the loss of transparency in the lens is already considerable. If the cloudiness has gone too far to admit of this, the probable state of the fundus should be investigated by ascertaining whether the eye is still capable of discerning light objects, and by testing the perceptive power in all parts of the visual field by means of a candle moved before the eye at a distance of twelve or fifteen inches, in a darkened room.

No age is so advanced that an operation is inexpedient, provided the general health and the ocular conditions are good. I have operated on four persons between ninety and ninety-five years of age, three of whom recovered good vision for reading. Operations for cataract may be done at any season of the year, if the patient can be made comfortable and protected against extremes of temperature. Very hot weather is not favorable, because it causes restlessness after the operation.

Some authorities advise operating on but one eye at a time, on the ground that if the result is unfortunate a different method may be adopted for the other eye. But any possible advantages in this respect are counterbalanced by the less hopefulness of the patient in submitting to an operation after the loss of one eye. Oftentimes he absolutely refuses to have a second operation, although there may be scarcely a doubt of its success ; whereas, if the two eyes were operated on at the same time, he would not only have a double chance of vision, but if, as could reasonably be expected, both eyes recovered their sight, he would be so much the more benefited.

We are often asked, What are the prospects of success? —and can assure the patient that since the adoption of improved modes of operating the danger of failure is comparatively very small. More than nine cases in ten should result favorably; though the chances of each individual must depend in part on the soundness of his general and local conditions, and on his docility in following the instructions given him, during the treatment subsequent to the operation.

The question of anæsthesia or its omission is important. The pain attending the operation is trivial, and it can be very well performed, if the patient is steady, without etherization. But there is nearly always dread of having anything done to the eye, which is regarded as being exquisitely sensitive; and it is impossible, for many persons, to resist the involuntary tendency to roll the eye upward when it is touched. There is, moreover, an uncontrollable disposition to compress the eye by contraction of the recti muscles, which tends to cause expulsion of vitreous, or even intra-ocular hæmorrhage. These dangers seem to more than offset the chance that if nausea and emesis should follow the inhalation of ether a loss of vitreous might ensue. But with rapid and continuous administration of ether there is little risk of vomiting, provided food has not been taken within a short time or since the previous night; and, where it has occurred, I have not seen it result in as serious consequences as those resulting from the involuntary resistance of the eye. On many accounts the patient's prospects appear to be better when the operation is done while the eyeball is in the absolute quietude of unconsciousness; especially if he be, like so many Americans, of nervous temperament.

If the person is in good health, no preparation of the system is required before operating; but any complications, whether as regards the state of the system or local morbid conditions, should be removed, if possible.

While vision continues sufficiently good in one eye for most of the patient's purposes, it is often desirable to postpone an operation on his other eye, because, even where the most complete success is obtained, the eye which has been operated on is necessarily destitute of accommodative power. Provided with the proper compensating cataract glasses, the patient cannot harmonize vision of this eye with that of the other, and except for certain distances, and when he looks directly through the centre of his glass, the image in the operated eye confuses rather than assists him. In fact he often actually sees better if he covers this eye and uses only the other, even when this is already partially obscured by commencing cataract. As a rule, therefore, it is best to wait until vision is sensibly diminished in the second eye, though it is not necessary to await complete helplessness. Exceptions, however, occur: where a person is going to a distant place, and at a future time cannot have the services of a skillful operator; or where, on account of the conspicuous appearance of the cataract, a person wishes, for cosmetic reasons, to have it removed, even if this is to result in some inconveniences of vision.

CONGENITAL CATARACT.

Congenital cataract may appear in two forms, either of which may for a time pass undetected. This is especially true of the lamellar variety, since, unless extensive, it does not greatly interfere with sight.

In lamellar forms, an opacity occupies apparently the centre of a lens, the margin and outer layers of which remain clear. But if this cloudiness is closely observed, it is seen to be everywhere uniform, and not denser at its very centre, as would be the case were the entire nucleus affected; it is thus evident that only layers intermediate between the surface and the centre of the lens are involved, both the outer and the nuclear portions continuing transparent. The opacity is usually sharply defined, appearing like an inner grayish lens inclosed in a transparent medium; but fine radii of opacity sometimes extend through the cortex as far as the capsule. Occasionally, small spots, whiter than the rest, are seen in the cloudy layers, or fine dots are scattered in the cortical parts. This abnormal state may be congenital, or may first appear in childhood. Rachitis has been regarded by some as a predisposing cause. The clearness of vision depends on the extent and the degree of cloudiness, and on the amount of light entering the pupil. Many cases have good vision if the light is not very bright; though small things cannot be well seen unless brought quite near the eyes, so as to have a magnified image; as in other conditions of amblyopia. Others, where the opacity is greater, see much better if the pupil is dilated by atropia, in which case convex glasses, to replace the accommodative function, will be needed in looking at small objects. These means are, however, preferable to removal of the lens, for, unless hyperopic, the eye sees at a distance without glasses.

Many lamellar cataracts are stationary for a long time, or for the whole life. In these cases, if vision is tolerably good, the patient can be allowed to remain as he is, or iridectomy may be done downward and inward to extend the available pupil beyond the limits of the opacity. If the cloudiness progresses, as is perhaps oftenest the case where lines or dots are visible in the cortical substance, removal of the lens may be required. This should be done by careful division of the capsule, so as to obtain slow absorption of the lens, rather than by an attempt to evacuate the lens substance at once. Iridectomy is much to be preferred where this is likely to be sufficient, as the power of accommodation is thus preserved to the eye, the loss of which, if the lens is removed, is a serious and permanent inconvenience.

Another still more common form of congenital cataract is made up of a cloudy nucleus, with faint diffused opacity in the outer layers, which has a disposition to increase until the whole lens has a bluish-white color, like milk diluted with water. This increase may take place very slowly, and the opacity scarcely occasion complaint until adult life, when it develops with all the characteristics seen in congenital cases. This variety is rarely stationary till it has reached its full maturity, and generally requires an operation for removal of the lens. This may often be completed at once, the soft, flaky lens being withdrawn through a linear incision, with or without suction; or, if of firmer consistence, the capsule may be incised, and the lens left to be gradually absorbed by the aqueous.

Congenital cataract is often hereditary, and sometimes affects several children of one family. I have seen instances where five or six children of a family were born with cataract, and once operated successfully on six eyes of brother and sisters at one time.

Where vision is very imperfect, the infant does not learn to fix his eyes upon objects, and they acquire irregular rolling and rotatory movements, termed nystagmus. The required operation should therefore be done at an early period of infancy, before this motion becomes a confirmed habit; so that the retina may begin to be educated in the recognition of objects, and not perhaps remain permanently deficient in perceptive faculty.

SOFT CATARACT IN ADULTS.

In addition to traumatic cataract, described in the chapter on Traumatic Injuries, several varieties of cataract are found in young adults.

Fluid cataract is now and then seen, the lens substance being almost or entirely degenerated to a milky fluid. This sometimes exhibits evident stratification of the contents of the capsule, or a small nucleus lying at its lower part. It was described by Morgagni, and is sometimes designated by his name. On incising the capsule with a cataract needle, the contents pour in a milky jet through the pupil into the anterior chamber; the nucleus, if any such remain, being afterwards slowly absorbed. Should the nucleus be large, its immediate extraction through a linear incision of the cornea is sometimes indicated.

Diabetic cataract, occurring in middle life, is usually of less marked whiteness than other forms of soft cataract, having rather a gelatinous appearance. It may be removed by operation, where the degree of perception of light indicates a sound condition of the retina, if the general state of the patient warrants the procedure.

Cholesterine crystals are occasionally developed in the lens, and can be distinctly seen before operation. After division of the capsule and lens they continue floating, as glistening showers, in the posterior chamber. Such crystals may also derive their origin in the vitreous, as in a case I have lately seen, where they were very numerous behind a quite transparent lens.

Cataracts which have formed as a secondary result in eyes disorganized by injury or by inflammatory or other processes, may undergo a slow, partial absorption, with thickening and shrinkage of the capsule, which becomes tough as a piece of kid leather and takes a yellowish color. As the pupil is sometimes widely dilated in such cases, this altered lens constitutes a glaring deformity. To be successful, an operation must be adapted to the special conditions, as the firm capsule resists incision, and is readily torn from its suspensory attachments, to float in the fluidified vitreous and possibly cause subsequent ciliary irritation. If extraction is attempted, much vitreous is generally lost, and the globe sometimes collapses. Such a capsule should be transfixed with a cataract needle introduced through the cornea, and thus kept in place, while it is cut open with a second needle or a minute knife, held in the other hand and passed through another part of the cornea. This will allow it to collapse and shrink so as sometimes to disappear from the pupil. This kind of cataract is at times the subject of another secondary change, the transformation of the capsule into a cretaceous yellowish or whitish mass, generally less than the normal size, and frequently rugous, so that it may act as an irritating foreign body, and possibly require extraction to avert sympathetic dangers.

When these two forms of cataract are a sequel to large deposits of lymph, formed in the course of an irido-choroiditis, or in the scar following an injury, the lens is sometimes kept in place by these exudations, but in other instances is wholly or partially detached from its connections, and shifts more or less with the movements of the eye, even falling out of sight behind the iris. One would expect such conditions to be a frequent source of cyclitis, but experience proves that this occurs but rarely; these disorganized eyes being very tolerant of what would excite destructive processes in a healthy eye. Operative interference in such cases is therefore not to be resorted to unless active symptoms supervene.

Cataract may appear, in a special form, as a secondary alteration, in eyes already disorganized by glaucoma. Such cataracts have a sea-green or greenish-white aspect, are usually pushed against the atrophied iris and the cornea, and are accompanied by great hardness of the globe and loss of all light perception, and sometimes also by vesication of the epithelial layer of the cornea. No operation is admissible, unless for relief of acute or lingering pain, when recourse can be had to enervation.

CAPSULAR AND PYRAMIDAL CATARACT.

The many varieties of capsular cataract formerly described were for the most part peculiarities of change in the cortical layer of the lens itself, and really only infrequently occupy the capsule. But limited opacities, distinct from the pigment deposits, sometimes form upon the capsule in iritis attended with synechiæ, or when perforation of the cornea has occurred in ophthalmia neonatorum. These are rather to be regarded as false than as true cataract. When the lens, after the anterior chamber has been emptied by perforation, lies in contact with the cornea, the plastic lymph poured out to close the aperture is also partially deposited on the lens capsule, and remains there as a white conical mass when closure of the perforation has reëstablished the anterior chamber and separated the lens and cornea. Another form of central whitish opacity, anterior polar cataract, resembling the appearance which would be exhibited if a cone were inverted within the capsule, is now and then seen in the lens, where there is no scar of perforation. It is supposed that this is the effect of some arrest of development during intra-uterine life, rather than of any inflammation of contiguous parts. These pyramidal cataracts generally continue without change, and disturb vision so slightly that they require no interference. Posterior polar cataract is sometimes associated with albinism, as a congenital defect. It may also occur as a sequel of morbid changes at the fundus.

SECONDARY CAPSULAR CATARACT.

Such is the elasticity of the crystalline capsule, that after it has been incised and the lens removed it often contracts or curls upon itself, so that the pupil is left clear. But if not sufficiently divided, or if plastic deposits form which unite it to the iris, a part or the whole of the pupil may be obscured; sometimes by opaque bands of capsule, sometimes by a very delicate net-work sufficient to partially intercept the light, and yet so slight that very careful inspection with the ophthalmoscope and by oblique illumination is needed to detect the obstruction. If fastened at one point only, these bands may retract after a little time; if held by firm adhesions at different parts of the pupil, they require laceration or removal to permit of perfect vision.

OPERATIONS FOR CATARACT.

The person to be operated on should sit or lie near a window which admits a clear light but not the direct rays of the sun; the light falling upon his eyes at such an angle that reflections from the cornea shall not interfere with the surgeon's clear view of the part in which he proposes to make his incision, or of the field of the pupil. The position, whether sitting or lying, should be such that the patient's head is well supported; and this is especially desirable if anæsthesia is to be induced. The anæsthetic employed should be absolutely safe, so that the operator may feel entirely at his ease, and not have his thoughts or attention occupied by any apprehension of possible danger. Sulphuric ether, the original means by which, here in Boston, it was first demonstrated that capital operations could be rendered painless, is becoming more and more extensively accepted as the best agent for the production of complete insensibility. Chloroform is unquestionably sometimes, though not very often, fatal; and unfortunately it is so in the healthiest subjects, and without any timely warning of danger. Other objections apply to various articles which have from time to time been proposed as substitutes. The mode of inducing unconsciousness by means of ether is by no means a matter of indifference. Properly administered it causes little annoyance to the patient, and its quantity may be so small that there is little risk of unpleasant effects during or subsequent to the operation. There are advantages in having the patient abstain from food and from much drink for some hours before the operation, as emesis is thus less likely to occur during or after the anæsthesia. The neck and chest must be free from tight clothing. No other apparatus is needed than a napkin folded in the form of a cone, in which is placed a moistened sponge, whereon the ether may be freely poured. Air entering at the summit of the cone becomes saturated with ether vapor. The open end of the cone should be closely held to the face, covering the mouth and nose, so as not to admit much air in this direction. At first, and until the patient has taken a few inspirations, the exclusion of other air than that which has passed through the sponge need not be too rigidly insisted on ; but soon after this, and especially with children, rapid substitution of air charged with the ether vapor for the atmospheric air is not only safe, but accomplishes the insensibility much more quickly and pleasantly. As a rule, a young child will not inhale the vapor voluntarily ; but if he is held for a few seconds, and not permitted to push away the sponge, the momentary struggle is quickly succeeded by quiet sleep and entire unconsciousness. If, on the contrary, his resistance is partially yielded to, and he is allowed to inspire air freely, it is a long time before he is overcome by the ether ; he has far more, because prolonged, discomfort ; he inhales a much larger amount of ether ; and the return to sensibility is proportionally slower, and often accompanied by nausea and vomiting. At the point of semiunconsciousness, adults also often make a strong resistance; but a fresh supply of ether should be poured into the sponge and the person brought as quickly as possible under its full influence. Less ether is thus inhaled, recovery is more prompt and complete, and the chances of nausea or other unpleasant after-effects are reduced to a minimum. Any needed quantity of ether may be safely used, and its effect kept up for whatever required length of time, without anxiety. I have never seen a patient who could not be rendered quite insensible by a sufficient amount of it. Anæsthesia being obtained, the cone is removed, so that the movements of the operator may not be interfered with, and the patient respires only fresh air; but if signs of returning consciousness are manifested, ether inhalation should be recommenced before the recovery goes too far.

Some of the advantages of etherization are that under its influence the eye is entirely passive; the lids may be kept apart and the globe turned in any direction without resistance; and, what is a great desideratum in cataract operations, there is no involuntary pressure on the globe, from contraction of the recti, after incision of the cornea, and during or after the expulsion of the lens. Almost the sole objection is the possibility of nausea and retching, and this, as has been stated above, is nearly always avoided by rapid administration of the ether. If, however, vomiting does occur, the risk of expulsion of a portion of the vitreous, or other accident, is very slight, — certainly far less than from the involuntary contraction of the ocular muscles, which even the bravest person cannot control. The amount of actual pain in cataract extraction is only trivial; but an eye has a dread of being touched, which makes anæsthesia safer for the patient, as well as an immense relief in sparing him painful apprehensions: yet this unconsciousness may be dispensed with, if such is the preference of the surgeon or patient.

The operation by displacement, formerly much employed in cases of hard or semi-hard cataract, has come to be generally regarded as less scientific and less successful than extraction, but will be briefly described.

OPERATION BY DISPLACEMENT.

The operation by reclination, or couching, had for its object a displacement of the lens from behind the pupil to a position beneath the lower and outer portion of the vitreous.

The instruments needed are an elevator of the upper lid, unless this is raised by the surgeon or his assistant, fixation forceps, and a cataract needle, having a spear-like head slightly curved on its flat. The pupil should be well dilated with atropia previous to the operation. Etherization is less essential than in extraction operations, yet it may be advantageous.

The best position for the patient is sitting on a chair facing a window. The assistant with one hand supports the head against his chest, and raises the upper lid with the first and second fingers of the other hand, or with an elevator. The surgeon, sitting in front of the patient, seizes a fold of conjunctiva with fixation forceps, and holds the globe in such a position that he has a good view of the pupil, undisturbed by any corneal reflex. Then, taking the needle like a writing-pen, with the thumb and first and second fingers of the other hand, its convexity turned upward, he passes it through the sclera by a quick thrust, about three mm. from the temporal border of the cornea, and nearly in the horizontal meridian. The third and fourth fingers rest on the malar prominence during the operation. The point of the instrument is directed toward the centre of the eyeball. After having penetrated the globe, the needle is turned one fourth on its axis, as it is carried over the upper margin of the crystalline and brought into the field of the pupil in front of the upper third of the lens. The anterior capsule is now to be divided with the edge of the needle. Its concave surface is then applied against the lens, a little above its equator, and this is tilted backward and downward, and carried by a steady movement to the desired place in the vitreous. After a short pause, to allow the vitreous to close around the lens in its new position, the needle is slightly rotated, to free it from any possible entanglement with the lens, and brought again into the field of the pupil, from whence it is withdrawn from the eye in the same position in which it entered. Both eyes should be closed, and the patient kept very quiet for a few days, until the lens becomes established in its new place.

This operation, so seemingly easy of execution, and so brilliant in its immediate results, maintained for a long period preëminence among operative methods. Yet it was in many respects objectionable. It involved traction upon the suspensory ligament, and thus upon the ciliary body; it created serious lesions of the vitreous; and the ultimate position of the cataract, as regarded the retina and the ciliary processes, could only be judged of, but not seen. Among its immediate dangers were cylitis, from the irritation excited at the attachments of the ligament; disorganization and the formation of opacities in the vitreous; retinal or choroidal inflammation from undue pressure upon these structures. The subsequent perils were reascension of the lens, from its not being retained in place on account of fluidity of the vitreous; pressure by the lens, which had become swollen by imbibition or displaced in movements of stooping, upon the retina or the ciliary processes, inducing destructive changes in these parts. These dangers, which resulted in the loss of many eyes where the operation had been at first successful, and which might even involve sympathetic destruction of the other eye, gradually led to disuse of this method by most skilled operators, who, as a rule, consider some mode of extraction a more scientific and reliable means of relief.

EXTRACTION OF CATARACT.

Extraction of hard or semi-hard cataract is now usually done according to one of three methods, each of which is modified in the practice of different operators.

FLAP EXTRACTION.

Flap extraction is generally understood to mean a removal of the lens through a large or even a nearly semi-circular incision near the border of the cornea.

The patient may be either sitting or lying; the latter position being generally preferred when ether is given to produce insensibility, because of the support afforded to the back and head. The bed or couch is placed with its foot toward the window, and the head of the patient so inclined that the light shall fall favorably upon the cornea. So much of the upper clothing should be removed that the patient may not be disturbed after the operation by movements of undressing. It is well, in cataract operations, to have the bowels previously unloaded, that there may be no need of evacuation during the first subsequent days.

The instruments required are a cataract knife, of which the shape may vary according to preference, the broad triangular-shaped knife of Beer and others being generally employed, one or two curettes, having a cystitome at their other extremity, fixation forceps, and an elevator for the lids.

The corneal section may be made upward or downward. Prior to the use of anæsthetics in ophthalmic surgery, the lower section was more easily made than the upper, because of the involuntary tendency of the globe to turn upward when touched. But while the patient is unconscious, the fixation forceps may hold the eye in any position. There is this advantage in the upper section, that the wound is covered, and its edges in a measure kept in place, by the upper lid; whereas, when the incision is downward, the edge of the lower lid may insinuate itself between the lips of the wound and delay the healing processes.

For an operation on the right eye by the upward section, the patient lying down, the surgeon sits on a high chair or stands behind the patient's head, and raises the upper lid with the first and second fingers of his left hand, or with an elevator, while an assistant depresses the lower lid and keeps the eye in the required position by seizing a large fold of conjunctiva with the forceps. If the operator has no assistant, the lids may be kept apart by means of the spring elevator (which should make no pressure on the globe), and he fixes the globe with the forceps held in his left hand. The knife is held between the thumb and two fingers of the right hand, the third and fourth fingers resting upon the temple or cheek so as to give steadiness. The wrist and elbow should be unsupported. The fingers holding the knife are to be drawn back so far, before beginning the incision, that it may be completed by simply extending the fingers, without moving the hand from its support. The cornea is punctured close to its temporal border, in the horizontal axis, or a little above this, if the cataract is deemed to be of small size or to have a small nucleus so as not to require so large a wound for its exit. The wound should not be too small, as the lens does not readily escape, nor too large, because healing is more difficult. In penetrating, the point of the knife should be directed toward the centre of the globe; but as soon as it is within the anterior chamber, the knife is to be brought parallel with the plane of the iris and pushed steadily onward, till the counter puncture is made at the opposite point of the horizontal axis. The incision is then completed by continuing the onward movement of the knife with great steadiness, so that the aqueous shall not escape and allow the iris to fall in front of the instrument. Should this happen, the incision may still be made, including a bit of the iris, without materially affecting the result; or the knife may be withdrawn, and the cut finished with a blunt-pointed cornea knife or with fine scissors. Should the onward movement of the fingers be insufficient to complete the flap, it may be finished in drawing back the fingers. A semi-circular incision is thus made, everywhere equidistant from the corneal border. The cystitome is then introduced through the wound and through the pupil, care being taken not to contuse or wound the iris, and the anterior capsule is divided sufficiently to allow an easy exit of the lens. This incision is made easier by pressing with a curette upon the globe to render the capsule more tense. The cystitome being withdrawn, gentle pressure is made with a curette at that part of the sclera which is beyond the lower margin of the lens, which should then slowly make its way through the pupil and the corneal wound. Suddenness of expulsion must be carefully avoided. Should the size of the lens prevent its easy exit, a second curette may be used to slightly depress the posterior lip of the corneal wound, and facilitate its escape. If portions of cortical substance are separated from the nucleus and remain behind, they are to be brought into the pupil and expelled by gentle friction upon the cornea with a finger placed upon the upper lid; or, after a few minutes, when the aqueous has been re-secreted, they may flow out if the wound is pressed open, or may be carefully lifted out with the curette. No fragments of the lens or hernia of the iris should be left between the edges of the wound, which should be in perfect apposition before the lids are closed. Should the corneal flap be accidentally everted, it must be replaced.

I have found a single suture at the centre of the flap, made with a delicate needle one fourth of an inch long and a single strand of silk, a very serviceable means of promoting immediate union, which is of such great importance in all methods of operation by extraction.

A drop or two of a solution of pilocarpine nitrate or chlorhydrate may be applied, with advantage, to contract the iris and prevent hernia.

Various dressings have been used after operation. Both eyes should be covered. Sichel employed narrow strips of isinglass plaster, crossed upon the lids in the form of the letter X, without bandages, keeping the patient in a darkened room, and leaving the strips undisturbed for some days, if all went on apparently well. Bandages in some form are generally used at present. I usually place over the eyes a strip of soft cotton or linen cut in the shape of a pair of spectacles, but larger. Upon this is placed a layer of the fine absorbent cotton, so carefully prepared for surgical uses. Spread so as to extend a little beyond the orbital margin, these soft and elastic pledgets exclude septic agents. They should not be heaped upon the eye so as to cause much pressure, which creates an uneasy feeling. These are retained in place by a few turns of a bandage, for which a flannel roller is the best material, as its elasticity allows it to be drawn sufficiently tight to prevent slipping, without making constriction upon the eyes. A strip of knitted material to cover both eyes, retained in place by tape strings, is preferred by some. This should never be used as a pressure bandage, as was formerly recommended. It is impossible to make effective compression at one point upon a rotating eyeball, which, as it rolls upward, as eyes naturally do when uncomfortable or during sleep, will infallibly shift the pressure to a direction which would tend to cause instead of preventing separation of the lips of the wound. In hot weather, a cotton or linen bandage may be substituted for the flannel after the first days. The patient should be watched during the first night, or have his hands secured so that he cannot raise them to his head, that he may not involuntarily touch his eyes during sleep. He should keep his eyes quiet, as if asleep, and avoid moving them, and should lie upon his back, if possible, for the first day or two. An anodyne, chloral hydrate or an opiate, is given with advantage, at bedtime, to most patients, for a night or two at least, even though no pain is complained of, as it insures quiet for the eyes.

If no pain is felt, the dressings should be left undisturbed for two or three days; or, which is perhaps better in the majority of cases, the outer dressings may be carefully changed daily, without opening the eyes. These should not be examined for five or six days, unless tumefaction of the lids, abnormal secretion, or pain, indicates that something is wrong. Should suspicious symptoms declare themselves, it is generally best to make a careful inspection of the eye with a moderate light, so as not to excite reflex contractions, in order to detect, and if possible arrest, any incipient morbid change.

In aged persons there is often objection to much change from the usual diet, though for the first days all food should be soft or cut fine, so that chewing shall not be required. A Russian oculist has lately stated that his operations on poorly fed peasants have been far more successful since he adopted the plan of giving a certain amount of stimulants after extraction of cataract, without altering in any other respect his previous treatment of cases. A mild laxative or an enema may be useful after a few days, if the bowels are constipated.

A loss of vitreous, on account of its abnormal fluidity, or from spasmodic contraction of the recti, may occur during or after an operation. Where this has its normal consistence it should be excised with curved scissors close to the eye. If fluid, no excision is needed. The lids should then be carefully closed and bandaged, and the eyes kept very quiet, to prevent any further vitreous escape. This is a by no means fatal accident, if the amount lost be not too large, the deficit being supplied by an increase in the amount of aqueous, which has about the same index of refraction. Hernia of the iris occurring at the time of operation should be reduced with a fine probe, and pilocarpine or eserine used to preclude its renewal. Should it happen at a subsequent period, the hernia, if considerable, is to be excised with fine curved scissors, so as to allow the edges of the wound to come together; if small, the wound may slowly heal without interference. In very rare instances, whatever mode of extraction has been chosen, all hope of vision is at once destroyed by the giving way of some vessel at the fundus, in consequence of the diminished pressure within the globe; vitreous mingled with blood being forced out at the time or within a few hours of the operation. Sloughing of its contents, followed by partial or complete atrophy of the globe, subsequently results. Suppuration at the edges of the wound or a sloughy ulceration of the cornea may occur from defective nutrition, causing delay in healing; or from the application of even moderate pressure. These processes may be limited, and only defer, without preventing, a good recovery; or the morbid action may involve the whole cornea, or extend to the ciliary region, causing irido-choroiditis, or even suppuration of the entire contents of the globe. Hot fomentations have been advised as a means of arresting these changes, but their efficacy is doubtful. Tonics, and if need be stimulants in moderate amount, are to be preferred to depletive measures. Where hopeless ophthalmitis is established, the wound should be reopened and the sloughing contents of the globe scooped out, to save time and suffering. This procedure is as effectual as enucleation, in these circumstances, and less dangerous. Irido-cyclitis sometimes supervenes where the healing of the external wound has been favorable. This is accompanied, if not caused, by proliferation of the endocapsular cells and thickening of the capsule, and the pupil may become closed by plastic lymph. Deep-seated and supraorbital pain, ciliary injection, chemosis of the conjunctiva, and tumefaction of the lids attend this process. The eye may sometimes be saved, when the pain and chemosis have not continued long, by introducing the fine canula forceps through the centre of the recently healed wound, and extracting the opaque capsule before its adhesions to the margin of the pupil have grown too firm; but to be useful this interference must be prompt.

A copious outflow of fluid vitreous, with displacement of the lens into the vitreous space during extraction, requires the employment of a scoop, fine hook, or forceps to search for and remove the lens, as this cannot safely be left in the eye.

If the surgeon be ambidextrous, the extraction is done on the left eye without change of position, the knife being held in the left hand instead of the right. If he cannot thus operate, he changes places with his assistant, and sits or stands at the side of the patient. Where the incision is to be made downward, the *modus operandi* is otherwise the same as by the upward section. When the patient is seated instead of lying down, the ambidextrous surgeon sits in front of him for the operation on either eye. If the surgeon prefers to use his right hand in making the incision, he sits in front of his patient in operating on the left eye, and stands behind him to operate on the right eye.

EXTRACTION, WITH IRIDECTOMY.

In the hope of lessening the dangers of the operation, iridectomy has been practiced as supplementary to extraction, sometimes as a preliminary, several weeks before the removal of the lens, sometimes by the conjunction of the two operations.

The principal reasons in favor of this procedure are the supposed more ready exit of the lens and the lessened chance of prolapsus iridis through the corneal wound. Preliminary iridectomy has slight, if any, advantages over that done at the time of extraction.

If iridectomy is to be done the operation should be by the upward section, so that the unsightly appearance of the artificial pupil and the dazzling caused by the excessive amount of light entering the enlarged aperture may be avoided by its being covered by the upper lid. The corneal incision being completed, the iris is seized near its pupillary border with the curved iridectomy forceps and drawn through the wound. A part of this membrane adjoining the pupil may then be excised by cutting the flap across with fine scissors, leaving its ciliary portion intact; or the iris may be simply incised radially with one cut of the scissors; or an entire segment may be removed, to the ciliary margin, by dividing one edge of the flap close to one extremity of the wound, drawing the forceps toward the other end, and there severing the iris by another cut with the scissors, the size of the segment removed being according to the estimated size of the lens and the judgment of the operator. The succeeding steps for the expulsion of the lens do not differ materially from those already described. Care must be taken that no portion of iris remains lodged between the edges at either extremity of the corneal wound.

Iridectomy may be combined with any of the methods of extraction. The objections to it are the attendant hæmorrhage, which renders the succeeding manœuvres more difficult, and makes it less certain that all cortical fragments of the crystalline have been removed; the perhaps greater chance of escape of vitreous; and the less perfect optical condition of the eye. These, however, would not be essential, were the proportion of recoveries notably increased by the removal of a part of the iris. This is claimed by the partisans of this method, but has not been conclusively demonstrated.

EXTRACTION BY OUTSCOOPING.

Removal of the lens, after corneal or scleral section and iridectomy, by passing a scoop behind it and drawing it through the wound, generally piecemeal, deserves mention, as having been warmly advocated a few years since by some of the ablest operators, nearly all of whom made some modification of the scoop spoon or of the external incision. The cut was smaller and healed more readily than the larger section made in flap extraction; but the contusion and disturbance of the internal parts, with the loss of vitreous, caused by the free and repeated introduction of rather large instruments within the globe, more than neutralized the supposed advantages, and the method has already become obsolete. The scoop is, however, now and then useful in searching for a lens which has fallen into the depths of the eye during an attempt to extract it.

PERIPHERAL LINEAR EXTRACTION.

This method, the latest of those devised by Von Graefe as a substitute for "outscooping," which he had previously supported, has been extensively tried, upon his authority, but more, perhaps, than any other operation has been variously modified by those who have adopted it. Iridectomy becomes a necessary factor in this mode of operating.

The instruments needed are a spring or other elevator to keep the lids open, fixation forceps, Graefe's narrow knife, an important improvement upon other cataract knives, curved iridectomy forceps, scissors, cystitome, and two curettes, one of which may, if preferred, be of hard rubber, for friction upon the globe.

The patient lies on a bed or couch, with his head so placed that the light falls favorably upon the eye. The surgeon, sitting behind his head for the operation on the right eye, separates the lids by means of the spring elevator. A large fold of conjunctiva is then seized with fixation forceps by the assistant, and the globe is steadily kept in the position desired by the operator. The knife, held like a writing-pen, with its edge upward and its point directed toward the centre of the eye, is passed through the sclera at a point about one mm. from the cornea at its temporal side, and at the extremity of a tangent drawn across the cornea at one mm. below its upper edge. Having thus entered the anterior chamber just in front of the iris, the knife is brought to a horizontal position, and carried forward to make a counter puncture through the sclera at the opposite end of the tangential line. The incision is completed by pushing the knife onward with its edge turned slightly forward, or by drawing it back and forth, keeping within the limits of the sclera, so that the incision shall be terminated close to the upper edge of the cornea. The conjunctiva being but loosely attached to the sclera, a sawing motion of the knife is required for its division, which can be deferred, if expedient, until after incision of the capsule with the cystitome. The iris is now seized with the forceps, the conjunctival flap being lifted forward if necessary, drawn out and excised to its periphery, so as to remove a large segment at its upper part; or the portion withdrawn may be clipped across, so as to include only a part of its pupillary margin, forming a key-hole addition to the central pupil. The cystitome is then introduced, and the capsule lacerated at its centre and upper part by a T-shaped or peripheral incision; slight pressure being made upon the globe with the curette or fixation forceps, to hold the lens and capsule fixed. The scleral wound is made to gape slightly with one curette, while with the other gentle friction is applied to the globe below the margin of the cornea, so as to push the nucleus of the lens through the wound. Much of the cortical substance is usually left behind as the nucleus escapes through the linear incision, and this is to be evacuated as completely as possible by gentle rubbing upon the cornea, made in the direction of the wound, care being used before closing the eye that no cortical fragments or portions of iris remain between the lips of the wound. Much time and friction are sometimes required for completing the expulsion of all portions of the lenticular substance. If the nucleus is evidently large and hard, as shown by the depth and extent of its amber color, the incision may be made with its terminal ends a little lower, thus gaining more room for the exit of the lens.

Numerous deviations from Graefe's plan have been proposed: some preferring an incision having a less linear and more flap-like form; others making the section at the sclero-corneal junction; others placing it entirely in the cornea instead of the sclera, so as to avoid the dangers of an incision so near the ciliary region.

The advantages of linear extraction are the more ready union of a small linear wound, of which the edges are likely to continue coadapted, than of a larger flap incision; the asserted better disposition to heal, because of more vascularity in the sclera than in the cornea; and a less tendency to hernia of the iris, which, by interposing itself between the edges of the flap wound, delays its union and favors suppuration.

On the other hand, the linear method has its own peculiar dangers. Loss of vitreous is more frequent than in flap extraction. Inclusion and traction of the iris or of the capsule at the extremities of the cicatrix is a not uncommon result. A cystoid scar, with alterations in the ciliary body and of the curvature of the cornea, is sometimes seen. Complete failure of the operation from immediate inflammatory processes is shown by statistics to be nearly as common as in flap extraction, being, according to Zehender, five per cent. as compared with seven per cent.; although the partisans of a new method are usually disposed to represent it in as good a light as possible.

But the gravest objections to peripheral extraction of hard cataract are only now beginning to manifest themselves; because sufficient time has not yet elapsed for the full development of its secondary consequences. The most important of these are precisely the accidents which might be anticipated from the situation of the cicatrix so near the ciliary body; namely, separation of the retina and irido-cyclitis, with reflex sympathetic inflammation and loss of the other eye. In less than fifteen years since Graefe's first linear extraction, a large number of cases of the latter misfortune had been observed in Europe, and many cases have recently occurred in this country, which gives reason to fear that the ultimate results of this method may prove to be less favorable than had been hoped.

MEDIAN-FLAP EXTRACTION.

The proposal to extract cataract through a smaller and more favorably placed incision of the cornea than that of the semi-circular flap method, so as to avoid the chances of non-union of the larger corneal section, and also the dangers attending the peripheral linear incision, has been advocated, under the term median-flap extraction, by Lebrun and Liebreich; the only essential difference in their operations being that the former makes his incision upward, the latter downward.

It is admitted that a successful extraction through the cornea, without iridectomy, gives better after-conditions of the eye than are otherwise attainable, — vision being best when the normal movements of the pupil are preserved. It is hoped that the smaller incision of the median operation will in a great measure obviate the dangers attending the older flap method, while retaining its advantages. If the value claimed for this method is confirmed after a still more extended observation of the immediate and secondary results, it will take an important place among the recognized modes of operation. Among its advantages are a wound of sufficient size to allow of the easy escape of the lens, and yet not so large as to involve much risk of non-union; the form of the wound, favoring accurate coadaptation of its edges; the position of the incision in relation to that of the upper edge of the crystalline, allowing the latter a ready exit; the absence of bleeding from the torn iris, obscuring the latter steps of the operation; the slight risk of loss of vitreous; and the expulsion of both the nucleus and cortical substance of the lens without long-continued friction and pressure on the globe.

The dangers attending median-flap extraction are only those which are common to every operation, and it has none peculiar to itself. A slight synechia of the pupillary border to the corneal scar may occur in cases where, from restlessness of the patient, slight prolapse of the iris, or any other cause, the corneal wound is not promptly healed; but this is far less serious than the extensive prolapsus of the iris sometimes seen in the old flap operation, and may generally be prevented by a judicious use of myotics. There is less risk of loss of vitreous than by either the semi-circular flap or the linear methods of extraction. A small iridectomy of the margin of the pupil may prove to be useful in preventing synechia; the place and the form of the incision of the cornea still being as advised by Lebrun. The necessary instruments are an elevator for the lids, a narrow cataract knife, a cystitome, two curettes, and fixation forceps.

The patient may lie on a bed, couch, or reclining-chair, near a window, and the operator sits or stands behind his head. Or he may sit on a chair, which can be drawn close to a window, while the surgeon takes a slightly higher seat in front of him. I operate without change of positions, with the right hand upon one eye, with the left upon the other, which has some advantages as to the direction of the light; but if the surgeon is not accustomed to use either hand alike well, he must shift his place for the operation on the second eye.

For the right eye, if the patient is lying down, the lids are opened by the spring elevator, or the operator raises the upper lid, while his assistant depresses the lower lid and fixes the globe with the forceps. The knife is to be lightly held, like a writing-pen, with the thumb and two fingers. The blade is not to be kept parallel to the iris, but its edge turned slightly forward as well as upward, if Lebrun's operation is the mode selected. The puncture is made at the temporal margin of the cornea, at or near the horizontal meridian. If the nucleus of the lens is probably large the incision may begin a little lower than this meridian; if small, a little higher. As in other methods, the point of the entering knife should be directed towards the centre of the eyeball, so that the internal extent of the wound may be equal to the external. As soon as it penetrates to the anterior chamber the blade is brought parallel to the iris, and pushed steadily on to make the counter puncture at an opposite point in the diameter, at the nasal side. Then, the edge being still turned a little forward, so that it is directed toward a point of the cornea midway between the upper margin of the pupil in a state of average dilatation and the corneal border, the incision is completed by pushing the knife onward till it cuts itself out at this point. If the section is steadily made the aqueous does not escape until the cut is nearly finished, and there is no danger of wounding the iris. The fixation forceps being now removed, the cystitome is carefully introduced, and, slight pressure being made upon the globe with a curette, the capsule is incised and the cystitome withdrawn. The posterior lip of the wound is now gently pressed upon with a curette, so as to cause it to gape, while another curette is applied against the globe near the lower margin of the cornea. Frequently the lens at once escapes entire; if not, any cortical fragments can be expelled by sliding the curette upward, so as to impel them toward the wound. If any portions are supposed to be hidden behind the iris they are brought into the field of the pupil by gentle friction upon the cornea, either by means of the curette or by rubbing the upper lid over it. A drop or two of a one per cent. solution of pilocarpine or of eserine may be put into the eye, to keep up for a few hours a degree of tension of the sphincter fibres of the iris, and prevent prolapsus or synechia.

Care being taken that the pupil is clear and the edges of the wound are free from lens substance, the eyes are closed and covered with suitable dressings, as already described.

The patient should be watched till quite recovered from his unconsciousness, and, unless he has a careful attendant, it is well to have the hands confined at night, so that he cannot touch his eyes. An anodyne is useful to secure quiet sleep, even if no pain supervenes.

If the dressings are well in place and unsoiled by discharges from the eye, and if no pain is complained of, no change need be made the next day. On the second day the dressing may be renewed without opening the eye, if no symptoms seem to call for its inspection. By this time the rounded form of the lids often indicates that the corneal incision is healed and the anterior chamber refilled. The patient may carefully turn on his side to relieve his position after the first day or two, and may sit up after three or four days. The dressings may be changed, but if all goes well the eyes should not be opened for several days.

EXTRACTION OF THE LENS IN ITS CAPSULE.

The removal of the whole lenticular apparatus in the operation for extraction would be desirable for several reasons. There would then be no danger of irido-cyclitis from irritation excited by the presence of remaining fragments of lens or lacerated capsule, or from proliferation of endo-capsular cells. Myotics could be freely used to draw the iris in front of the vitreous and give it support, without danger that it might be fretted by cortical masses lingering in the field of the pupil. Secondary capsular cataract, requiring another operation for its division or complete removal, would no longer be a source of annoyance, as it now so often is whatever method may have been employed.

The theoretical objections to this plan are the danger of loss of vitreous from want of the support afforded by the posterior capsule, and the chance that traction upon the zonula may excite ciliary inflammation. Such accidents, however, do not seem to have proved formidable in the experience of those who favor the simultaneous extraction of both the lens and its envelope. The method has not yet gained general acceptance, but it is unquestionably deserving of more extended trial. Endeavors should be made to improve upon the manner of extraction of the lens in its capsule which has been hitherto practiced by some operators; who make a downward flap, and combine with this a large iridectomy downward and outward; the most unfavorable position for an iridectomy both as regards visual and cosmetic effects.

SUTURE OF THE CORNEA AFTER EXTRACTION OF LENS.

The use of a suture to bring together the edges of the corneal wound was proposed by me about ten years since. Extensive further trial has proved the value of this expedient in many cases, whatever method of operation is employed; as also the perfect tolerance by the cornea of the exceedingly minute suture.

By holding the edges of the wound in contact the suture promotes immediate union; and tends to lessen the danger of hernia of the iris, loss of vitreous, and suppuration of the wound; while, by securing early restoration of the anterior and posterior chambers, it removes the iris from contact with the cornea, or with portions of lens substance or capsule; thus preventing synechia, or inflammation of the ciliary body. In my judgment, the suture deserves attention, as a means of gaining quicker and better results in any mode of extraction.

The needle I use is one fourth of an inch long, and has a flattened point with cutting edges. The needle-holder should not be fastened with a spring catch, but must be held with the fingers, so that the needle may be instantly released, without jar, at the proper moment. Only a single strand of the finest silk, scarcely larger than a filament from a cocoon, is used for the suture. One edge of the flap is taken hold of with a fine-toothed forceps, and held, while the needle is passed through it close to its border; the needle may be pulled through at this side before the opposite edge is seized and penetrated at a corresponding point. The slight contusion of a small point of the cornea by the forceps, or the continued presence of the suture, does no apparent harm. The silk may be left *in situ* till it comes away, or may be removed in a few days after the healing is consolidated, too much haste in this respect being avoided.

Suture of the cornea or sclera may also be used with great advantage in many cases of traumatic injury, so as to gain immediate union of the divided parts.

LINEAR EXTRACTION OF SOFT CATARACT.

Traumatic cataracts, which are always soft unless they have undergone secondary degeneration, and the various forms of soft and fluid cataract which are met with in the earlier periods of life, may be extracted through a linear incision of much smaller extent than the wound required to allow of the exit of the hard lens of advanced age, with of course a proportionally less risk than attends the larger wound. This incision should always be in the cornea. No removal of any portion of the iris is necessary. A bent iridectomy knife, fixation forceps, a cystitome and curette, and lid elevator, are the only instruments needed. The elevator may be dispensed with, and the upper lid raised by the surgeon or assistant. The pain is so insignificant that anæsthesia is not called for on that account; yet, if the patient is of a nervous temperament, or unmanageable, it may be prudent to obtain entire passiveness of the eye by its means. The pupil should be previously dilated by atropia. The operator, sitting or standing behind the head of the reclining patient, opens the lids with the elevator, or raises the upper lid with one or two fingers. If the elevator is used, the surgeon may himself hold the eye with fixation forceps; if not, this is done by the assistant. The bent triangular knife is then passed through the cornea at its upper or outer side, and about half-way between its border and the margin of the pupil when in a state of average dilatation, and pushed onward till the cut is of suitable size, the point of the knife being directed toward the centre of the anterior chamber and its flat surface toward the iris. In some cases of fluid cataract the lens capsule may be at once opened with this instrument, if preferred, by carrying the point toward and puncturing it. The section being made, the knife is withdrawn, and if the capsule has not been already divided the cystitome is introduced, and a crucial or other free incision is made. The curette is then applied to the posterior lip of the wound, causing it to gape, and the soft lens substance flows out, often leaving the pupil immediately clear. If too coherent to escape at once, portions of the lens may be coaxed toward the aperture by gentle friction upon the cornea with a hard rubber curette, or with the finger placed upon the closed lid, after waiting a few moments for the refilling of the anterior chamber with aqueous. Should a hard nucleus be unexpectedly found, the incision should be enlarged sufficiently for its removal without violence. Atropia should be continued after the operation, especially if any fragments of lens remain in the eye. The light should be moderated and the eyes kept closed ; — but no bandage is necessary, if the patient will follow these directions ; otherwise it should be used as a precaution against imprudence. Cold compresses may be laid over the lid if their effect is pleasant. This operation involves slight danger in the cases of soft consistence of the lens, to which only it is adapted. It is but very rarely, unless where there has been a mistake of diagnosis as to the softness of the lens, and some violence has been used to expel the nucleus, that loss of vitreous or hernia of the iris is observed.

DISCISION OF CATARACT.

If congenital, traumatic, and other forms of soft cataract implicate the entire lens, they may be removed by linear extraction, as above described, or may be operated on by division with a cataract needle, so as to obtain their subsequent solution in the aqueous humor. If only the central, or limited lamellar portions are affected, other means of relief may be found in atropia or in iridectomy, as I have already indicated. Formerly two methods were recognized as legitimate: an operation through the sclera, or through the cornea. Scleral division was effected by introducing the needle through the sclera, at the temporal side, a little behind the iris, bringing it over the top of the lens into the field of the pupil, and then cutting the lens into fragments by free movements of the needle. But the great expansion of the lenticular substance, like a sponge, when acted on by the aqueous, often excited cyclitis and irido-choroiditis, with loss of the eye; for which reason this method has fallen into disuse. In fact, it has been found that even corneal discision should be restricted within moderate limits, and the lens substance not too freely broken up at one time, it being safer to repeat the operation.

For division through the cornea, a lid elevator, which may be replaced by the finger, fixation forceps, which can often be dispensed with, and a fine cataract needle are the only instruments required. The last has the shaft enlarged at about half an inch from the point, as a stop from penetrating farther in case the eye should make a sudden movement toward the needle; or the shaft may increase slightly in size from the point, so as to fill the wound and prevent escape of aqueous from the anterior chamber, which, if it occurs, greatly impedes the manœuvres of division. Except in case of children the operation can be done without anæsthesia: for children, this should always be a preliminary. The pupil is to be previously dilated by atropia, a two-grain solution being sufficient. The patient should lie near a window, with his feet toward it. A young child may be placed upon a pillow on a table, which is pushed close to the window. The surgeon, standing behind the head, raises the upper lid with the forefinger or an elevator, and the eye is fixed, if necessary, with his middle finger or the forceps. The needle is introduced at the temporal side of the cornea, a little way from its margin, and carried toward the lens, the capsule of which is then carefully and not too largely divided by a linear or crucial incision. Unless the lens substance is very soft it is usually best to leave it undisturbed, to be slowly dissolved by the aqueous. Should it prove to be as soft as curd it may be partially disintegrated by a rotatory movement of the needle upon its axis; and should flakes of lens exude from the capsule some of them may perhaps be pushed with the needle into the anterior chamber. The instrument is withdrawn, and atropia is instilled to continue the dilatation of the pupil. The patient should be secluded from much light, and a cold compress laid upon the eye; or, if the patient is a young child, who is annoyed by any unusual covering, all dressings may be omitted. In case of infants the atropia solution should not exceed two grains to the ounce; otherwise toxic effects may follow. Its use should be continued daily or oftener, *pro re nata*, to maintain mydriasis. If the capsule has been largely cut, rapid expansion of the lens is likely to occur as the aqueous comes into contact with it; and flocculi protrude through the capsular opening and the pupil, to be more or less quickly dissolved, or to fall into the anterior chamber, giving place to fresh masses. Occasionally this sudden change of conditions in the lens and aqueous is accompanied by severe nausea and vomiting, and sometimes by pain, continuing for twenty-four hours or longer. If the capsular aperture is smaller, these changes may not at any time be very conspicuous; but absorption goes on more slowly within the capsule until the lens is all taken up.

After the lenticular mass has been much lessened by these means, a second operation may be done if only a very slow progress is apparent, or if the patient or his friends are anxious to hasten the result. At this time the rest of the lens may be entirely broken up, or it may only be more subdivided, as thought prudent. It must be borne in mind that it is safer to "make haste slowly;" doing a little at each sitting, and waiting patiently, or, if necessary, repeating the operation two or three times; than to incur by too free discision the risk of plastic inflammation of the sensitive structures surrounding the lens, and a probable loss of the eye.

If too rapid formation of flocculi fills the anterior chamber and crowds upon the iris, causing increased injection and much ciliary irritation, with disposition to contraction of the pupil, it is best to evacuate at once at least a portion of these masses by linear extraction, or perhaps by a suction operation. No local depletions, or other measures than the removal of the expanded flocculi, suffice to quiet this irritability when once established. But slight symptoms may manifest themselves, as effects of changes of pressure in the anterior parts of the globe, without giving cause for alarm so long as the iris retains its normal look and yields readily to atropia.

The time required for complete solution, after a single operation, may be six weeks or less, or it may extend to more than as many months. While absorption is going on, if even a slow change can be observed, it is often desirable, where no circumstances call for an immediate result, to leave the process to be gradually completed without resorting to a second operation. In such cases the improvement, slow at first, is much more obvious and rapid after the bulk and consistency of the lens has been partially diminished.

Early operation on infants born blind is essential, because, if unable to see, their eyes acquire involuntary rolling movements, nystagmus, — which, if continuing so long as to become a fixed habit, persists even after vision has been given to the child by removal of the cataracts, and is a serious impediment to the clear perception of objects because of this unsteadiness of the eyes.

REMOVAL OF CATARACT BY SUCTION.

Very soft cataracts may be immediately removed, and the pupil instantly cleared, by aspirating the lens through a very small tube, either by means of a syringe devised for this purpose or by the mouth. The silver tube, which is generally made larger than is necessary, is connected with a glass receptacle, into which the flocculi of lens are drawn by the syringe if this is used, or by a mouth-piece attached to a flexible rubber tube. The flexible tube and aspiration by the mouth are to be preferred, as being not only simpler, but as insuring a more intelligent application and regulation of the aspirating force than is possible with the syringe.

The cornea is punctured with a broad needle at about one fourth of the distance from the margin to the centre, and the capsule may be opened with the same instrument. This should be done with steadiness, and the needle quickly withdrawn, so as not to allow the anterior chamber to be emptied through the small wound. Should this happen, it is best to wait a few minutes, for refilling of the chamber with aqueous, before introducing the small tube. This is to be carried to the aperture in the capsule, and the lens substance drawn into the tube and its attached receptacle by gentle suction.

In favorable cases the immediate result is brilliant. But instances now and then occur where irido-choroiditis supervenes, even when no apparent violence had been done in the manœuvres of suction. On the whole, linear extraction seems to be a safer method, and equally applicable to these forms of cataract.

When the lens has become absolutely fluid, no introduction of a suction tube is required; but after incision of the capsule the turbid material is at once discharged into the anterior chamber, whence it can be removed, with the aqueous, by pressing upon one edge of the small corneal wound with a fine probe.

SECONDARY OPERATIONS ON THE CRYSTALLINE CAPSULE.

Whatever method has been followed in the removal of the lens, some portion of the capsule not unfrequently still remains stretched as a more or less complete veil behind the pupil, affecting the clearness of vision in a greater or less degree. In many instances the pupil appears to be clear at and soon after the operation, but the capsule subsequently becomes opaque. This cloudiness may be considerable, the field of the pupil as seen with the naked eye being uniformly or partially obscured by thickened capsule; or merely a slight haziness may exist, only discoverable with the mirror of the ophthalmoscope or by oblique illumination.

In some cases, within a few days after extraction of the lens, inflammation is set up, resulting in proliferation of the endo-capsular cells, thickening of the capsule, and plastic iritis, which, if not at once arrested, causes adhesion of the capsule to the margin of the pupil and destructive cyclitis. These phenomena are often rapidly developed in eyes where the corneal wound is already closed, and where all seemed to be going on well. The patient is restless, complains of pain, and there is a beginning of chemosis upon the globe. The pupil is contracted and the iris congested. Then, or soon after the manifestation of these symptoms, the pupil is found to be filled by a grayish or yellowish opacity, adherent to the pupillary margin, perhaps accompanied by hypopion in the anterior chamber. If an expectant, or a derivative depletive or alterative treatment is adopted, the pathological changes increase, and the eye is almost always lost. The only means which offers much chance of saving the eye is the prompt removal of the degenerated capsule, before its adhesions have become too firm and the contiguous parts too far involved. Canula forceps may be introduced through the centre of the former incision, and being opened as they reach the capsule this is to be grasped and drawn out, the recent adhesions of the capsule to the iris readily giving way. The pupil is often thus cleared at once, and the eye goes on well from this moment; but to be serviceable the operation must be immediate.

The above are the only circumstances in which secondary capsular operations should be done soon after extraction of the lens. In other cases where they are necessary, they should, if possible, be postponed until three months or more from the original operation, and until the eye has fully recovered from its effects. Delay is especially indicated where synechiæ, or other evidences of there having been plastic inflammation, are present. A judicious choice and modification of the operative procedure according to the indications of each particular case is here of the greatest importance. As a rule, etherization is desirable, so that the unconscious eye may be turned into different positions for the most advantageous use of instruments, and that no involuntary movement of the globe shall cause contusion of internal parts during the operation.

Where the ciliary attachments are but slight, dislocation of the opaque membrane, by carrying it downward or laterally into the vitreous space by means of a fine needle introduced through the cornea or sclera, and used as a lever, may be resorted to. But the suspensory attachments sometimes have much firmness and great elasticity, so that this manœuvre proves more difficult than had been anticipated, the capsule yielding to the action of the needle, but springing back to its place without a giving way of its adhesions. If not completely severed, these suspensory bands sometimes subsequently draw the capsule back to its former place. Even several attempts with the needle do not always suffice to detach them, while the capsule is rendered so flaccid by its partial separation that endeavors to tear its tough structure with the needle are not successful. There is considerable danger, in such cases, that the traction, if too long continued, may cause cyclitis, which is a reason for confining the application of this method to cases apparently favorable to a happy result. A very minute knife, with a slightly conical shaft, like a cataract needle, so as to retain the aqueous, but having one cutting edge for a short distance from its point, is a very serviceable instrument for these operations. Being directed upon the capsule, this is to be incised as freely as possible, so as to form an opening which shall be sufficient for visual purposes. The instrument may also be used as a lever, like a cataract needle, to detach some point of adhesion, or to enlarge an existing opening by laceration. If, from the toughness or elasticity of the membrane, it cannot be satisfactorily incised or lacerated with a single instrument, a second needle may be passed through the cornea at another part; and the points of the two needles, being carried through the capsule at a central spot, are then to be separated by moving the handles, lacerating the capsule to the desirable extent without traction upon the sensitive parts at its periphery.

When firm synechiæ have formed, with contraction of the pupil, it is difficult to divide or lacerate the false membrane without implicating or making dangerous traction upon the iris; and it is sometimes necessary to cut through and excise a part of the occluding mass by means of Wecker's scissors, introduced through a small wound in the cornea. Where this mass is very dense and firm, it may be best not to attempt to obtain a central pupil, but to form another, at a part of the iris which seems healthiest, by iridectomy; or by iridotomy or incision of the iris, done with the minute knife above mentioned, or with Wecker's scissors.

Extraction of the capsule by means of canula forceps is applicable to certain cases. Where this is suspended by small attachments, it is nearly impossible to displace or to lacerate it by needles or similar instruments; and in some other conditions the removal of the capsule from the eye is accomplished with more ease, and, by delicate manipulation, with less risk, than the obtaining of a sufficient opening through it. A small wound is made in the cornea with a broad needle or the point of an iridectomy knife, at a part which is the most favorable for seizing the capsule; the globe being for this purpose turned in such a direction as will allow of the use of instruments without hindrance from the orbital or nasal bones. The closed canula forceps is then passed in, and if possible as far as the capsule so quickly and steadily that the aqueous shall not escape till the membrane is grasped. The pressure of the thumb on the spring being relaxed, the blades open, and one of these may be pushed through any opening or against the centre of the capsule, so as to get hold of as large a portion as may be. Then, the blades being closed by pressure on the spring, the included portion or the whole capsule is to be drawn toward and out at the wound. Should there be adhesions to the iris, care must be taken not to pull too hard upon these, and thus tear the iris itself from its ciliary connections. In such case it is better to separate the capsule from its adhesions by means of a fine needle held in the other hand and introduced at another part of the cornea, or to withdraw the canula forceps, slightly enlarge the corneal wound, and divide or excise the false membrane with canula scissors or Wecker's instrument. Where the pupil is wholly occluded, and the smooth veil cannot be grasped with the forceps, a fine sharp hook may be substituted, which is to be fastened in the membrane at the side of the pupil opposite to the corneal wound, and the adhesions detached by cautious rotatory movements. If only a portion of the capsule is brought away by the instrument, it is usually better to be satisfied with this, rather than to reintroduce the canula while the anterior chamber is collapsed, as a second operation, if required, may be done with less risk than in persisting too long at one sitting. Moreover, it is often found in such cases, as well as in operations for laceration or incision, that when the anterior chamber is refilled the opening in the capsule proves to be all which is needed.

EXTRACTION OF SECONDARY DEGENERATED CATARACT.

In those secondary cataracts which result from disease, and not from traumatic injury or from operation, with the exception of cases of glaucoma, there is usually shrivelling and disorganization of the lens, attended with toughening of the capsule which defies all attempts to lacerate it. At the same time the zonular attachments become weakened; and the altered lens may be removed with canula forceps or a sharp hook through a linear opening in the cornea of moderate extent. This is done only for cosmetic reasons, to remove the deformity of a conspicuous white or yellow cataract in the field of the pupil, and of course with no hope of restoring vision. The operation requires care to avoid much loss of vitreous, which is generally abnormally fluid; but it is seldom followed by inflammation. Should the lens be cretaceous, a larger corneal incision and toothed forceps are needed.

Glaucomatous cataract should not be interfered with unless its removal is demanded by the persistence of severe pain in or around the eye, for which optico-ciliary neurotomy should first be tried before resorting to other measures.

EXTRACTION OF A DISLOCATED LENS.

The lens may be forced through the sclera by an injury, and remain beneath the more elastic conjunctiva without causing so much irritation as would be expected. But it is advisable to extract it at once through a small incision in the conjunctiva, closing the scleral wound by a fine suture or two, so as to retain the vitreous and preserve the fullness of the globe; as, if allowed to remain, the lens hinders the closing of the scleral wound. Such crushing force as has sufficed to rupture the sclera and eject the crystalline from its place is generally destructive of visual power in the eye; and it is wise to inform the patient of this before doing any operation, by which, as we should tell him, we merely hope to restore his comfort and avert or lessen the danger of sympathetic inflammation of his other eye, but cannot improve his sight.

If the lens has been thrown into the anterior chamber by traumatic agency, or from spontaneous dislocation, it may sometimes be replaced, as has been elsewhere shown. If it remains in this abnormal position, and causes much dull pain and irritation, its extraction is required. A linear incision or small flap is made with a narrow knife near the lower border of the cornea, and the lens may be assisted in its exit by drawing it out with a sharp hook, or with the fine iridectomy forceps or the curette. It is important not to urge the lens through the wound by the usual pressure upon the globe, lest there should be a loss of vitreous. Should there appear to be any danger that the lens may be pushed into the posterior chamber in making the incision, it may be transfixed, through the cornea, with a cataract or other fine needle, and thus held in place till its removal through the wound can be effected.

Where the lens is displaced backward into the vitreous, it should be carefully watched, and if it becomes a source of irritation should be extracted. Patients having such a movable lens must be careful as to stooping and as to violent exercise. Should extraction be determined on, it should be made through a median flap; the displaced lens being sought for, if not seen, with the sharp hook, the curette, or Waldau's scoop. Much disturbance and loss of vitreous is a probable feature of the procedure; but this is unavoidable, and is a less evil than the presence in the eye of a lens which has begun to act as a foreign body. After the extraction, suture of the wound with the delicate cornea needles is a great advantage in retaining the contents of the globe.

CHAPTER XV.

AFFECTIONS OF THE VITREOUS.

HYALITIS.

THE vitreous is but slightly susceptible of primary inflammation, though cloudiness or bands of connective tissue may form around a foreign body, or in the track by which it entered. The vitreous may, however, become disorganized and softened, sometimes without the occurrence of active symptoms. In ophthalmitis, supervening after ablation of staphyloma or other operations, or arising from disease, the vitreous is transformed into a mass of degenerated tissue resembling that of carbuncle. When this condition is clearly manifest from the extreme pain, injection, and phlegmonous chemosis, an immediate outscooping of the whole contents of the globe should be resorted to, not only to alleviate the intense suffering and hasten the otherwise slow recovery, but to obviate danger of septicæmia from purulent absorption. This may be done by making a sufficient incision in the cornea, and using a lid elevator as a scoop.

OPACITIES OF THE VITREOUS.

Temporary cloudiness of the vitreous accompanies certain pathological conditions of the internal parts of the eye, especially those where the tension of the globe is increased, as in glaucoma or serous iritis. The view of the fundus with the ophthalmoscope is obscured or completely lost for the time; but transparency is restored by the timely removal of the morbid conditions which create the haziness.

Fixed and definite, or more often floating, opacities of the vitreous, are frequent sequelæ of retinal or choroidal inflammation, and are often associated with the chronic choroidal alterations, in the form of posterior staphyloma, which so generally accompany high degrees of near-sightedness. They also result from hæmorrhagic effusion into its tissue. Softening of the vitreous usually coexists with these changes.

Vision is more or less affected, according to the amount of opacity; and in case of sudden effusion, or of an acute glaucomatous attack, it may at the moment be nearly abolished. Where the disease is less acute, the patient complains of fixed or movable spots before his eyes, oftentimes thrown upward if the eye is turned in this direction, and then sailing slowly down across the visual field. If, when at rest, these are in the axis of vision, the sight is sometimes bettered for the moment by such movements, which displace them. In other cases, the person complains in a general way of enfeebled sight, without having observed these spots as distinct phenomena, though they are revealed by the ophthalmoscope. When found in connection with other morbid changes, they make the prognosis more grave. If seen in myopic or other chronic alterations of the fundus, they should serve as an additional warning against congestion of the circulation by over-use of the eyes, or by over-exertion.

Separation of the retina from the choroid is now and then a sequel of vitreous disease; not, perhaps, so often from the traction or shrinking of fibrous bands which have formed in the vitreous as from the continued influence of other conditions of the fundus.

Opacities of the vitreous are best seen by the aid of the ophthalmoscopic mirror, without the object-glass. They appear as dark filaments or flocculi, more or less dense, and of various size and number; occupying positions nearer or farther from the fundus, and differing greatly as to their mobility. Sometimes they are detected only by careful search with the ophthalmoscope, and after several movements of the eye to bring them into the field; in other cases they are numerous and easily perceived. To bring them into view, the patient is told to turn his eye downward and then suddenly upward, to the right and left, and then to keep the eye for a few moments at one point, either looking upward or directly toward the observer, when the floating clouds are seen behind the pupil. The extent of their motion corresponds to the degree of fluidity of the vitreous.

No direct treatment of these opacities is indicated. Such measures should be adopted as may be required by other conditions of the case, for preventing further mischief, even if the state of the vitreous is unaltered.

MUSCÆ VOLITANTES.

Floating spots, of various form and number, known as muscæ volitantes, because they seem like insects, are often a source of great annoyance and anxiety to those who make constant use of their eyes. They are not to be confounded with the visible opacities of the vitreous above described. That they are not the result of important structural change is evident from the fact that they vary from one time to another, and in different circumstances; being seen, for instance, more numerously and distinctly after congestion from fatiguing use of the eyes, or when looking at a light surface, such as the ceiling, a cloudy sky, the page of a book, or the snow-covered ground. Most often, as their name indicates, they appear like little flies, but they may also resemble hairs, or beaded filaments, or transparent globules. As the eye looks from one side of the page to another, in reading, they float across the page; as it is turned quickly up, they rise, to descend slowly if the eye is kept in position. They doubtless depend to some extent on microscopic changes in the vitreous capable of throwing shadows upon the retina, but these are not discoverable by ophthalmoscopic examination. As nearly all studious people observe them at times, especially if the eyes are fatigued by work at late hours, or if suffering from indigestion, these muscæ are scarcely to be ranked as pathological phenomena.

The former idea, that these appearances are to be regarded as premonitions of amaurosis, is still so far preserved as a tradition that is often very difficult to convince those who have become alarmed from perceiving them, even by the most positive assurances, that they have no important significance.

CRYSTALS IN THE EYE.

Before the invention of the ophthalmoscope, crystals, sparkling like grains of gold-dust, were occasionally observed in the vitreous or crystalline. After operations for cataract by division or displacement, or in cases of softening of the vitreous, these could now and then be seen floating with the movements of the eye, and falling like a shower of gold rain when these movements ceased. Where the lens had been removed, they sometimes came through the pupil into the anterior chamber. These formations are generally associated with some other deviation from the normal condition, and with more or less, though not always very marked, depreciation of vision. With the ophthalmoscope mirror, or by oblique illumination, these crystals, usually of cholesterine, are readily seen, often in great numbers, giving bright and changing reflections.

These are to be let alone, rather than meddled with.

FLUIDITY OF THE VITREOUS.

Synchisis, or softening of the vitreous, exists in some cases where its presence is not indicated by floating opacities. It may be suspected where, without previous traumatic injury, there are tremulous movements of the iris; the iris and lens being less supported by the vitreous than in the normal condition. So long as the vitreous continues transparent vision is little affected, and the fluidity only becomes important in cases of cataract extraction. Most commonly, however, synchisis is but a sequel of changes in contiguous parts which may lessen or endanger the sight.

CYSTICERCI IN THE EYE.

Cysticerci were occasionally seen in the anterior parts of the eye prior to the invention of the ophthalmoscope, but their more frequent presence in the vitreous and in the posterior membranes has been revealed by its aid. Certain peculiarities of diet render the introduction of the germs of cysticerci into the human system more common in Germany than in other European or American countries. Graefe at Berlin saw more than eighty cases of cysticercus in the deeper parts of the eye, while in England, France, and Austria it is exceedingly rare. Wells, of London, reported only a single case, and Klein, of Vienna, none at all in 18,000 eye patients. I have never seen an instance in this country, and it must be very seldom met with in America, except, perhaps, among the German population.

As described and delineated in Liebreich's Atlas, the cysticercus first appears as a grayish-blue spot beneath the retina, which in a few weeks is developed into the well-defined parasitic vesicle. It may make its way at once through the retina into the vitreous, or, previous to doing so, may cause sub-retinal effusion and separation. As seen with the ophthalmoscope in the vitreous it is a bluish-gray sac, with whitish or reddish reflection of light from its edges. If closely watched, movements of the head and neck may be observed. Its presence causes dimness of sight, gradual opacity in the vitreous, and irido-choroiditis, terminating in the course of a year or two in atrophy of the globe. It should therefore be extracted before the transparent media have become so far affected as to conceal its position.

The operation is done by the aid of such a mirror as is used for exploration of the ear; which is to be fastened in front of the surgeon's eye by a band passed around his head. If full dilatation of the pupil does not give a sufficient view of the parasite on looking through the central aperture of the mirror, iridectomy may be done to obtain its better illumination. A small linear incision is made in the sclera, and, Graefe's blunt hook or the canula forceps being introduced, the cysticercus is to be seized at its neck and drawn gently out, without rupturing the vesicle, if this can be avoided. A point of suture in the scleral wound will prevent further loss of vitreous after the operation. Extraction of the crystalline, and afterward of the cysticercus, through the cornea, has also been done. Vision is not preserved by the removal of the parasite, but the eyeball is saved from the slow degeneration which otherwise takes place.

CHAPTER XVI.

AFFECTIONS OF THE MOTOR MUSCLES.

ACTION OF THE MOTOR MUSCLES.

THE central point of the globe is virtually the centre of rotation. A vertical line drawn through the centre of the cornea is the vertical meridian. The direction of action of a muscle is a straight line drawn through its middle from one insertion or attachment to the other. A plane through this line and the centre of rotation is the plane of the muscle, and a line drawn perpendicular to this plane through the centre of rotation is the axis of rotation for any given muscle.

For determining the movements of the eyeball we take as our points of observation the centre of the cornea and the vertical meridian, and in speaking of the inclination of this meridian the position of its upper end is that which is referred to.

Professor Donders, to whom we owe so much of our knowledge of the physiology of the eye, lays down the following rules as to the position of the vertical meridian in the various rotations of the eye : —

1. In looking in the horizontal meridian plane, straight forward, to the right or to the left, the vertical meridian is not inclined, but remains vertical.

2. In looking in the vertical meridian plane, straight forward, upward, or downward, the vertical meridian also remains vertical.

3. In looking diagonally upward to the left the vertical meridians of both eyes are inclined parallelly to the left, that of the left eye slanting outward, that of the right eye inward.

4. In looking diagonally downward to the left the vertical meridians of both eyes are inclined parallelly to the right, that of the left inward, that of the right outward.

5. In looking diagonally upward to the right the vertical meridians of both eyes are inclined parallelly to the right, that of the right outward, that of the left inward.

6. In looking diagonally downward to the right the vertical meridians of both eyes are inclined parallelly to the left, that of the right eye inward, that of the left outward.

The six muscles may be regarded as three pairs, of which the plane of rotation is virtually, though not absolutely, the same for each pair.

The action of the superior and inferior recti is not only to turn the eye upward and downward, but, on account of the slight obliquity of their insertions, to turn it slightly inward, and incline the vertical meridian inward for the superior and outward for the inferior recti.

The external and internal recti act as an antagonistic pair, turning the globe directly outward and inward, without inclining the vertical meridian.

The superior oblique rolls the eye downward and outward, and inclines the vertical meridian inward. The inferior oblique rolls it upward and outward, and inclines the vertical meridian outward.

Combinations in the action of these muscles produce all the various rotations of the globe, very few of which are affected by the sole action of one pair.

In rolling the eye directly upward the tendency of the superior rectus to draw it slightly inward and incline the vertical meridian inward is counteracted by the inferior oblique, so that, acting together, the vertical meridian is not deviated.

In turning it upward and inward, the vertical meridian being turned inward, the internus is associated with the superior rectus, and any excessive inclination inward of the vertical meridian is prevented by the inferior oblique.

In rotating the eye upward and outward, the vertical meridian being turned outward, the externus acts with the superior rectus, and the inferior oblique coöperates in neutralizing the disposition of the superior rectus to incline the vertical meridian slightly inward.

In looking directly downwards the disposition of the inferior rectus to turn the eye a little inward and to deviate the vertical meridian a little outward is counterbalanced by the superior oblique.

In rotating downward and inward and downward and outward the inferior rectus acts respectively with the internus and externus; the superior oblique, in both cases, coöperating to prevent the slight deviation outward of the vertical meridian by the inferior rectus.

The rectus externus turns the globe directly outward. The rectus internus turns it directly inward.

Acting altogether, the recti tend to retract the eye within the orbit, the obliqui to draw it forward.

In upward and downward movements the superior and inferior recti of the two eyes act together. In looking in lateral directions the externus of one eye acts with the internus of the other. All such movements as keep the optic axes, or, more accurately, the visual lines, parallel with each other, are termed associated movements. But in looking at near things the interni of the two eyes act together, so as to make the visual lines converge upon the object; and this movement, which is associated also with simultaneous action of the ciliary muscle in the two eyes, is termed the accommodative act.

PARALYSIS OF THE MUSCLES.

The ocular muscles derive their motor stimulus from three pairs of nerves. The third nerve, — motor oculi, — supplies the recti interni, superior and inferior, and the obliquus inferior. It also furnishes a branch to the levator palpebræ superioris; and, through the ciliary ganglion, furnishes the ciliary nerves to the iris. The fourth nerve, patheticus, is devoted solely to the obliquus superior. The sixth nerve, abductor, supplies only the rectus externus.

Suspension of function in either of the nerves will weaken or abolish contractile power in the muscles it animates. Occasionally more than one of these nerves are simultaneously or successively affected. If all are completely paralyzed the eye may be immovable, but the immobility caused by pressure from tumors within the orbit or beyond its walls is not to be mistaken for paralysis. If the paralysis is incomplete, the action of the muscle is limited, but not abolished. Where the third nerve is involved, one, or more, or all of the muscles to which its branches are distributed may be deprived of power.

Paresis or paralysis of either of the motor nerves gives rise to symptoms which are usually readily to be discovered. The affected eye does not turn, or turns but partially, in a certain direction, and its visual axis does not follow the movement of that of the other eye. This loss of parallelism of the visual axes causes the formation of double and inharmonious images upon the retinæ; to avoid which the patient directs his head toward the side where the paralysis exists, giving to him an appearance which is often in itself sufficient to indicate a diagnosis as to which is the affected nerve.

In addition to the visible signs of motor inability, and sometimes where these are scarcely distinguishable, other symptoms are present, which are recognized only by the patient. What is termed muscular consciousness is an important part of the visual act; the ocular muscles being, as it were, aware of the position of the globe, and of the degree of tension conforming to that position, which is necessary for the formation of harmonious images in the two eyes and for the correct estimation of dimensions, direction, and distance. When, by default of consentaneous action in one or more muscles with the corresponding muscles of the other eye, this consciousness as to the position of the eyes is much disturbed, the brain becomes confused by the double images conveyed to it, and the patient is uncertain as to the relations of external objects to each other and to himself. A very slight defect of muscular action may, however, be neutralized or disregarded by the sensorium. Where the paralysis is sudden, and especially if it implicates more than a single nervous branch, or those turning the eyeball downward, the person cannot at first even walk without vacillating or staggering; since the projected images of things appear to the two eyes to be in two different places, of which he cannot determine which is the spot really occupied by the object. If the paralysis affects but one eye, the direction of things is correctly seen with the healthy eye when the other eye is covered, and he is thus enabled to walk steadily; but the estimate of distance and of size is still inaccurate, binocular vision being necessary for the exact appreciation of these.

When the paralysis weakens the abductor and causes convergence, the diplopia is homonymous, the image to the right being formed in the right eye, that to the left in the left eye; the image being impressed on the inner or nasal side of the retina, so that its projection appears at the temporal side.

When the adductor is paralyzed and the eye diverges, the images are crossed; that formed at the outer side of the retina of the diverging eye crossing in its projection, so that it appears to the nasal side.

A red glass may be held before one eye in determining which is the false image. In a downward squint this image is above that in the healthy eye; in an upward squint it is below it. The image of an object as seen by the affected eye always appears to the patient in a direction opposite to that in which the eye is deviated. When the eyes are turned toward the side of the paralyzed muscle, the double images are further apart; and it is in order to unite these into one that the head is kept turned to the opposite side, or, if the deviation is oblique, is inclined toward one shoulder while the face is turned a little inward. When in normal conditions we turn the eyes down there is also convergence; convergent squint will in this position be increased, while divergent squint is greater when the eyes are turned upward.

Where there is only paresis of a muscle, the images are not so much doubled as confusedly blended; but this effect is increased by fatigue or illness, which still further weaken the innervation. Great relief from this confusion is obtained by closing or covering one eye.

Paralysis of the muscles is distinguishable from the want of harmonious action occurring in strabismus by the fact that the secondary deviation of the sound eye, when this is covered and the other eye is caused to make an attempt to use the paralyzed muscle, is greater than the primary deviation of the affected eye; whereas in strabismus they are equal. The effort to contract causes a consentaneous action in the corresponding muscle of the opposite eye, according to the law of muscular consciousness which makes these two recti act together as one pair. For instance, if the sixth pair of the right eye be paralyzed, so that the right external rectus has lost its power, we have a primary deviation inward of the right eye when a distant object is looked at; but if the left or sound eye be covered with a screen, and the patient is directed to fix the same object with his affected eye, a secondary deviation will occur inward in the sound eye, which will be greater than the primary convergence of the other eye. The ineffectual effort of the paralyzed externus being greater than would normally be necessary to give a certain degree of rotation, causes a similar excess of action in the rectus internus of the fellow eye, and a resulting greater movement of convergence.

Rays entering the deviated eye may be so changed in direction, by means of a prism, that they fall on the part of the retina which corresponds to the place of the image in the sound eye, and double vision is thus obviated. This means may be useful in making a diagnosis; but, as rays, to be thus correctly refracted, must fall in a certain direction upon the prism, it is not practically available for ordinary wear, as the patient cannot keep his head always in the needful position.

If paralysis continues for some time, the opposing muscle may become actually contracted by absence of antagonism.

Central oculo-motor paralysis may ensue from central affections of the brain, most frequently from pressure of abnormal growths or of apoplectic effusions. As a rule, the paralysis in these cases is monocular, and is at first partial rather than total, and it is associated with other evidences of cerebral affection. If caused by pressure from a tumor it is generally slowly progressive, and in the later stages is accompanied by gradual loss of power in other cerebral nerves; the special sensations of sight, taste, smell, and hearing being often abolished.

If arising from basilar meningitis, or from syphilitic enlargements or other disease at the base of the cranium, the loss of mobility is often at once complete, the entire trunk of the nerve being affected by the pressure. If occurring during coma, the deviation may be but temporary. Fortunately, paralysis of the motor nerves of the eye is oftenest peripheral, monocular, and the attack generally acute and of favorable prognosis. Either nerve may be affected, though the third and sixth are most frequently so, the fourth more rarely. The loss of power may be complete, as is most common, or only partial. One or more branches of the third nerve may be enfeebled, while the other filaments retain their function. Exposure to cold is often the exciting cause: a person has perhaps been riding, walking, or sitting in a cold or cold and damp wind, and within a few hours, or on rising the next morning, finds himself endowed with double vision and the accompanying confusion of sight. The recovery is by no means so sudden as the onset of the attack, being often protracted through weeks or months. But when improvement is once begun the symptoms generally subside more and more rapidly.

In the treatment of these paralyses, general indications should be carefully noted and followed. Where chronic cerebral disease exists, remedies are usually of little avail. If caused by basilar meningitis, or, especially, by syphilitic changes, suitable alterative treatment is to be instituted, and the prognosis may be more or less favorable.

When only the peripheral terminations of the nerves are implicated, remedies adapted for the removal of rheumatic conditions are to be employed, with perhaps stimulating lotions, such as bay rum, spirits of camphor or of rosemary, applied about the temples and brow. No active treatment by depletion or counter irritation is of service; time and the *vis medicatrix naturæ* being in fact our main reliance. It is doubtful if the use of electricity accelerates the cure.

To avoid confusion in walking, the affected eye, or, where both are involved, the eye most deviated, may be covered by a shade, or by very dark-colored or frosted glasses. Prisms sometimes give partial relief.

PARALYSIS OF THE ABDUCENS.

When the sixth nerve is completely paralyzed, the external rectus is disabled, and the eye is turned inward by the action of the internus. If an effort is made to turn the globe outward it cannot be brought beyond the line of the vertical meridian, but remains fixed, or turns obliquely from action of the oblique muscles. Objects in front are seen double in the horizontal meridian, and the distance apart of the two homonymous images is increased if the object is carried toward the paralyzed side. If it is placed toward the opposite side, there is no diplopia and no defect of position or rotation of the eye. If the object is moved upward and outward, the image in the affected eye is inclined a little outward from the vertical, and appears a little lower than that in the sound eye. If it is carried downward and outward, the image inclines inward, and is a little higher than that in the other eye.

The patient will be disposed to keep the head turned toward the affected side, and he is thus able to avoid, in a great measure, uncertain movements in walking, and erroneous estimates of the distances of objects.

Where the paralysis is not complete, the eye may be rotated a little outward; but this position is maintained with difficulty and tremulousness, as when any other muscle is overstrained. Movements are also irregular, from the simultaneous action of the associated obliqui.

In case of long persistence of this, as of other paralyses, a secondary contraction of the opposing muscle may take place, which persists after restoration of the normal nerve stimulus to the externus.

If the muscle has been only enfeebled, frequent exercise may conduce to the recovery of its power. Prisms, with the base turned outward, may sometimes be useful; not to the extent of fully correcting the diplopia, but of such a degree of refraction as brings the double images nearly together, and stimulates the muscle to make an effort to unite them.

PARALYSIS OF THE OCULO-MOTORIUS.

Instead of supplying but a single muscle, the third pair of nerves, entering the orbit in two branches, has a distribution to all but two of the ocular muscles: namely, to the superior, inferior, and internal recti and the inferior oblique; as well as to the levator of the upper lid, and through the ciliary ganglion to the iris and ciliary body. This various distribution of motor power gives rise to many complications of symptoms. When all branches of the third nerve are completely paralyzed, the upper lid is closed, and if this is raised by the finger the eye is seen to be turned outward by the action of the externus, and cannot be carried far in other directions. The pupil is moderately dilated, and insensible to light. The fourth and the sixth nerve continuing to act, the eye can be rotated a little downward and outward as well as outward. As the globe is not held back by the recti muscles, it may seem slightly prominent. The diplopia is crossed; that is, the image appears to be on the opposite side from the eye in which it is formed. The enfeebling of the ciliary branches usually causes loss of accommodation for small near objects, and a certain degree of dazzling from the greater influx of light through the enlarged pupil.

Remedies for neutralizing a rheumatic or syphilitic diathesis should be used when indicated. Other treatment has little therapeutic value, but mild, stimulating applications about the orbit may be prescribed. The prognosis is generally favorable in the peripheral paralyses, though many weeks often pass before complete recovery of power. In the rare cases, where the simultaneous implication of other of the motor nerves or evident cerebral symptoms denote a central lesion rather than a peripheral loss of function, the prognosis is graver, though recovery is by no means impossible, especially in syphilitic cases.

One or more divisions of the motorius are sometimes affected without loss of power in the other branches.

The inferior oblique is rarely, if ever, solely involved. Paralysis of the superior rectus is the least inconvenient of all the suspensions of muscular motility, inasmuch as rotation upward is relatively seldom called for. When it occurs, there is slight divergence, from the action of the inferior oblique, when the eye is turned upward, the crossed double image is above that in the fellow eye, and the images are inclined outward from each other. These are more widely separated in height as the eye looks outward, and more inclined when it is turned inward.

Where the inferior rectus is paralyzed the patient has much annoyance in walking, from the loss of power of directing the eye downward. The diplopia is crossed, the false image appears lower than that of the other eye, and the images converge toward each other at their upper part.

Paralysis of the rectus internus causes divergent squint and crossed diplopia, but, except in the oblique rotations, no inclining of the vertical meridians.

PARALYSIS OF THE FOURTH NERVE.

Like the sixth, the fourth nerve, — trochlearis, patheticus, — supplies but a single muscle, the superior oblique. Its paralysis is more rare than that of the third or the sixth. When the eye looks at objects a little above the horizontal meridian there is no deviation, but when the object is below this, in the middle line, instead of turning toward it, the eye deviates upward and inward. The double images are homonymous, and the image in the deviating eye is below that of its fellow, their upper ends converging toward each other. This obliquity is increased if the object is moved farther toward the temporal side, while the distance and difference of height are lessened. As seen with the affected eye, the object often appears nearer than with the other.

The position of the head is characteristic: it is inclined a little forward, and toward the shoulder of the unparalyzed side, the face turned a little inward.

Prisms, with the base downward and outward, alleviate the diplopia in some directions but create it in other parts of the field, and are therefore not available for treatment. The prognosis is generally favorable for a slow recovery. In a few instances, chronic paralysis of the fourth nerve has induced secondary contraction of the inferior oblique.

PTOSIS.

Drooping of the upper lid may not only occur as one of the symptoms of complete paralysis of the third nerve, but may ensue from other causes. Traumatic or other œdematous infiltration, erysipelas, and in a few exceptional cases hypertrophy of the skin of the lid may so increase its weight as to overpower the levator muscle. Ptosis may also exist congenitally.

Want of power in the levator muscle is sometimes the initial symptom of loss of function in the third nerve.

Where paralysis exists without hypertrophy or infiltration, the frontalis muscle acts to a certain extent as a substitute for the levator, raising the lid a little; but the patient has to make considerable exertion to accomplish this. The head must be thrown back in order to see things in front of a person, and elevated objects cannot be seen. In congenital ptosis of both eyes, the deformity as well as inconvenience is considerable; and if its degree is extreme an operation to remove an elliptical fold of the skin and subjacent tissue of the lid, with union of the wound by sutures, so as virtually to shorten the lid and to obtain yet more aid from the muscles of the forehead and eyebrows, is indispensable. Care must be taken, however, to make the excision too small rather than too broad, as in this latter case the lid is so far drawn upward by the cicatrix that it cannot be shut by the action of the orbicularis, and the cornea is thus left exposed, especially during sleep, to irritating and desiccating agencies, imperilling its safety.

PARALYSIS OF THE ORBICULARIS PALPEBRARUM.

Partial or complete paralysis of the seventh nerve, — facial, — which supplies this muscle, weakens or abolishes the action of the orbicularis, and the lids cannot be closed. The upper lid is held more or less open by the unopposed action of the levator, and the edge of the lower lid tends to droop outward from lack of the usual support given by its fasciculi of muscular fibres. The secretions are not duly conveyed toward the puncta lachrymalia, and linger in the lower palpebral sinus, tending by their weight to increase the lid eversion. The everted surface of the conjunctiva becomes thickened and inflamed, and the cornea, no longer suitably moistened and cleansed by the movements of the lids over its surface, is irritated by the contact of air and dust, and acquires a chronic vascular or ulcerated condition, very difficult to heal, and often resulting in loss of the eye.

Caries of the petrous portion of the temporal bone, intracranial syphilitic disease, as also exposure of the side of the head to cold and damp, are the usual causes. If the seat of disease is in or beyond the petrous bone, other lesions, especially loss of sight and hearing, may coexist. Where the symptoms have been occasioned by unfavorable atmospheric influences, the paralysis is usually of only temporary duration.

Syphilitic affections require alterative means, which slowly have a favorable effect. Warm or stimulating applications over the course of the nerve, and such remedies as are useful in rheumatic affections, may be employed in treatment of the more superficial cases. In chronic conditions, surgical shortening of the lower lid, by removal of a V-shaped portion from its centre, are available in some degree in relieving its everted position.

NYSTAGMUS.

Involuntary oscillating movements of the eyes are not uncommon in albinos, in those born blind, or those who from any cause have for a long time had imperfect vision. Acquired nystagmus is also mentioned as sometimes seen in miners, who spend a large part of their lives in a semi-obscurity.

I once saw, and exhibited to the American Ophthalmological Society, a most remarkable instance in a middle-aged man, whose account of himself was as follows: Observing, while a young child, that by moving his eyes rapidly he could make the light of a candle dance before them, he had practiced this movement more and more, until, when I saw him, he could move the eyes laterally, vertically, or with a rotatory motion with amazing rapidity. That he was able to do so with impunity was the more surprising, as he had dislocation of both crystalline lenses.

These movements of the eyes may often be measurably controlled by those who are subjects of them, especially when they place the head or eyes in some position as regards the objects looked at. They are sometimes as frequent as one per second, and excitement increases the quickness of oscillation. This is oftenest in the horizontal meridian, from the action of the lateral muscles, but is sometimes rotatory, from action of the obliqui, and occasionally vertical. The imperfect sight, which is an exciting cause, is also a consequence of this affection, it being difficult for the retina to form clear images of objects which are, as it were, in constant motion before it.

INSUFFICIENCY OF THE RECTI INTERNI.

The rectus internus has an importance altogether beyond that of its mere function as one of the motor muscles of the eye, since, by its indispensable aid, one of the most essential acts of vision, the accommodation for near objects, is accomplished.

The insufficiency now to be described is not the effect of paralysis. The movements of the muscle, for a time, are normal in quickness, in extent, and in their coördination with the action of the internus of the opposite eye. But after a certain period of close application to near vision, the innervating power becomes temporarily exhausted or enfeebled, and the muscle is no longer capable of keeping up the required degree of convergence of the eye. This fatigue of nervous and muscular function causes a sensation of strain, if the visual effort is continued, and is termed muscular asthenopia. The patient complains that after continuous reading or writing the characters on the page are blurred and run together, and this confusion gradually increases, till work with the eyes can be pursued no longer. These symptoms are accompanied by a dull pain and tension, generally first felt at the inner angle near the insertion of the internus, and afterwards extending through the eyeball and to the frontal region. These phenomena disappear after a greater or less interval of rest, to be again manifested after another prolonged use of the eyes in near vision. If the attempt is made to continue reading after the visual sensations have become thus confused, the letters grow still less distinct or appear doubled; and patients are often conscious that to avoid this diplopia they are involuntarily using only one eye, allowing the other to turn outward far enough to relinquish its share in vision; the image in the diverging eye being then formed so far from the macula lutea and so faint that it does not send a distinct impression to the sensorium. Thus, or by covering the weaker eye, these persons are enabled to continue work for some time longer with less discomfort.

Muscular may be distinguished from accommodative asthenopia by the fact that the range of accommodation in each eye, when tested by itself, remains normal; and from retinal asthenopia, caused by feeble perceptive power, or by interception of a part of the rays required to form a clear image, by the absence in this latter case of the symptoms of muscular inability.

Insufficiency of the internal recti may be quickly discovered by holding a pencil or the finger in the median line, some four or five inches in front of the nose; then, one eye being covered with the other hand or a piece of paper, the covered eye will be seen to diverge, behind the screen, while its fellow converges toward the near object. If the screen is now suddenly removed, the eye makes a quick movement of convergence, to bring itself into a position for seeing a clear image of the object, in harmony with that in the opposite eye. For the instant before this is accomplished the patient either sees two objects, or the pencil appears to shift its place. Insufficiency may also be tested by holding a prism before one eye, with its base upward or downward, so as to cause double vision, with one object higher than the other; if there be incapacity of the internus, there will be a deviation of the eye outward and crossed diplopia. The amount of inadequateness, in any case, is indicated by the degree of a prism which, placed with the base inward before the eye, would unite the double images.

Where illness has enfeebled nervous force, or the eyes have been disused from reading, weakness of the recti may exist for a time and require careful and moderate use of the eyes. Insufficiency may also be developed in the internal rectus after loss of sight in an eye, divergence of this eye being gradually established.

The necessity for bringing small things very near to myopic eyes, and thus demanding of the interni excessive strain in convergence, is partially provided for by greater muscular development; but it is a very frequent cause of insufficiency. Especially is this true in the higher degrees of short-sightedness, where the internal recti have added difficulties to overcome in their insertion too far forward relatively to the axis of the elongated eyeball, and in the deformed shape of the globe as regards the orbital cavity, which impedes its free rotation in the orbit. When, at length, the effort of sustained convergence becomes too fatiguing, the eyes are often turned strongly outward to avoid the constant discomfort, and divergent strabismus is accepted as a lesser evil.

Mere rest of eyes which have this insufficiency does not restore their ability to work. They should be carefully exercised according to directions laid down for them, rather than wholly disused, and will not be injured, but improved, if this is reasonably done. Myopes who have insufficiency often find great advantage in using concave glasses for near work, which virtually increase the apparent distance of objects, and thus obviate the need of so much convergence. The glasses should not be set too near each other, but sometimes should even be decentrated, so that the inner edges of the glasses may have the effect of prisms, with base inward.

The use of prisms with base outward has been proposed as a means of gradually increasing the power of a feeble rectus internus; the angle of the prism being diminished from time to time.

In hyperopia, intermitted use of the eyes, with the aid of suitable convex glasses, is to be insisted on.

Tenotomy of the external rectus, to weaken its antagonistic action, though theoretically applicable, has not proved practically useful for the relief of insufficiency of the internus.

Use of the eyes in reading, etc., interrupted every few minutes by looking for a moment at objects across the room, so as to bring the visual axes parallel and relieve the recti interni, and not continued too long at one time, but repeated several times a day, is a valuable method for gradually removing insufficiency which has resulted from strain of the eyes, or which is an effect of previous disease. These exercises should at first be prolonged for only a very few minutes, but may be lengthened by degrees, taking care to avoid inducing asthenopic sensations. Convex glasses should be worn while the eyes are thus trained if the person is hyperopic, or if the power of accommodation is limited from any cause.

STRABISMUS.

In normal fixation of the eyes upon any object in front, the optic axes intersect at a point in the object looked at; in strabismus, the axis of the squinting eye deviates from this point; and whereas in paralysis the inability to fix the eyes depends on loss of nerve power, in strabismus the motive power is intact, but its action is inharmonious in the two eyes, so that they do not take a corresponding or parallel direction. An eye suffering from paralysis or paresis of motive force does not accompany the movement of the other eye when turned in the direction of its paralysis. If the sound eye is covered, the deviating eye will make an effort of fixation, and the secondary deviation in the sound eye behind the screen will be larger in amount than that of the affected eye. In strabismus the rotations of the two eyes are concomitant and of equal extent, and the degree of secondary deviation when one eye is covered is the same as that of the primary squint. There is no paralysis, for the swerving eye can be turned in all directions. But in all these movements, the axes, as before, continue inclined to each other.

Most cases of strabismus are in the horizontal plane, it being only exceptionally that other than the lateral muscles are involved.

The degree of squint is best determined by Bowman's method. The extreme range inward is marked by the position of the pupil in extreme inversion as compared with the lower punctum lachrymalium; the extreme outward range by the position of the outer margin of the cornea in extreme eversion as compared with the outer canthus.

Occasional strabismus, the eye squinting only when the child is ill, tired, or excited, or has used the eyes a long time on small objects, is not seldom observed at the outset of the affection; and it may continue thus awhile, when the accommodative power in the ciliary muscle, lessened by insufficient nervous stimulus, does not effect the requisite changes of form in the crystalline lens, and must be supplemented by the instinctive auxiliary action of the internal recti.

Alternating strabismus, where either eye deviates by turns, is not uncommon. Here the visual power does not become impaired to the same extent as in ordinary squint, since each eye is successively brought into use.

An apparent strabismus, on account of an unusually great inclination of the visual line to the optic axis drawn through the centre of the cornea, is sometimes observed. In hypermetropes this apparent strabismus is divergent, giving to the eyes an expression as if the person were, as we say, lost in thought.

It was formerly supposed that strabismus was often congenital, or that it arose from a constant attraction of a young child's eyes toward an object always in the same position, or ensued from imitation of others who squinted, or was a direct effect of some disease of childhood. It was therefore believed that it would disappear as the influence of these agencies was lessened. We now know that these were erroneous opinions, and that, though supervening about the period when a child begins to look closely at things, strabismus is generally, at the outset, only a symptom resulting from certain refractive conditions; although, when actually established, it becomes in its turn the cause of other optical defects and often of great deterioration of visual power.

It is to Professor Donders that we owe the discovery that convergent strabismus is nearly always a consequence of hypermetropia, and divergent strabismus a sequel of myopia. In thus scientifically demonstrating the ætiology of this affection he proved the futility of former methods of treatment, and at the same time determined laws, according to which optical means or operative measures should be employed.

In a few exceptional cases permanent deviation may result after long-continued paralysis or insufficiency of a muscle, from contraction of its antagonist. To this condition the term luscitas has been applied.

Those who squint not only lose the advantage of perfect binocular vision, by being unable to accurately fix the object with the visual axis of both eyes, but vision in the eye which is habitually deviated becomes gradually enfeebled, and often is eventually almost wholly lost, because the image in this eye falls on some part of the retina which does not correspond to the place of the image in the other eye, and therefore does not harmonize with it in the impression conveyed to the brain. The brain seems to be capable of neutralizing for a time even considerable discrepancies of the images in the two eyes; but if this difference is long continued, the brain at length disregards the less perfect image formed in the deviated eye (which merely tends to confuse the clearer picture formed on the macula in the eye which fixes the object), and relies for its sensations upon one eye alone. Binocular vision being thus virtually abandoned, the retina of that eye from which the impressions are as it were ignored begins in its turn to give up participation in the visual act, and its perceptive power thus becomes blunted and at length nearly lost from lack of exercise. Where the squint alternates in the two eyes this does not happen, but the acuteness of sight is retained. For the reasons above stated the advice formerly given by physicians, to wait till the child had grown older before employing treatment, is not judicious. On the contrary, the sooner the abnormal conditions can be removed the greater the subsequent amount of vision and the better the chance of restoring power which has grown feeble.

Convergent squint as a symptom of hypermetropia results from the fact that to see distinctly, and especially to see near objects clearly, the eye must use more of its accommodative power than an emmetropic eye. But in looking at near things, the action of the ciliary muscle increasing the focal power of the crystalline in each eye must be associated with and governs the other factor in the accommodative act, —

convergence of the visual axes of the two eyes toward the object. And it is the constant excessive exercise of this convergence which at last establishes it as a permanent condition. Moderate degrees of hyperopia give rise to strabismus more frequently than the lesser or the greater amounts of this refractive defect, as it is in these that increased convergence affords most relief. If the hyperopia is slight, the required convergence is but little more than the normal; and if it is extreme the utmost possible convergence does not suffice for the needed effect.

We see also why we do not meet with strabismus as a congenital affection, or very soon after birth. The young child has no occasion for accommodative efforts; and it is only when he begins to use the eyes on small and near objects, to look more closely at playthings, or to learn to read small letters that he finds that a clearer image is obtained by greater convergence. The same reasons explain the gradual increase of strabismus as the eyes are more and more applied to fine details of objects.

But strabismus does not always develop itself, even in these circumstances; because the clearer image obtained by exaggerated convergence is in but one eye, and binocular vision is so instinctively desired that the larger number of those who are equally hyperopic in both eyes content themselves with less distinct but more harmonious images in the two eyes, which convey more acceptable sensations to the brain. But if in one eye there is a deficient sharpness of retinal perception, or if there is corneal opacity associated with a higher degree of hyperopia than in the other eye, the disposition to strabismus is increased.

Strabismus being due in a large proportion of cases to errors of refraction, as Donders has demonstrated, we find optical appliances forming an important part in its remedial treatment. In some instances efforts may be made to correct the obliquity by exercising the eye which is found to have less acuteness of vision than the other, for a few minutes several times a day, the fellow eye being covered. In other cases, convex glasses of suitable focus will enable the eyes to see objects clearly and harmoniously; and if used before the strabismus is confirmed will neutralize the tendency to it, without an operation being necessary. Where an operation is required, glasses may often be subsequently worn, as being important auxiliaries in confirming its good results, and in preventing relapse in consequence of the continued action of the original causes of the deviation and the enfeebled action of the over-stretched and weakened external recti.

Operative measures are employed with two objects: to remove deformity, to which patients are generally very sensitive after they reach a certain age; or to increase the visual power in the deviated eye. It is nearly always possible to obtain great improvement in appearance, if not absolute correspondence in the direction of the axes of the eyes, by a skillfully performed operation; and in cases of alternating strabismus this is its chief object, as in this form of the affection vision has not become enfeebled in either eye. In other than these cases the subsequent gain in visual power is greatest where the operation is done early, before the retina has lost by involuntary disuse its sharpness of perception.

The use of myotics appears to be worthy of a trial, as a means of increasing the accommodation, and also of lessening the effects of defective refraction by cutting off the lateral pencils of rays. But I have not yet had time for sufficient experiment in this direction.

If optical means of correction prove ineffectual after a suitable trial, or if these cannot be employed on account of the tender age of the child, no time should be lost before resorting to surgical measures. Since the discovery of anæsthetics there is no such excuse as formerly for delaying the operation, in order to spare the child pain, until he should become old enough to bear it, or to decide for himself. And we now know, what formerly was not understood by the profession, that the vision, lessened during this period of waiting, can never be made so perfect as it might have been at first. But, even in strabismus of long continuance, considerable gain in clearness of sight and in ability to use the eyes without fatigue often follows surgical treatment.

The operation of tenotomy, for the relief of strabismus, requires careful judgment in its performance. In fact, after its first introduction into surgical therapeutics, in 1839, it fell for a time into disfavor because of the imperfect or unsatisfactory results often obtained; and instances are even now occasionally seen where eversion of the eyes, causing very conspicuous deformity, has followed an unskillful operation for convergent squint. It is safer to do a second operation, on the eye which apparently did not deviate at first, than to make too free division of the collateral attachments in the first eye.

The most favorable cases for operation are those where vision is not much lessened in the squinting eye, and the antagonist muscle has not been greatly weakened by protracted deviation. In other conditions only partial correction can be promised.

CONVERGENT STRABISMUS.

Professor Donders has clearly demonstrated that hypermetropia coexists with, and is in most cases the initial cause of, convergent strabismus, because of the mutual dependence of convergence of the internal recti and the act of accommodation. The antero-posterior axis in hyperopic eyes being too short to allow of even parallel rays being brought to a focus upon the retina, some portion of the accommodative power must be used for clear vision of even distant objects, from which such rays are received. In looking at near and small things, from which only divergent rays reach the eye, the accommodation must be proportionally increased; and, as convergence of the visual axes is one factor of the accommodative function, this is brought into play to reinforce this function in vision of near objects in far higher measure than in emmetropic eyes, in order that the increased accommodation may compensate for the deficient refraction. The constantly recurring practice of this excessive convergence in looking at print and other small objects gradually increases the power of the recti interni, and develops first a temporary, and at length a permanent, squint.

If systematic exercise of the affected eye alone, or the use of convex glasses of sufficient power to allow of distinct near vision without the necessity of an inordinate degree of accommodation, does not relieve the strabismus, division of the tendon of the rectus internus is called for. This muscle habitually acting too strongly, the object of the operation is to limit its relative power by separating it from its usual point of insertion, about three lines from the corneal border, and causing it to form a new attachment farther back upon the sclera. Having at this new insertion a lessened traction, the converging force of the muscle is thus more or less weakened. Operative measures should not be resorted to where the strabismus depends on only temporary causes, such as debility or the loss of accommodation often following some diseases of children.

In abnormal convergence of more than three lines both eyes should generally be operated on at one time, although the strabismus may appear to be confined to one eye; as, if we attempt to rectify the obliquity by an operation on this eye only, so large a division of the tendinous attachments is required that there is danger of a resulting divergent strabismus, which constitutes a more disagreeable deformity than the original affection.

Before the days of etherization, when young children were to be operated on, it was necessary to confine the body and limbs to a piece of board by winding some yards of cloth around them. The patient was then laid upon a table, the head firmly held by an assistant and the lids kept open by elevators. Of course the whole procedure was terrifying to the child, and its parents and friends consented to it with great reluctance. Now, in operating on children of tender years, insensibility can be quickly and safely induced by a brief inhalation of sulphuric ether. The child is thus spared all pain and a fright even worse than the pain itself, and there is no need of any forcible control of movement. In operating on older children or on adults, there are advantages in dispensing with anæsthetics, so that during the operation we may be able, by testing the mobility of the eyeball, to measure the effect obtained, and decide whether other attaching fibres require to be divided, — which cannot be so well determined while the patient is unconscious.

The patient may lie upon a couch, or recline in an easy-chair which supports his head. The surgeon stands behind or sits before him.

The mode of making the conjunctival incision varies with different operators: some make a vertical incision across the whole width of the tendon, — others a smaller incision over its border; — by some a horizontal incision is preferred. All of these methods need not be given in detail, and I shall simply describe the steps of the operation as it may be done in ordinary cases, mentioning any such modifications as may be important in special instances.

The instruments required are a spring or other elevator of the lids, fixation forceps, fine-toothed forceps, scissors curved on the flat, having their points a little rounded, so that there may be no danger of penetrating the sclera, and two strabismus hooks of different sizes.

The lids being kept widely apart, either by the fingers of an assistant or by an elevator, the patient, if conscious and docile, is told to turn the eye outward, so as to expose the globe at its nasal side; if he is not so, the globe may be held in this position by fixation forceps during the first step of the operation. The surgeon then raises a small horizontal fold of the conjunctiva, including the sub-conjunctival tissue, with toothed forceps, and divides it vertically over the lower border of the tendon of the internus and at about two lines from the cornea, with the scissors. Outward rotation of the globe is now relinquished and the muscle thus relaxed, so that the hook, with its point upward, may be introduced, with gentle pressure against the sclera to carry its rounded end below and under the tendon of the muscle. If the sub-conjunctival tissue has not been sufficiently divided to allow the hook to glide beneath the tendon, this tissue must be raised with forceps and further opened with the scissors. Being then drawn forward a little with the hook, the tendon is to be divided close to the cornea, between its scleral insertion and the hook, by means of the scissors, which are introduced through the small conjunctival wound. The conjunctiva may be drawn up with forceps by the assistant, so as to bring the tendon to view, if desired. If, after section of the tendon, the eye can still turn completely toward the inner angle, a smaller hook may be passed upward and downward, with its blunt extremity close to the sclera, to discover any collateral fibres which may have escaped division and still offer resistance to the hook. These are also to be severed, as, if they remain uncut, the connection of the muscle with the eye is too quickly regained, and a second operation may be necessary.

If there is much sub-conjunctival hæmorrhage, a small counter puncture may be made in the conjunctiva over the upper margin of the rectus, to permit the blood to escape. The advantages gained by a small conjunctival incision over the lower border of the muscle are, the lessened chance of the formation of fungous granulations at the severed end of the tendon, delaying healing of the wound, and the less tendency to retraction backward of the caruncle, which may follow a too extensive vertical incision of the conjunctiva. To preclude this last-named result some operators make the incision horizontally, exposing the muscle and then dividing the tendon ; or, if the incision is large and vertical, a suture is used to bring together the edges of the wound and obviate the falling back of the caruncle.

As will be remembered, in passing through Tenon's capsule the muscle is united with this by fibres derived from its sheath. These retain the muscle in place, and, together with the cellular tissue which connects it with the conjunctiva and sclera, prevent much retraction after the tendon is cut, as well as an abnormal protrusion of the globe, and even before reunion is established exercise a certain amount of converging motive power. The causes of a bad result in some of the older operations were the too free division of these auxiliary fibrous and cellular connections, or perhaps the section of the muscle itself instead of its tendinous extremity; thereby causing complete retraction of the divided muscle into the orbital tissues, and hindering its reattachment to the globe; giving rise to divergent strabismus from the unopposed action of the rectus externus, and creating a greater deformity than that originally present. Once occurring, such consequences can only be remedied by an operation for readjustment, which will be hereafter described.

When consciousness is recovered, we measure the position and mobility of the eye, so that we may judge as to the apparent effect and probable ultimate result of the operation; and, if these seem likely to be insufficient, may at once do anything which is needed to complete it. If an object is brought within six or eight inches, the operated eye should be able to converge slightly toward it, or at least to remain with the axis directed forward. If it now diverges, the divergence will tend to become, ultimately, still greater; a suture should therefore be passed through the conjunctiva, to bring the tendon, which has a certain degree of connection with this membrane, nearer to its former insertion than it will be if left to itself, thus limiting in some measure the effect of the operation. This suture may be left in place two or three days, till reunion of the tendon has taken place. If, after section of the tendon in one eye, the correction seems to be sufficient, it is best not to operate at that time on the second eye. Where the inward deviation is less than three lines in amount, an operation on one eye, with, or perhaps without, subsequent optical assistance, may suffice. Should the second eye apparently need rectification, this should be deferred for at least a few days, till the effect already gained can be definitely determined; as parallelism is sometimes obtained, after a short time, when at first it seemed unlikely to be; or, if done at once, should be most carefully performed, and with as little disturbance as possible of adjacent parts. In cases of doubt, delay is safest, as it is easier to supplement a deficiency than to correct an excess in operative effect. In operating at this or a later time upon the second eye, a partial division of the tendon is sometimes sufficient, or the conjunctival suture should be applied to lessen the effect, if this seems to be redundant. If, as now and then happens, the double operation does not wholly correct an excessive squint, a second division of the tendon may be carefully made in the eye most deviated.

When the operation is done at a public institution or at the surgeon's office, the eyes should be sheltered with a bandage while going home; but the bandage should then be removed, the light in the room moderated, and the eyes bathed occasionally, if this is agreeable, with cool or tepid water, or milk and water. The patient should be directed not to have the eyes covered with shade or bandage, as this disposes them to keep a position which might favor a reunion of the divided ends of the tendon. It is better that the eyes should be moved about while reunion of the muscle is taking place, and especially that they should be turned in the opposite direction from that of the former squint. But reading or looking much at near objects should be avoided, as this involves convergence. Double vision is sometimes an immediate temporary effect of the operation, passing off after reunion of the muscle to the globe. If, even when combined with subsequent use of convex glasses, section of the tendon in one eye proves ineffectual, an operation on the second eye is indicated for the complete correction of the strabismus.

Numerous modifications of the operative methods have been proposed, as, for instance, forced outward rotation after section of the internus, by means of a thread passed through the conjunctiva and fastened in the skin at the outer commissure of the lids, to cause union of the divided tendon as far back as possible, and thus increase the rectifying effect.

Liebreich dissects the conjunctiva, as far as and including the caruncle, from Tenon's capsule, after which he divides the rectus tendon and the capsule somewhat largely, and brings together the conjunctival wound with sutures.

Snellen makes a horizontal incision over the central line of the muscle, and separates this toward each border from the conjunctiva. The tendon is then raised with forceps and divided with scissors. Falling in of the caruncle is thus avoided.

J. F. Noyes proposes setting forward the rectus externus by dividing its tendon and fastening the divided ends by sutures, with or without excision of a portion of the tendon, so that they overlap, according to the amount of deviation it is desired to correct; considering this preferable to the division and setting back of the internal rectus. Some English oculists have favored a sub-conjunctival operation.

DIVERGENT STRABISMUS.

Absolute divergent strabismus not unfrequently occurs where one eye becomes either sightless or much deficient in vision; or differs greatly from the other eye in its refraction. In such cases, the eye seems instinctively disposed to give up attempts to participate in binocular vision, and to take a position in which such ill-defined images as may still be formed in it shall least interfere with the vision of the other eye. It may likewise result from an unskillful operation for convergent strabismus, or from pressure from an intra-orbital or other tumor.

Relative divergent strabismus may occur in high degrees of myopia where convergence is impossible; but it may also be due to insufficiency of the internal recti, without myopia, the eye deviating outward when the internus is fatigued.

Unless exceptionally caused as above stated, divergent strabismus generally manifests itself later in life, and is nearly always a consequence of myopia. The elongation of the antero-posterior axis at the posterior part of the globe brings the insertion of the internal rectus relatively farther from the centre of rotation and renders its action less effective than in a normal eye; and the shape of the globe becoming ellipsoidal and less conformed to that of the orbit, rotation inward is made more difficult, and if it is continued soon gives rise to muscular fatigue. Sufficiently great convergence for near objects is impossible or painful, and the eye turns outward to relieve the ineffectual strain of the internus and the accompanying tension of accommodation. Small objects are now brought near to one eye, and the effort to obtain binocular vision by using the other is relinquished, the pain of muscular asthenopia yielding as divergence is established.

As the myopia progresses, the divergence, which at first only occurs when near objects are too continuously looked at, is also apparent in distant vision, and the divergent strabismus becomes absolute, outward deviation of one eye being unconsciously encouraged to relieve the annoyance caused by double images when efforts are made to maintain convergence. Concave glasses, by affording clear vision of distant things, assist in keeping up binocular sight and preventing absolute divergence.

The anatomical conditions, as they may be termed, are so far changed from the normal, in a myopic eye where divergent squint has become established, that no such benefits are obtainable from section of the external rectus as those which follow division of the internal rectus in convergent strabismus. Paralysis of the recti interni, it is true, does not exist, but they are inadequate to rotate the ellipsoidal eye inward, and the altered conditions of the globe and orbit will still continue to act as hindrances to convergence and binocular vision. Division of the tendon of the rectus externus should therefore not be attempted for the relief of myopic divergent strabismus. Much may be done in the way of prevention, by giving up excessive and continuous use of the eyes upon small objects, by which muscular asthenopia is so readily induced, and by allowing the eyes suitable concave glasses for distant objects, which, by rendering images distinct, encourage efforts to maintain binocular vision, and thus keep up the proper direction of the optic axes.

Section of the external rectus is performed in the same manner as in dividing the tendon of the internus, except that, on account of its insertion being broader and farther from the corneal margin, the strabismus hook must be carried farther back to seize the muscle.

REATTACHMENT OF A MUSCLE.

When, on account of division of the muscle itself instead of its tendon, or from any other cause, the operation for strabismus convergens has been followed by non-union of the internal rectus muscle with the sclera, or by its reuniting too far back; much eversion of the globe, from unopposed action of the externus, takes the place of the previous convergent squint. To remedy this secondary deviation it is necessary to search for and set forward the misplaced muscle.

A vertical incision is made in the conjunctiva nearly over the place of former insertion of the tendon, and the conjunctiva is separated from the globe, in a direction toward the caruncle, by careful use of fine scissors. If, as is usually the case, the muscle has retracted into the orbital cellular tissue and formed adhesions with it, or if it has connected itself with the conjunctiva or the sclera, it must be completely detached from its surroundings; care being taken that in so doing the pale and partially atrophied muscle is not cut, and thus still further shortened. The muscle being thus separated from adjoining parts, the second step of the operation is section of the external rectus, so that its action may be suspended during the reuniting of the internus. A suture thread, with a needle at each extremity, is now to be passed vertically through the whole breadth of the recovered muscle, and the needles are then carried through the edge of the conjunctival wound close to the corneal margin, so as to include a considerable extent of conjunctiva; one end of the thread corresponding to the lower, the other to the upper, edge of the muscle, which is now to be drawn forward and secured in position by tying together the ends of the suture. A fine stitch may also be used, if desirable, to close the conjunctival wound. Unless the muscle has retained nearly its normal length, another thread should be placed in the conjunctiva close to the corneal margin, and the needle should be carried through the skin of the nose near the inner commissure of the lids, so that when the thread is tied the eyeball shall be kept in forced convergence, to insure that no traction shall be made upon the newly forming adhesions of the muscle. This thread must not be passed through the stump of the tendon of the externus and carried across the cornea to the nose, as is sometimes advised, lest ulceration of the cornea should ensue. If the effect of this operation of adjustment is well estimated the result is often a nearly perfect restoration of the normal aspect and movements of the eye, or the two eyes, if both have required replacement. But if, in consequence of much shortening of the muscle, the reunion should be followed by slight convergent strabismus, the cosmetic effect is still a vast improvement on the previously existing fixed stare of divergence. The sutures should remain for some days, till firm union is established.

In the exceptional instances where *convergent* strabismus accompanies a high degree of myopia, as well as in cases of paralytic squint, tenotomy is rarely indicated.

It is seldom that the superior or inferior recti are affected to an extent demanding operative interference.

As has been said, slight degrees of strabismus depending on hypermetropia may sometimes be rectified by the use of convex glasses, without recourse to tenotomy. Where its greater amount requires division of the tendon, the subsequent use of convex glasses, to neutralize at least a portion of the hyperopia and diminish the necessity for convergence, is often useful, and sometimes is essential to the preservation of the good results gained by the operation. If not constantly worn in looking at a distance, they are often helpful for reading or writing. But where the hyperopia is slight, glasses may often be dispensed with, the eyes having sufficient accommodative ability to allow of any requisite use without inducing a renewed squint.

The action of the newly discovered myotics, pilocarpine and eserine, on the accommodation, is such as to render it reasonably probable that these may be usefully employed in increasing the refractive power and lessening the need of convergence, as a substitute for convex glasses in relieving recent and moderate convergent strabismus without operation.

DEVIATION AFTER CEREBRAL APOPLEXY.

After cerebral effusion with hemiplegia and generally with loss of consciousness, the eyes are often drawn by tonic spasm of the muscles toward the non-paralyzed side. Occasionally the eyes are not fixed, but oscillate, though they cannot be turned in the opposite direction. If the patient recovers from the attack these ocular symptoms disappear in from a few hours to a few days.

CHAPTER XVII.

REFRACTION AND ACCOMMODATION.

To the vast advance of ophthalmology toward the distinction of being preëminently one of the departments of medicine having accurate knowledge and scientific principles as its basis, two men have especially contributed: Helmholtz, whose invention of the ophthalmoscope, not as a fortuitous discovery, but as a noble reward of intelligent research, gave us in one brilliant moment an immense addition to all our previous knowledge of the normal and pathological conditions of the eye; Donders, whose demonstration of the attributes of the visual organ in refraction and accommodation was a no less welcome revelation respecting its functions.

As an optical instrument, the eye combines the offices of the camera obscura and of the photographic apparatus. The dark chamber, and the convex lens which forms an inverted image of objects on the screen in the chamber, are represented by the pigment-lined cavity, and the combined refractive media, the cornea, aqueous, crystalline, and vitreous. The sensitive plate of the photographic chamber corresponds to the retina, in which the retinal purple, recently discovered by Boll, undergoes some as yet mysterious processes of chemical transformation during the visual act. But, unlike these instruments, the eye is endowed with a capability of instantaneous self-adjustment, and its retinal purple with a capacity of constant and spontaneous reproduction, fitting it for an incessant reception of new images. Furthermore, in the act of seeing, the impressions of the inverted images received upon the retina are transmitted to the nervous centres, and produce there sensations corresponding to the upright outward projection of those images.

In a normal eye at rest the retina is so placed, at the principal focus of the refractive media, that virtually parallel rays, such as come from objects at an infinite distance, are concentrated upon its layer of rods and cones, and form there a small real image, without change of condition or position of the eye or of the object seen. In practice, objects beyond eighteen feet from the eye are regarded as at infinity, the rays coming from these being so slightly divergent as to be in effect parallel.

Eyes which have this normal refractive power are termed *emmetropic*. Those which vary from this form, so that in a state of rest the retina is no longer at the principal focus for parallel rays, are *ametropic*.

The axis of the dioptric system which comprises all the refracting media, or *optic axis*, is a line drawn from the centre of the cornea to a point midway between the macula lutea and the optic disc. This differs slightly in direction from the *visual axis*, which is a line drawn from the object looked at, through the nodal point of the eye, to the macula lutea. The visual and optic axes cross each other at the nodal point, at a small angle varying according to the refractive condition. This is termed the *angle alpha*. At the cornea the visual line lies toward the inner side of the optic axis. At the macula it lies toward the outer side. The *visual angle* is determined by the size and distance of objects, and is the angle which the rays from the opposite edges of an object make with each other at the nodal point of the eye.

Every convex lens and every more complicated dioptric system has a principal focus, at which rays parallel to its axis, coming from what we term infinity, intersect. The distance of this point of intersection from the optical centre of the lens is the focal distance or length, when the index of refraction is 1.5′, and corresponds very nearly with the radius of curvature of the lens. The anterior and posterior principal foci are equidistant from the optical centre. Though rays from very remote objects, from infinity, are really slightly divergent, they are considered as practically parallel. Rays are regarded as coming from a finite distance, and as divergent, when they emanate from objects within eighteen feet from the eye. For all distances between infinity and the anterior principal focus, rays falling axially upon a lens will be refracted so as to intersect at a distance behind the posterior principal focus proportionate to the distance of the object from the lens; the nearer it is placed the farther the point of intersection, and, *vice versa*, rays proceeding from this latter point will be focused at the point occupied by the object. These are termed conjugate foci. If the object is at twice the focal distance in front of a lens, its focus will be formed at twice the distance behind it. If the object is placed at the anterior principal point, rays from it in passing through the lens become parallel; no intersection can take place, and no real, but only a virtual, image can be formed. If nearer the lens than its anterior focus, rays which pass through the lens continue divergent and will not be brought to a focus behind it; but a negative focus, at which will be seen the magnified object, is formed in front of the lens by the prolongation backward of these divergent rays.

Convergent rays do not exist in nature, and are only created by artificial optical means.

In every lens there is an optical centre, and all rays which pass through this emerge from the lens unchanged in direction. The *principal axis* passes through this point at right angles to the refracting surfaces.

If rays enter the lens in a direction inclined to the principal axis of the lens, the lines of direction are *secondary axes*, and, intersecting with each other at the nodal point, are brought to a focus upon corresponding points at the opposite side of the principal axis. The images of objects are thus inverted upon the retina: rays coming from the upper part of an object in secondary axes being focused at a point below the optic axis, and those from the lower part of an object at a point above the axis.

We express the power of lenses by fractions, of which the numerators are 1 and the denominators the focal distance in inches, or, in the metric system, in dioptrics.

As concave lenses do not unite rays, but render them divergent, their negative focus, as it is called, is found by prolonging backwards the divergent lines formed by the dispersion of parallel rays, so that they shall form a virtual focus in front of the concave lens.

What is termed the *nodal point*, which is nearly the optical centre of the eye, is the union of the two nodal points, which almost absolutely coincide, in one; and is situated on the principal axis, at about three lines behind the anterior surface of the cornea, and just in front of the posterior surface of the crystalline lens.

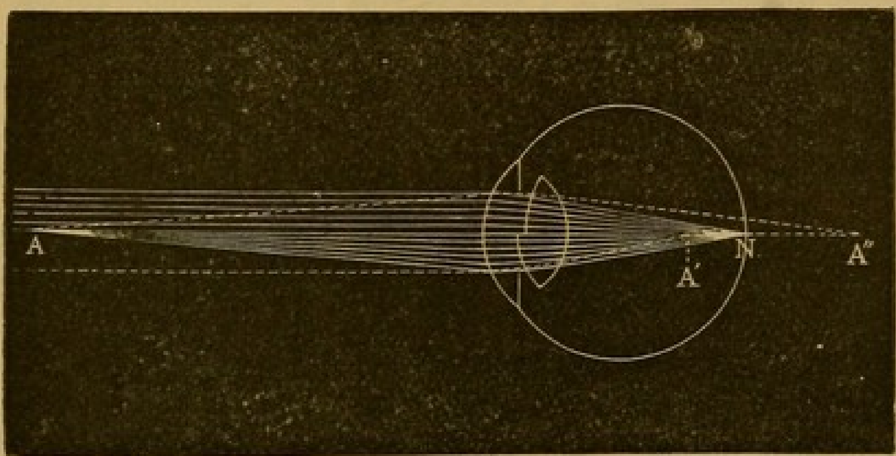
What is called the *principal point* is just posterior to the cornea. The *principal focus* of the eye, where parallel rays coming from the air intersect each other, is where the principal axis meets the layer of rods and cones of the retina, about twenty-two millimeters behind the anterior surface of the cornea. At this point an emmetropic eye in a state of rest should bring rays to a focus from all objects more than eighteen feet distant. The *anterior focus*, where parallel emergent rays from the vitreous unite, is at a point about thirteen mm. in front of the cornea.

The smallest visual angle for clear vision being 5′, letters which at given distances subtend this angle have been adopted as tests for the acuteness of sight; all test cards having a series of letters of different sizes and arranged for various distances printed upon them.

ACCOMMODATION.

We have seen that an emmetropic eye, when at rest, is adjusted, as a refracting instrument, to bring only virtually parallel rays — that is, those which emanate from objects more than eighteen feet distant — to form a clear image upon the retina. At any nearer distances things appear indistinct. They can, indeed, be made clearly visible by rendering rays derived from them parallel, by means of refracting glasses, before they enter the eye; but this would require a lens of different focal power for each slight variation in distance of the object. The only other conditions which would admit of distinct vision at short distances, from which only diverging rays are received, would be a change in the position of the retina, or a change in the optical constants of the refractive media. This latter constitutes the wonderful provision by which emmetropic eyes are enabled to adapt themselves, instantly and without conscious volition, for vision of far or near things, and by which, moreover, ametropic eyes can compensate, to a certain degree, for their imperfections of construction. This faculty of the eye thus involuntarily or voluntarily to change its refractive condition is termed the *power of accommodation* (A). It is now con-

FIG. 23. Diagram illustrating the physiology of accommodation in the emmetropic or normal eye.



The upper half of this diagram represents an emmetropic eye in a state of rest, the lower half in a state of full accommodation for the near point A. The only difference in the refractive media is in the crystalline, which in the lower half of the figure is shown thicker and more sharply curved than in the upper half. In the upper half is shown a bundle of parallel rays which undergo successive refractions at the cornea and the two surfaces of the crystalline, so as finally to converge to a focus and thus form an image upon the retina N. In this condition of the eye divergent rays, as from the point A, and indicated by the upper dotted line, are not brought to a focus upon the retina, but tend to converge to a point farther back, as to A'', thus forming upon the retina N a vague circle of dispersion, instead of the clearly defined image which is essential to perfect vision.

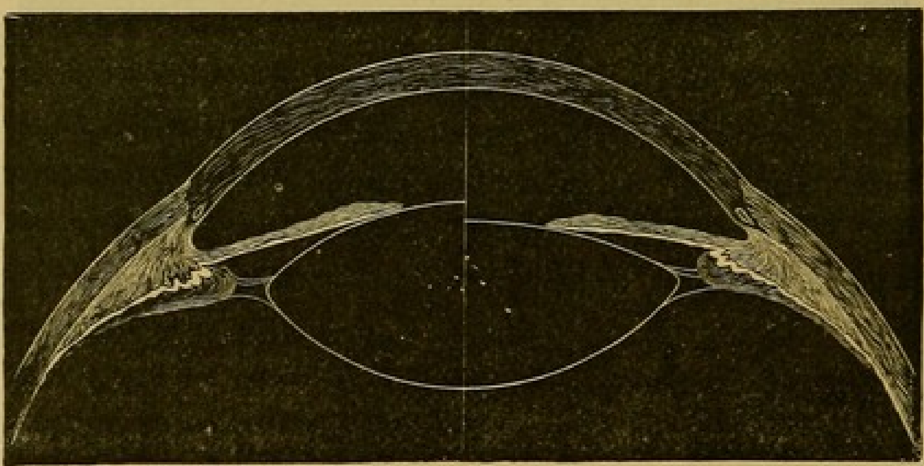
In the lower half of the diagram is shown a pencil of divergent rays, emaceded that this change is accomplished through action of the ciliary muscle, — the tensor choroideæ of Brücke, — upon the crystalline lens ; increasing the convexity of its anterior, and to a slight extent also of its posterior, surface, and thus enhancing its refractive power.

The exercise of accommodation enables an eye to see objects clearly at all distances between its *far point*, punctum remotum (p. r.), which in emmetropic eyes is at infinity (∞), and its *near point*, punctum proximum (p. p.), which is within a few inches from the eye.

nating from a near point, A. These divergent rays, having undergone partial refraction in passing through the cornea, are again very strongly refracted by the sharply curved crystalline, so as finally to converge to a focus on the retina at N. Less divergent rays, or parallel rays, as indicated by the lower dotted line, are, under the same conditions, refracted so strongly as to converge to a point in front of the retina, as at A′, a result wholly incompatible with distinct vision. The point A, representing the nearest point of distinct vision, is called the near point, *punctum proximum* (p).

It follows, therefore, that in a state of rest the emmetropic eye can see distant objects only, and the same eye in active accommodation is fitted only for near vision.

FIG. 24. Diagram showing the relative condition of the eye when at rest and in strong accommodation (after Kramer and Helmholtz, the anatomy after Arlt).



The right-hand half of the diagram represents the eye in a state of rest, the left in full accommodation for near vision, the relative curvature of the crystalline on the two sides corresponding quite accurately in scale to the calculations of Kramer and Helmholtz. The pupil is also shown as projected forward and somewhat contracted in accommodation. It will be noticed that the ciliary processes do not, in either case, touch the margin of the lens, an observation due to Von Graefe, and confirmed by other investigators.

FIG. 25. Diagram illustrating the action of the accommodative faculty in the myopic eye.

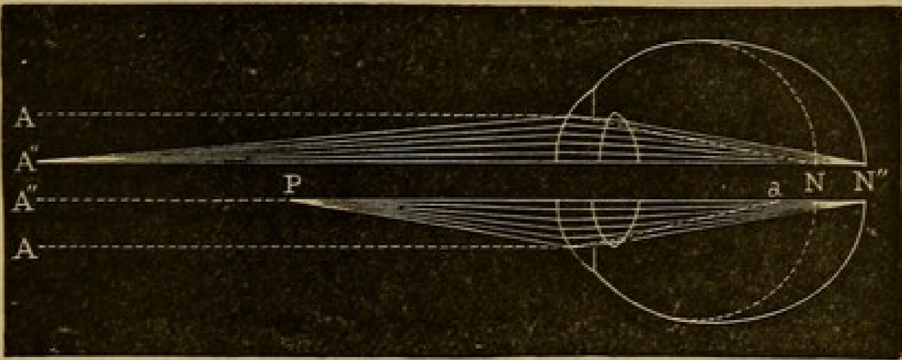


Figure 25 represents the two halves of a myopic eye, the upper half in a state of rest, the lower half in full accommodation for near vision. The refractive media are substantially the same as in the emmetropic eye, but the retina occupies a position farther back than normal, owing to the elongation of the eyeball. The relative position of the retina in the myopic as compared with the emmetropic eye is indicated by the elliptical outline N″, the dotted curve N representing the normal condition. In the upper half of the figure, which shows the eye at rest, parallel rays, indicated by the dotted line A, are brought to a focus at the normal distance of the retina N, but the actual retina N″, lying as it does behind this point, is not in a position to receive the image. The result is that the myopic eye, even when at perfect rest, cannot see distant objects clearly; the only rays, in fact, which can form a distinct image upon the retina N″ are those which emanate from a comparatively near object, say at A″, and which are sensibly divergent. This point A″ represents, therefore, the extreme distance at which distinct vision is possible, and is called the far point, *punctum remotissimum* (r).

In accommodation, as shown in the lower half of the figure, the increased curvature of the crystalline greatly augments the refractive power of the eye, so as to bring to a focus upon the retina N″ rays emanating from the very near point P, *punctum proximum* (p), which is considerably nearer the eye than in the normal condition.

FIG. 26. Diagram illustrating the action of the accommodative faculty in the hypermetropic eye.

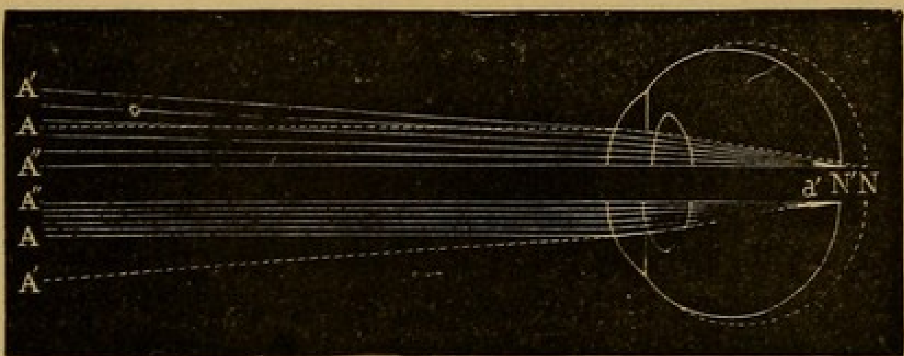


Figure 26 represents the two halves of a hypermetropic eye, the upper half in a state of rest, the lower in full accommodation. The hypermetropic is shorter than the emmetropic eye, as is indicated by the flattened outline N′, the dotted curve N representing the normal position of the retina. In the upper half of the figure, showing the eye at rest, the refractive power of the cornea and crystalline is just sufficient to bring parallel rays A to a focus at the normal distance of the retina N, but is not sufficient to form an image at the actual distance N′. The only rays, therefore, which can converge upon the retina of the hypermetropic eye in a state of rest are convergent rays A″ A′, such as no natural object gives off.

The exercise of the full accommodative power may be just sufficient to admit of the convergence upon the retina N′ of parallel rays A″ A (in the lower half of the diagram), in which case distant vision is possible, but no power remains to be exerted in viewing near objects. Such a person has no effective power of accommodation. If, on the other hand, the hypermetropia is less in degree, there may still remain a surplus of accommodative power sufficient to bring to a focus rays somewhat divergent; in which case there will be a near point of distinct vision, but farther from the eye than the near point of a normal eye. In very high degrees of hypermetropia the accommodative power may be insufficient to form a clear image even with parallel rays, in which case distinct vision is impossible at any distance except by the aid of glasses.

FIG. 27. Diagram illustrating aphakia (absence of the crystalline) and its effect upon vision in the emmetropic and in the myopic eye.

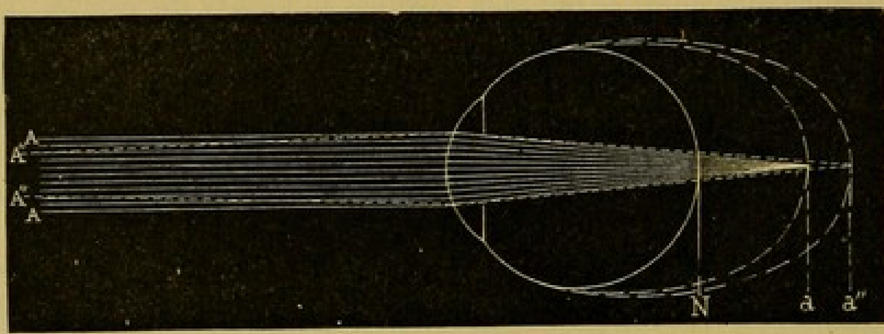


Figure 27 represents an eye in which the crystalline is wanting, either as the result of absorption or of removal by an operation for cataract. The refractive power which remains is too feeble to bring parallel rays A A to a focus at the retina N, but suffices only to give them a convergent direction toward the point a, which is about three eighths of an inch behind the normal position of the retina N. The feeble refractive power of the aphakial, but otherwise normal, eye needs therefore to be strengthened by the use of powerful convex glasses even for distant and still more for near vision; if, however, the aphakial eye happens to be very strongly myopic, as indicated by the elongated outline a, the patient may enjoy perfectly clear vision for distant objects without the aid of glasses. The still more elongated outline a″ shows the extraordinary degree of elongation of the globe which must be assumed to account for a very remarkable case, occurring under the care of the author, in which a patient after extraction of cataract was able to read small type with ease at the distance of twelve inches, and actually needed concave glasses for distinct vision at a distance. The course of the rays in this case is approximally indicated by the divergent dotted lines A″ A″.

FIG. 28. Diagram illustrating the use of a convex lens in determining the range of accommodation.

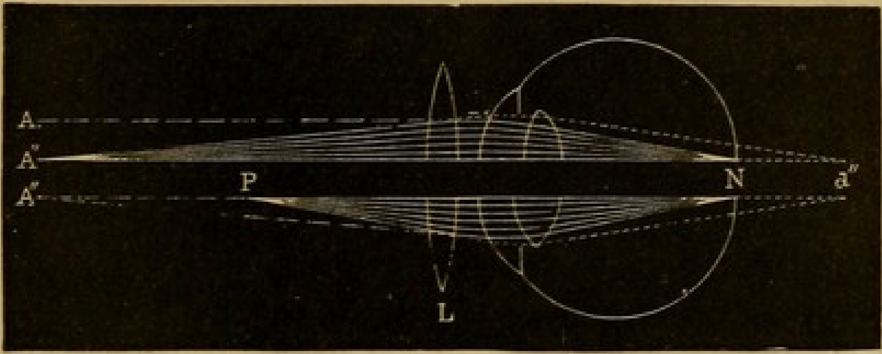


Figure 28 represents the two halves of an emmetropic eye, the upper half at rest, as required for distant vision, the lower half accommodated for the near point A''. By the interposition of a convex lens of about six inches focus, the divergent rays from a certain point A'', being the principal focus of the lens, (in the upper half of the diagram), are converted into parallel rays, so as to enter the eye as if they came from an infinite distance, as indicated by the dotted line A; the divergent rays from the point P (in the lower half of the diagram), being within the principal focus of the lens, are in like manner rendered less divergent, so as to enter the eye as if coming from the near point A'', of the eye, as indicated by the dotted lines. The result is that the eye thus armed with the lens has its far point (r) changed from an infinite distance to that of the principal focus of the lens (that is, six inches), while its near point is brought considerably within the principal focus. The whole region of accommodation is thus brought within the narrow limits of a few inches, and may, with a carefully constructed instrument, be very accurately measured. The range of accommodation is readily obtained by the following formula: —

$$\frac{1}{A} = \frac{1}{P'} - \frac{1}{R'},$$

$$\frac{1}{A} = \frac{R' - P'}{R' P'}.$$

P' being the distance from the near point P to the lens, and R' the distance of the far point A''.

Beyond these limits images of objects are no longer distinct, but circles of dispersion are formed upon the retina. This intervening space is termed the *region of accommodation*, and the distance between its far and near points, for which an eye can thus adapt itself, is the *range* or *latitude of its accommodation*. The region of A varies in ametropic eyes. The range of A is influenced, even in emmetropic eyes, by conditions of the health, modifying the innervation of the ciliary muscle; and especially by the lessened power in the ciliary muscle and the greater hardness and loss of elasticity of the crystalline which accompany advancing age. From these last-named physiological causes, without the supervention of any morbid change, an eye which in childhood had a range from its far point, at infinity, to its near point, within four or five inches from the eye, may have its near point removed, at sixty years of age, to twenty-four inches, requiring a glass of this focus to render near objects distinct.

The range of A is expressed by the formula $\frac{1}{A}=\frac{1}{P}-\frac{1}{R}$, and is represented by a lens of such focus as would render divergent rays coming from p parallel, as if they came from r. This would be $\frac{1}{5}$ if the object were at five inches from the eye; for $\frac{1}{5}-\frac{1}{\infty}=\frac{1}{5}$.

Professor Donders adopts these signs to designate conditions relating to accommodation: —

$\frac{1}{A}$ the region of A.
P the distance of the near point from the eye.
R the distance of the far point from the eye.
p punctum proximum, the near point.
r punctum remotum, the far point.

Accommodation has thus far been considered as taking place in one eye, but both eyes unite in associated movements, whereby binocular vision is obtained. For infinity the optic axes remain parallel; but for near vision the internal recti, by an instinctive action of muscular consent, act in harmony with the ciliary muscles of the two eyes, and produce a degree of convergence corresponding to a certain extent with the focal adjustment. This is termed binocular A, and is written A 2. In emmetropic eyes the binocular far point, r 2, being at ∞, and the near point, p 2, being at 4″. the range of binocular A would be $A\,2=\frac{1}{p\,2}-\frac{1}{r\,2}=\frac{1}{4}-\frac{1}{\infty}=\frac{1}{4}$. It is found, however, that convergence may be carried farther than the focal adaptation; so that, for instance, the binocular near point will remain at 4″, while the convergence may be at 3″. Clear binocular vision at 3″ would therefore, in such case, be impossible.

Moreover, though by involuntary muscular consent the convergence and the focal adaptation for different distances usually coincide in binocular vision, this coincidence is not invariable, the eyes being able to alter their focal adjustment, within certain limits, so as to see clearly without changing their convergence, and *vice versa*. This is termed the relative range of A, and is written A 1. The range of A may be measured with Snellen's or other test letters.

A convenient instrument for quickly determining the range of A, and at the same time ascertaining if ametropia exists, and estimating approximatively its form and degree, is made like a shoemaker's measure. In a slit at the top of

FIG. 29. Instrument for measuring the range of accommodation.

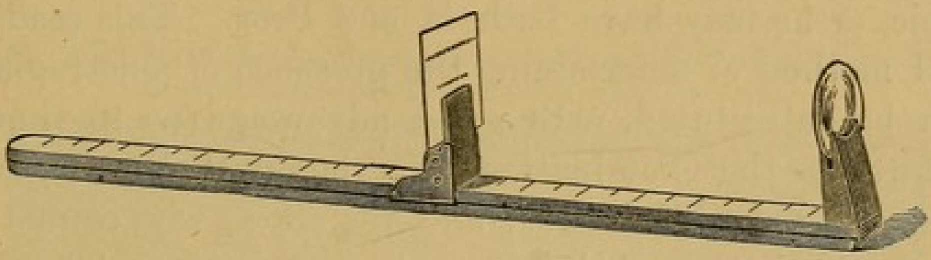


Figure 29 shows an instrument, altered from the ordinary shoemakers' measure, which is very useful for determinations of the range of accommodation.

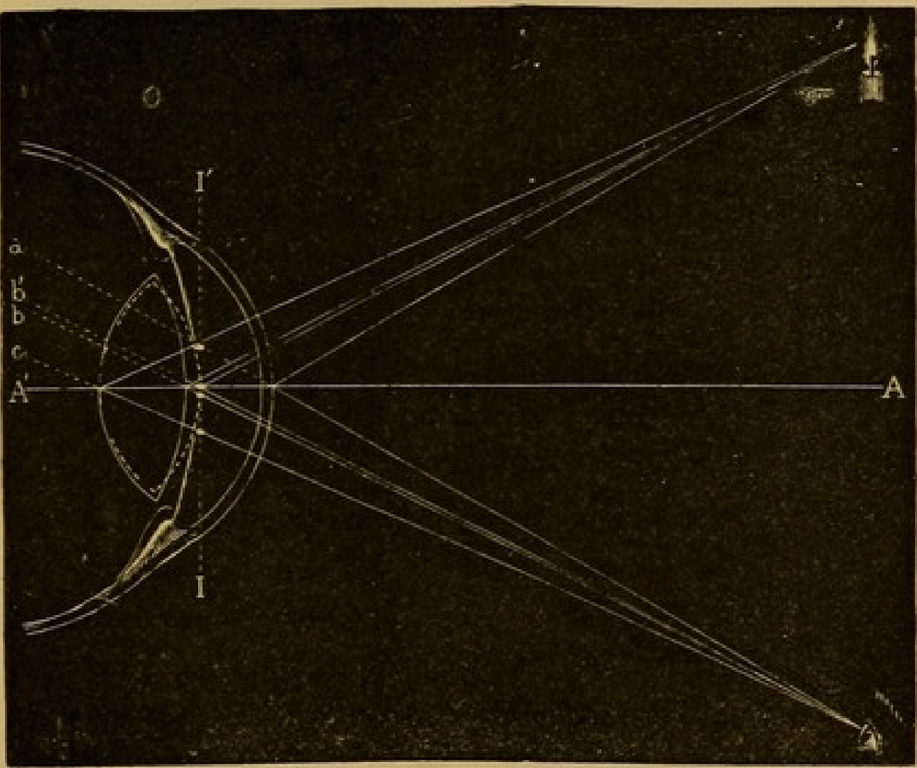
The scale is marked in inches and fractions of an inch, and the stationary and sliding upright pieces are cut off to about an inch in length. The stationary piece is notched for the insertion of a lens of six inches radius, and the sliding one for a card on which are Test letters No. 1. The instrument being supported against the malar bone, with the lens thus brought in front of the eye, it is easy to measure at once and with accuracy the distances at and within which the patient can read the letters with facility.

the fixed upright is placed a convex glass of six inches focus, and in a slit in the sliding upright piece is placed a bit of cardboard or paper, with words in *brilliant* type. The upright is placed against the patient's cheek, so as to bring the $+6''$ glass before the eye to be tested, the other eye being covered. The movable slide is then pushed along the graduated rule till the near point is reached at which the letters can be clearly seen, and is then carried farther and farther off till they begin to be indistinct, showing the far point. For an emmetropic eye the $+6$ lens will refract rays from the distance of six inches as if they came from ∞, and those from about three inches as if they came from the near point with unassisted vision. If for such an eye the range is less than three inches, we say the range is limited; in children, and sometimes in others, it may extend beyond this space. If the region of A is shifted nearer to the + 6 glass, — as, for instance, from 2″ to 5″, — we judge the person to be myopic, his far point being within the principal focus of the lens, and his eye therefore adapted for divergent rays. If his near point is at 4″, or beyond this, and his far point is beyond the principal focus, we decide that the eye is either hyperopic or presbyopic, and could bring convergent rays to a focus upon the retina. If the person is younger than forty-five, H is probable; if older than this, he may be simply presbyopic, or he may have both H and Pres. This ready and rapid method of determining the presence of ametropia may often be substituted, with great advantage as to time and comfort, for the examination with the ophthalmoscopes with revolving series of lenses; and for those who cannot readily relax their own A it gives more accuracy. The degree of Am. is approximatively estimated according to the amount of displacement of the region of A, it being brought very near the + 6″ lens in high degrees of M, and carried very far from it in excessive H.

MECHANISM OF ACCOMMODATION.

It is needless to recapitulate all the older theories regarding the parts concerned in the act of A; as it is now admitted that the crystalline lens is the medium through which the accommodative changes are obtained, and the ciliary muscle the agent for effecting these changes of refraction. A is therefore a physiological action, not, like refraction, a mere passive condition. That it does not depend on the iris was proved in a case of Graefe's, where the entire iris was removed without loss of A. During the earlier years of life the crystalline possesses much elasticity and flexibility, so that considerable changes of form are readily produced. That these alterations of form occur, and that they are sufficient to account for all the phenomena of A, and, further, that no A exists in eyes deprived of the crystalline, are facts capable of the clearest demonstration by means of Kramer's ingenious instrument. The *modus operandi* by which these changes are effected is yet a disputed point: whether the condition of the lens during its adaptation for distant vision is one of passive relaxation, and its increased curvature when the eye looks at near things is due to active muscular impulse; or whether, on the contrary, the lens is kept flattened by muscular action during vision at a distance, and acquires greater convexity of its anterior surface by its own elasticity, as this muscular tension is relaxed on looking toward near objects; is yet a matter of conflicting theory.

FIG. 30. Diagram explaining the change in position of the image formed by the anterior surface of the crystalline (after Donders).



The observed eye is directed to the point A, and a candle and the eye of the observer placed symmetrically on either side of A, as shown in the figure. Now the only rays from the candle which can reach the eye of the observer are those which are reflected from the central portions of the cornea, and anterior and posterior surfaces of the lens. The rays reflected from the cornea will then reach the observer as if they came from the point a, and those from the posterior capsule as if they came from the direction c. The rays from the anterior surface of the lens, when the eye is at rest, as is shown by the flatter outline of the lens, will reach the observer's eye from the direction b. Images of the flame, either real or virtual, will appear to the observer in the direction from which these rays respectively come, and will naturally be referred in position to the dark plane of the pupil, indicated by the line I I′, upon which they may be represented by the large white dots. If now the observed eye, still looking in the direction A, is strongly accommodated for some near object, the last-mentioned image will be seen to change its position so as to appear to be in the direction b′. This change in position can depend only upon a change in the place of the reflecting surface as indicated by the more convex dotted outline. The refraction of the rays from the two surfaces of the lens is not shown in the figure, as it occurs equally in the case of the incident as of the reflected rays, and therefore does not affect the demonstration.

FIGS. 31 and 32. Reflected images of a candle-flame, as seen in the pupil of an eye at rest and in accommodation for near vision.

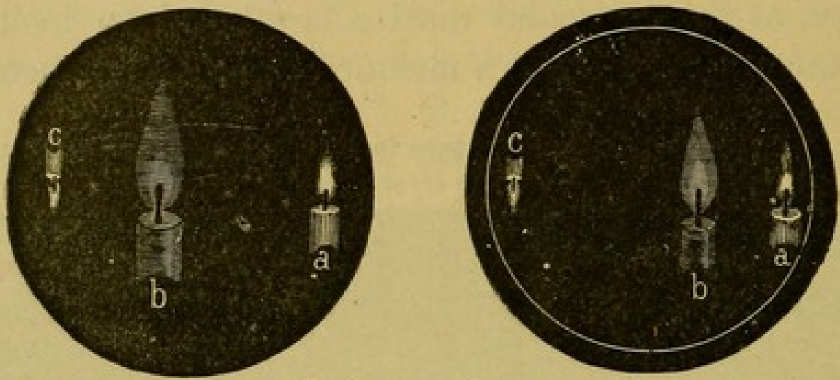


Figure 31 represents the pupil of an eye in a state of rest, showing the three images, a b c, of the flame of a candle, formed respectively by reflection from the cornea, anterior capsule, and posterior capsule. Figure 32 shows the same eye in a state of accommodation for near vision, — the pupil somewhat contracted, as indicated by the circular white line, and the image b, formed by the anterior capsule, changed both in size and in position. The smaller size of this image is the direct result of the increased curvature of the anterior surface of the crystalline, making it act as a convex mirror of less radius; the change of position depends upon the protrusion forward of the same surface in consequence of the increased thickness of the lens in accommodation. The images a and c, formed respectively by the cornea and the posterior capsule, are not sensibly changed either in size or position; proving that in accommodation there is no appreciable change in the curvature of the cornea, or in the curvature or position of the posterior surface of the crystalline.

Associated with this increase of thickness and increased refractive power of the lens during the act of accommodation for near objects, we have a contraction of the pupil by which the lateral rays, which require most refraction, are cut off from the retina, thus contributing to the formation of a clear image. With this contraction there is a slight advance forward of the central part of the iris, and slight retrocession of its periphery.

ACUTENESS OF VISION.

It is generally agreed that an eye may be regarded as having normal acuteness of vision when it is capable of reading letters which subtend a visual angle of (5′). Letters of accurately proportioned sizes for testing the visual power, which should be clearly seen at this angle of 5′ at the distances indicated by numerals placed above each line of the test type, were prepared by Professor Snellen, of Utrecht, and have been generally accepted as a standard; though numerous other series of letters, adapted for feet and inches, or according to the metric system, have also been proposed by other authors. Their principle is essentially the same. The degree of acuteness (designated by V) is found by placing as numerator the figure representing the distance (d) at which a certain size of letters is clearly seen, and as denominator the distance (D) at which they should be seen at an angle of 5′ with normal sharpness of vision. If, for instance, letters which should be recognized at 20′ are only seen at 10′, the formula would be $V = \frac{d}{D} = \frac{10}{20}$. Vision as well as A is most perfect in childhood. With advancing age there is a slight lessening of the transparency of the media and of the perceptive power of the retina. The image formed at the fovea centralis, in direct fixation, is also sharper than those of indirect fixation; and these images become less and less distinct as we go farther from the region of the macula, where the cones are most numerous, toward the periphery of the retina.

Pathological changes may affect central or peripheral, smaller or larger, portions of the visual field. The modes of ascertaining the degree and extent of limitation of the retinal perceptive faculty are elsewhere described under the head of limitation of the visual field. The optic disc itself, the "blind spot" of Mariotte, has no perceptive, but only conductive, power. But this is so situated as regards the visual axis, and of such relatively small size, that we are not conscious of any hiatus in the visual field; though the fact of its insensibility to images is readily demonstrated by making a + on a piece of paper, and tracing three or four inches to the right of this a ring half an inch in diameter. The left eye being closed, the right eye is kept fixed on the +, while the paper is slowly moved about at a distance of a few inches. In a certain position it will be found that the ring is no longer seen, the rays from it at that point falling upon the blind spot, the optic disc.

DEFECTS OF THE EYE AS AN ORGAN OF VISION.

Notwithstanding the wonderful organization of the eye, it yet has defects, scientifically speaking, as an optical instrument. A pencil of homocentric rays, having like qualities, should be uniformly refracted to the same point. But the blue and violet rays, having shorter wave length, are sooner brought to a focus, while the red and orange rays, having greater wave length, are less strongly refracted; giving rise to *chromatic aberration.*

Monochromatic rays, having equal wave lengths, if falling parallel upon a spherical surface at an equal distance from its axis, will continue homocentric. But if, while still parallel to its axis, they fall upon the surface at different distances from the axis, the rays farthest from the axis will be most refracted; causing *spherical aberration.* This defect is increased by the want of absolute centring of the refractive media as regards the optic axis, and especially by any asymmetry of different meridians of the cornea or of the crystalline, constituting *astigmatism*, and occasioning a quicker concentration of rays passing in one meridian than in the meridian at right angles to this.

But these theoretical imperfections, unless in exceptional circumstances or when they exist in a marked degree, do not essentially affect vision. Practically, the eye, as a living organ, is capable of neutralizing even considerable refractive defects. This fact should not be lost sight of in the adaptation of optical appliances, as superfluous correction of slight irregularities of refraction is often a source of more annoyance to the eye than was the original defect. Patients may be quite unable to use complicated glasses for ordinary purposes with any degree of comfort, although these have been most scientifically fitted to their eyes when tested by looking in one direction only at certain letters or other objects.

ASTHENOPIA.

A sensation of inability to apply the eyes intently and for a considerable time to small objects, and of pain after doing so, although only a functional affection, occurs so often, and depends on such various causes, that it deserves special consideration here, particularly as most of its subjects are young and intelligent persons, who find it a hindrance in the pursuits to which they wish to devote themselves. There is no lack of acuteness of vision ; distant objects can usually be looked at without fatigue, and small things near the eye can at first be distinctly seen ; but after a brief period of exertion a sense of weariness and strain is felt in the eyes, which extends to the frontal region, is perhaps accompanied by a blurred sight, and at last compels a suspension of use. After rest the person can again for a while resume his study or work, but the symptoms soon reappear.

The application of hypermetropic eyes, which call for more than the ordinary exercise of the accommodative faculty, to studies or trades or pursuits requiring close attention is one of the exciting causes of asthenopia. On the other hand, muscular asthenopia may arise from insufficient action of the recti interni in myopic eyes, which causes them to become readily exhausted by continued efforts at convergence while reading, etc. This form of asthenopia is often relieved by the use of concave glasses of suitable power, for near as well as for distant vision. Asthenopia also occurs in astigmatism, because of the confusion produced by unsymmetrical refraction. It frequently follows long use upon small objects or in an insufficient light, where opacity of the cornea or other want of transparency in the refracting media renders the retinal image indistinct.

Another class of cases of asthenopia depends on a partial or total suspension of the A, after exanthematous, diphtheritic, or febrile attacks. Imprudent use of the eyes should be avoided during convalescence from any severe illness.

Still other instances of asthenopia are seen after anxiety, fatigue, or want of sleep, or in exhaustion of the nervous system, or where there is anæmia or general want of tone, although the eyes have nearly normal refractive and accommodative power; if the eyes in such circumstances are severely taxed. A few exceptional cases are met with where asthenopia results from a congenital deficiency of visual acuteness, but where no apparent defects can be seen with the ophthalmoscope.

Where the symptoms depend on optical defects, and especially on want of accommodative power, the treatment must be adapted to relieve these conditions, as elsewhere directed, and the eyes brought gradually into use with the aid of glasses if required, or by the assistance of tonics and myotics if the A has been enfeebled by disease. Other cases need careful management to avoid over-use of the eyes or over-fatigue of the system, together with rest, tonics, and change of air, to improve the general condition, and thus to give vigor to the delicate functions of the eye. Moderate and interrupted use of the eyes is better, in most cases, than absolute rest; and too much attention should not be given to trifling sensations of discomfort, unless these are evidently increased by the attempted work. While being thus exercised the eyes are not to be fixed too long on near things, but should look often at a distance for a moment, so as to relax the accommodation. Iron combined with lupulin, or some similar general means, are beneficial; and stimulating lotions, with spirits of rosemary, camphor, allspice, or cannabis indica, may be of service.

The prognosis is absolutely favorable, although a persistence of symptoms sometimes requires a patient recourse to varied remedies.

PRESBYOPIA, OR OLD SIGHT.

Old sight is to be regarded not as an abnormal, but as a physiological condition, since it occurs in eyes which have no defect of refraction as regards distant objects, and is but a consequence of a decrease of the previously existing faculty of accommodation in the crystalline. From even ten years of age there is a gradual alteration in the consistence of this lens; it becomes denser and harder, and less susceptible to change its form and assume an increased convexity of surface under the action of the ciliary muscle. But until the age of about forty-five, an emmetropic eye can effect the change required in accommodation for small objects without any conscious effort, though the near point has already receded from the eye, lessening by so much the range of its accommodation, and though brighter illumination is perhaps needed for clear perception of minute details. Distant vision continues apparently as good as ever in such emmetropic eyes.

The first symptoms of presbyopia are sensations of effort or fatigue after continuous looking at small objects, especially by artificial or by insufficient light. Small print is no longer read with the former ease, and threading a needle, fine embroidering, etc., become difficult. This feeling of presbyopic asthenopia extends from the eyes to the forehead, and the discomfort at length compels suspension of the occupation. It is found, however, that at this early period reading can still be continued if the eyes are occasionally relieved by a relaxation of the accommodation in looking at far objects, or if the book is held farther from the eyes, so as to make the rays less divergent, or if it is brought nearer the light. The person often, also, observes that he cannot, so quickly as usual, change the adaptation of his eyes from the far to near distances, and *vice versa*. If a small object is brought near his eyes, the head is thrown back, to obtain a clearer view of it. Sometimes the lamp is brought between the eye and the book; not only to gain a better illumination of the page, but also, by causing contraction of the pupil, to shut out the lateral pencils of rays, which require more refraction than the lens can effect, and thus avoid circles of diffusion.

At a more advanced age, the loss of pliability in the lens substance is accompanied also by less perfect transparency, lessened refractive power of the lens, and sluggishness and contraction of the pupil, as well as diminished activity in Brücke's ciliary muscle.

The proposition of Professor Donders, that recession of the binocular near point to the distance of 8″ shall be regarded, arbitrarily, as the commencement of presbyopia, is generally accepted. The degree of Pr. is measured by subtracting the person's actual binocular near-point from $\frac{1}{8}$. If he reads without glasses at 24 inches, his Pr. would therefore be Pr. $= \frac{1}{8} - \frac{1}{24} = \frac{1}{12}$; a glass of 12 inches being needed for reading at the proper distance.

The following is given as an approximative scale of the power of glasses required to correct Pr. in emmetropes: —

Age	48	50	55	58	60	62	65	70	75	78	80
Focus in inches	60	40	30	22	18	14	13	12	9	8	7
Focus in dioptrics	.75	1.	1.25	1.75	2.	2.5	2.75	3.	4	4.5	5.

Hypermetropic eyes, which call for an effort of adaptation even for remote things although convex glasses have not been needed in earlier life, begin to need them sooner and of a relatively higher power than emmetropes, to compensate for the lessening faculty of accommodation. At fifty years of age, for instance, the glass to be worn for reading must equal the combined amount of the H and the Pr.

Myopic eyes, on the contrary, need convex glasses only when the M is slight or moderate in degree, and will assume them later and of a lower power than emmetropes. Should the M be equal in amount to $\frac{1}{8}$, Pr. will never be developed, and such glasses will not be requisite for near work at any age. It should not be forgotten that the myopia will persist, and the person will continue to see better at a distance with concave glasses, even when, in the lower degrees of M, the gradual loss of A makes convex glasses necessary, after a certain age, for near objects; such eyes being then at the same time myopic in refraction, but presbyopic from the lessened accommodation.

As Pr. is due to a loss of the requisite accommodative power for the formation of a clear image of divergent rays coming from the near point, the remedy is easy: the adoption of such convex glasses as render rays less divergent before they enter the eye, and thus allow of their proper concentration on the retina. It is obvious that so far from their use being postponed, from an idea that they will weaken the eyes, or increase the necessity for them, such glasses should be worn as soon as the need of their aid is felt. They not only give pleasure in enabling small things to be seen as well as ever, but afford much relief; and, by preventing strain of the A they actually retard rather than hasten the development of Pr. It is best, however, to choose a N° only adequate to give distinct sight, without magnifying the object; and to use them at first only by artificial or insufficient light. If thus chosen, they may often serve for a considerable time without change. When the symptoms of asthenopia begin again to declare themselves, a stronger pair of glasses must be obtained for evening use, those previously worn being retained for use in the brighter daylight. The intervals at which the power of glasses should be thus increased vary with the activity of A in different individuals; say, from two to six years. Glasses should not be needlessly assumed too early, in the hope of preserving the eyes; nor should tinted glasses be taken, unless exceptionally, with the same intent, as they render the eyes sensitive to light.

The simple sliding measure I have described for estimating the A enables us also to quickly determine if glasses are needed; and approximatively the power required in either H or Pr. If the tested eye, instead of seeing the letters at about 3″ distance, does not discern them except farther off, and continues still to discriminate them beyond the 6″, which, with this instrument, is the far point for an emmetropic eye, glasses are requisite; and these will be of higher power in proportion to the far distance at which the words can be read.

But after the power of the glasses to be worn is thus closely estimated, the final and essential test must be made with the glasses themselves, by actual trial. They should be such as give the person the most easy and clear vision at the distance suitable for his age. This should be about fourteen inches when glasses are first required, but at a nearer point in old age. In testing a person with glasses for reading, those of low powers should be first tried, by holding them or placing them in a frame before the eye, at about half an inch from the cornea, and parallel to the plane of the iris. If the glasses are held inclined at an angle to this plane, their power is increased unequally in the different meridians, and a blurred, astigmatic effect is produced. Should the glass be of insufficient strength, the person will still hold the book too far from the eye; if of too high power, the book will be brought too near, and the print will appear magnified. It is well to hold two N^os^ from the case of test glasses in the fingers of each hand, and to quickly substitute one N° for the other, beginning with the lower power, while the person tested keeps the book at the same distance. If he selects the higher power as the better of the two, this glass may then be tried in comparison with those of next higher power. If he prefers the glass of least power, or if he brings the book nearer, and says the letters seem not only clear but enlarged, the glass is probably too strong, and lower N^os^ should be tried. Weaker glasses may be given if the person wishes to use them for objects at a greater distance than 22 centimeters. Stronger glasses than would correspond with the age are sometimes preferred where the acuteness of vision is below the normal, as where there is haziness of the cornea, commencing cataract, or other cause of amblyopia. Reading glasses, as they are termed, — lenses having a large field, — are sometimes useful in these conditions; being held in the hand at about their focal distance from the book.

Where there is paresis or paralysis of A as the result of disease, or insufficiency of the internal recti, the required convex glasses may be set with their axes rather nearer than the usual distance from each other, in order to get a prismatic effect and thus relieve the eyes of a certain amount of convergence; and, ordinarily, glasses for close work may be set slightly nearer together than such as are to be used for far vision, because the axes of the two eyes converge when used upon nigh objects.

Spectacles have some advantages in steadiness of position, but eye-glasses are generally preferred as being more becoming, especially by ladies and by those who only require them for occasional use. These are made in such variety of pattern that they may be fitted to most noses without having so strong a spring as to cause discomfort, and are then unobjectionable. If convex glasses are required for reading at a somewhat long distance, as, for instance, in the pulpit, they should be of lower power than for nearer points; and the frames may be horizontal, instead of arched, at their upper edge, so as to allow of looking over them at the audience. (Such are sold as pulpit spectacles.) Persons having high degrees of H, who on reaching middle life become also presbyopic, may be enabled to see both far and near without having the trouble of frequently changing their glasses for distant sight for those suited for near vision, by having them of double focus (pantoscopic glasses); the lower part of the glass being of a power adapted for reading, and the upper part for distant objects. This is effected by setting in the frames two halves of lenses, of the different foci required; or by having a lens of the power needed for reading at the lower part of the frame, while the upper portion of the same lens is ground down to the lower power adapted for the correction of the H in looking at a distance. The first of these methods is the least expensive, as the glasses can readily be fitted by any optician; the latter is the more elegant, as the conspicuous fissure between the two portions of the glasses is obviated.

Persons who, from coquetry or other reasons, dislike to acknowledge their age, and wish to defer as long as possible the wearing of glasses, may do so for a while, on condition that they use the eyes very little, and interruptedly, for fine work, especially in the evening, unless with a very good illumination.

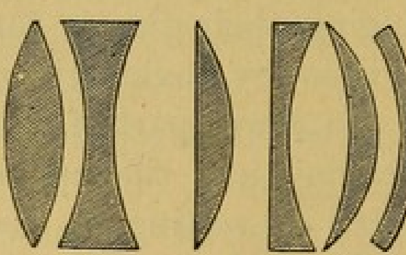
Friends sometimes say to each other: "If you do not put on glasses at the usual time you will afterwards be able to do without them, as I can." Such advisers are generally myopes, who believe that, because they have themselves never needed glasses for reading, others may have a similar experience, which is by no means the case.

A sudden need of stronger glasses, and a necessity for frequently changing them for those of yet higher power, is sometimes an early premonitory symptom of glaucoma, and should lead to a quiet inquiry as to the presence of other initial symptoms of this grave disease.

SPECTACLES OR EYE-GLASSES.

These words are applied, in a general way, to all collective or dispersive glasses worn before the eyes as auxiliaries to vision. Convex and concave lenses, as a rule, have their surfaces of like and equal curvature; but concavo-convex or convex-concave, (termed periscopic glasses), as well as plano-convex and plano-concave lenses, are sometimes worn. Periscopic glasses were at one time much in favor, as giving a wider lateral range of sight without movements of the head, and as being less brushed by the cilia than the higher powers of convex glasses;

FIG. 33.



1 2 3 4 5 6

1. Double convex lens.
2. " concave "
3. Plano-convex "
4. " concave "
5, 6. Periscopic "

but double convex or concave glasses are preferred, as having greater optical perfection.

The focus of a convex lens may be estimated by holding it at right angles to the direction of light from a distant window, focusing the image of the window clearly on a screen, and measuring the distance of the lens from the screen. Another method is to place against the convex lens concave glasses of known powers, and to look through the combined lenses at some distant object, until a glass is found which occasions no change in the size of the object as seen with the naked eye, and which gives no dancing motion to the object if the lenses are moved to and fro before the observer's eye. The same test applies also to concave lenses, against which convex lenses of known power are placed, till the combination is made which, when held in the line of vision, makes the object clear, and steady in position when the lenses are moved laterally. The glass which produces this effect is of the same focus as the lens to be measured.

Cylindrical glasses, having no refractive power in the direction of the axis of the cylinder, but a positive or a negative refraction in the meridian at right angles to the axis, are applied to the correction of defects of symmetry in different meridians of the cornea, which we designate as *astigmatism*. These may be plano-cylindrical (positive or negative), or the two surfaces may be ground with similar or differing cylindrical curves, or with a cylindrical combined with a convex or a concave lens, as may be required in special cases. Of course these glasses must be accurately fitted and carefully worn, with the cylindrical axis in the suitable direction; otherwise the astigmatism will be increased instead of neutralized.

Prismatic glasses, as well as decentred lenses cut from the periphery of a large lens, are sometimes used, generally with their bases turned inward, to deflect rays of light, in the hope of relieving muscular asthenopia due to impaired action of the internal rectus; and they would be of unquestionable service if the eyes could be kept in one position with respect to the incident rays. Since this is impossible, they are less practically than theoretically useful.

Blue or gray neutral-tinted glasses may be worn to protect the eyes from light, dust, and wind, and are a great comfort in many conditions of inflammation or sensitiveness. These should be large, and curved like a watch crystal, still more effectually to protect the eyes. They are generally to be preferred to the goggles surrounded with wire gauze or with glass side pieces, as these keep the eyes too warm. Cobalt blue glasses neutralize the orange and yellow rays of the light, which are the most annoying to the retina, and in a large proportion of cases are acceptable to the patient; but there is no objection to the neutral, or, as they are termed, French gray or smoke tints, if these seem to give more relief in any instance. Green glasses, as well as green shades, should be avoided, as being irritating rather than soothing in their effect.

Some sensitive eyes, especially those which are highly myopic, often find much benefit from having their refracting glasses slightly tinted. These are also sometimes useful after cataract operations. Highly myopic eyes, requiring concave glasses of excessive power, may have their vision improved, to only a partial extent, by such glasses, but in a few rare instances they derive more advantage from Steinheil's glass cones, which are in effect minute opera-glasses; the concave end of the cone being toward the eye, the convex extremity toward the object looked at. Cones of an inch in length cannot be conveniently worn, but they may be held up before the eyes when it is desired to see certain things with more clearness than is possible for these persons with the aid of the ordinary concave lenses.

Stone-cutters and other workmen sometimes wear glasses to protect the eyes from fragments of stone or particles of metal. These fly with so much force from the edges of tools when heavy blows are struck that the glasses are liable to be broken unless they are a quarter of an inch in thickness. Mica is also worn by workmen as a substitute for glass.

Stenopæic slits — horn or rubber discs in which is a slit-like aperture — are used in some cases of slight haziness or of conicity of the cornea, or in certain cases of irregular astigmatism, to exclude from the eyes all rays but such as pass through this diaphragm.

As a rule, for distant vision the centre of each glass should correspond to the centre of the pupil; otherwise, if there is much decentration, especially if the glasses are of high power, a prismatic effect is produced. Glasses for women are usually set nearer together than those for men. For the near distances, however, as I have already said, a position with the centres slightly toward the nasal side (as often happens when eye-glasses are worn) is not objectionable, as the visual line will then pass through the centres of the glasses in looking at near objects. Decentration, to obtain prismatic effects, is occasionally ordered to correct some peculiar conditions.

Crown glass is the best material for spectacles. Many of the glasses sold at a high price, as being of quartz crystal or "pebbles," are often mere impositions, made of flint glass. Neither quartz nor flint glass possesses any special advantages for lenses, and in several respects, especially as regards chromatic aberration, the lenses made from these materials are inferior to those of crown glass.

TEST GLASSES.

Until recently the cases of lenses arranged for the use of oculists as trial glasses contained thirty-two pairs of convex glasses, numbered as to focal length in inches, from No. 72, the lowest power, to No. 2, the highest; — the same number of concave glasses of similar denomination; — nineteen pairs of plano-cylindrical glasses, numbered from 60 to 6 inches; — nine prisms, numbered from 2 to 10 degrees angle of prism; — various tinted glasses, — stenopæic slits; and frames into which any of the glasses could be slipped for trial.

Sets of lenses, ground according to the metric scale adopted by the International Ophthalmological Congress at London in

1872, are now extensively substituted for the former method of numbering in inches. The unit of this scale is a lens of a focal length of one metre, termed one dioptric. This scale has a regular gradation, 2 D having twice the power of 1 D, etc., giving greater facility than under the former system in calculating or adding together different foci.

The N^os^ of the scale for convex or concave glasses are given in the following table, with nearly their equivalents in inches: —

Dioptrics.	Inches.
.5	74
.75	49
1.	37
1.25	29.6
1.5	24 5
1.75	21.
2.	18.5
2.25	16.4
2.5	15.
2.75	13.5
3.	12.3
3.5	10.4
4.	9.2
4.5	8.2
5.	7.4
5.5	6.8
6.	6.5
7.	5.3
8.	4.6
9.	4.1
10.	3.7
11.	3.3
12.	3.1
13.	2.8
14.	2.6
15.	2.5
16.	2.3
18.	2.
20.	1.8

CHAPTER XVIII.

AMETROPIA.

As we have seen, a normal eye in a state of rest forms an optical apparatus of such refractive power as is adapted for uniting parallel incident rays into a focus upon the layer of rods and cones of the retina, placed exactly at the "measure" for receiving the image of such rays. Thence the term *emmetropic*.

We have also seen that an emmetropic eye is endowed with the further power of accommodation, by means of which divergent rays from points at a less distance than infinity are brought by new conditions of refraction to form distinct images on the retina.

We have now to consider two deviations from the normal emmetropic form of the eyeball, in one of which the principal focus of the eye is before, in the other behind, the retina. To these conditions the term *ametropia* is applied, the surface capable of distinct perception being no longer at the requisite measure or point. Both of these conditions depend on abnormal construction of the globe, the defect being that its antero-posterior axis is in the one case longer, in the other case shorter, than in the emmetropic eye.

ANOMALIES OF REFRACTION.

An emmetropic or optically normal eye has, in a state of rest, a refractive power capable of concentrating parallel rays to form a distinct image upon the retina; and, furthermore, possesses the faculty of increasing this refraction, by the exercise of accommodation, to a degree which admits of the formation of a well-defined image from even strongly divergent rays.

But there are eyes which have not normal powers in a state of rest, and in which no change in the curvature of the crystalline lens which is within the capacity of the ciliary muscle to effect is sufficient for perfect accommodation. Such abnormal eyes owe their defect to one of three conditions; generally inherent in the construction of the globe: the optic axis is either too long, giving excessive refractive power, and constituting myopia; or it is too short, causing insufficient refraction, or hypermetropia; or the surfaces of the cornea or lens may present an unequal curvature in different meridians, creating irregular refraction, or astigmatism.

FIG. 34. Diagram showing the relative form of the myopic, emmetropic, and hypermetropic eye.

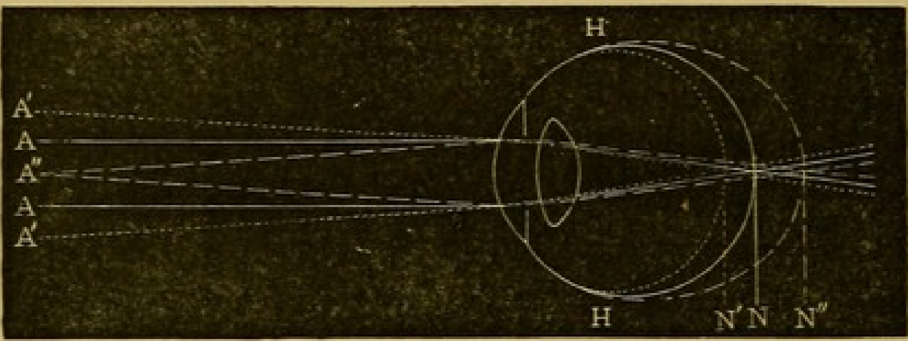


Figure 34 represents sections of three different eyes; the outer or elongated elliptical outline being that of a myopic eye, the middle or circular outline being that of the emmetropic or normal eye, and the inner or flattened elliptical outline being that of a hypermetropic eye. They are all represented as in a state of rest; that is, without the exercise of any accommodative power. The myopic eye, from its long antero-posterior diameter, is capable of converging upon its retina at N″, divergent rays emanating from a point A″, which is its far point for distinct vision; the emmetropic eye, under the same conditions, can only bring to a focus upon its retina at N parallel rays A A, or those which emanate from very distant objects; while the hypermetropic eye, with its antero-posterior axis abnormally short, has such a deficiency of refractive power that it can only bring to a focus upon its retina at N′ rays already convergent as A′ A′. Each of these three kinds of rays is shown by a particular style of engraved line; and it will be observed that while each set comes to a focus, and so forms an image at the retina of the eye for which it is adapted, the others are received either before or after reaching their respective points of convergence, and so form either mere circles of diffused light, or at best but very vague and confused pictures of external objects.

This figure also explains the reason for the diminished acuteness of vision often existing in myopic eyes. Inasmuch as the retina, which in a normal eye would occupy the space shown by the line H N H, has become distended over the larger surface H N″ H, its nervous elements, being thus diffused, are capable of receiving a less vivid impression of an image formed upon any given superficies.

DETERMINATION OF AMETROPIA WITH THE OPHTHALMOSCOPE.

In employing the ophthalmoscope as an optometer for detecting and measuring abnormalities of refraction, the examination is made by the upright method, and without the object-glass, the mirror being either used alone, or with various positive or negative lenses placed behind it in a rotating disc, so that one glass after another can be brought behind the perforation in the mirror.

In looking at the fundus of a myopic eye with the mirror, aided by a concave glass behind it, the observer at a distance of eight or ten inches will see an inverted image of the optic disc. If he moves his own eye laterally the image moves in an opposite direction. If the observed eye is hyperopic an erect image will be seen with the mirror alone, at a distance of from eight to ten inches, and this will seem to move in the same direction as the head of the observer.

If atropia has not been used, before the inspection, to interrupt the accommodative action of the eye, the patient should look at a distance, and thus suspend his A.

To measure accurately the kind and degree of ametropia, the observer's own eye and the mirror are brought close to the eye of his patient. He should be able to relax his A, or, if not, to estimate by experience the amount of A he employs. Then, bringing different lenses in succession behind the aperture in the mirror, the focal length of the strongest convex or weakest concave lens with which he sees the details of the fundus most clearly, plus the distance between his own and the other eye in cases of M, and minus this distance in H, will be the measure of the M or H of the observed eye. If the fundus is seen more clearly without the addition of any glass behind the mirror, the eye is emmetropic.

This method offers advantages for the determination of the degree of ametropia in deaf persons, in malingerers, and in children, who cannot or will not give correct answers to questions when tested by other modes of inquiry.

But in selecting glasses, the optometric use of the ophthalmoscope is to be supplemented and rectified by actual trial of the glasses themselves, especially if the ophthalmoscopic examination has been made during the effect of atropia; otherwise the glasses chosen, though perhaps fitted to correct the absolute defects of refraction, may not at all suit the eye as a working instrument, having accommodative qualities which enable it to neutralize even very considerable aberrations.

Dr. Loring has devised and perfected most convenient means of adapting a series of small lenses behind the mirror, so that they can be rapidly shifted to the aperture by a touch with the finger upon the edge of a revolving disc, and brought in succession in front of the observer's eye without removing the ophthalmoscope from its position, thus allowing of instant comparison of the clearness of the images formed by the different glasses. Various modifications have been proposed in these instruments, by other inventors, to fulfill indications which they have deemed important, the principle continuing essentially the same.

An experienced observer can make an approximative estimate of the degree of ametropia in the ordinary ophthalmoscopic examination by the inverted image, if he uses in all cases an object-glass of the same focal power, so as to be able to form a comparative judgment from the appearances at the fundus.

CHAPTER XIX.

MYOPIA.

THE word myopia, derived from the habit which very short-sighted persons have of nearly closing the lids when they wish to see objects distinctly, so as to give greater clearness to vision by cutting off the lateral pencils of light and thus lessening the circles of dispersion; is used to designate that condition where parallel rays are brought to a focus, by an eye in a state of rest, before they reach the retina. In order to have the image properly formed on the layer of rods and cones, the rays must be divergent when they enter such an eye. The far point is not at infinity, but at a limited, and oftentimes a very limited, distance from the eye, and the region of A is proportionally narrowed. This region is also brought nearer than in an emmetropic eye, because from the nearness of the far point no exercise of A is required until within a shorter distance than the normal, and therefore with the same accommodative power the near point would be closer to the eye.

FIG. 35. Myopia corrected by the use of a concave lens.

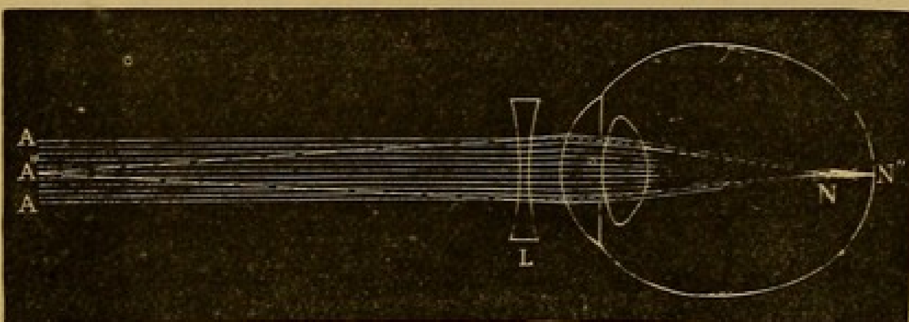


Figure 35 represents a myopic eye at rest, in which condition the divergent rays from its far point A″ are refracted to a focus upon its retina N″; parallel rays A A being, under the same conditions, refracted to a focus at the normal position of the retina N. By the interposition of the concave lens L the parallel rays A A are rendered divergent, so as to enter the eye in the same direction as if emanating directly from A″, and are thus made to converge to a focus upon the actual retina N″.

The letter M is used to express myopia. Eyes may be regarded as myopic if their distant vision is improved by concave glasses; which disperse the parallel rays and adapt them to being focalized by these eyes upon the retina. This condition depends on an elongation of the antero-posterior axis of the eye, which is no longer, properly speaking, a globe, but has an ellipsoidal form. The distance of the retina from the cornea, where refraction begins, being thus increased, the refractive power of the intervening transparent media becomes relatively greater than the normal. An emmetropic eye can be rendered virtually myopic by placing before it a convex lens, which will bring parallel rays to a focus in front of the retina.

The degree of M is that of the farthest distance where objects — test letters, for instance — subtending an angle of $5'$ can be clearly seen. This distance also indicates the focus of the concave lens which will be required to render rays parallel, as if coming from ∞. For exact correction this lens should be at the nodal point within the eye; but this being impossible, the distance of the glass from the eye, half an inch, must be added to the power of the lens: if, for example, $-\frac{1}{6}$ at the nodal point would render rays parallel, $-\frac{1}{5\frac{1}{2}}$ would be actually required to be worn. For glasses of high power this difference of distance is of importance, but in the lesser degrees of M it may be neglected.

The formerly accepted theories that M is due to increased convexity of the cornea, or to an exceptional form or position of the crystalline, were not well founded. It is by no means true, as was believed, that myopic are always more prominent than emmetropic eyes. Cases are occasionally seen where the anterior chamber is deeper and the lens farther from the cornea than the normal, but these conditions would in themselves cause H rather than M.

The presence and degree of M may be determined by several methods. A ready way is to hold print in front of the eye, and measure the farthest point at which it can be read. If this is 6 inches, we say the myopia is $\frac{1}{6}$. The degree may be ascertained by trial with concave glasses, beginning with a power corresponding with the far point for reading fine print. If this point is at 10 inches, N° — 10 glasses may be first tried; if with these the patient sees N° XX test letters at 20′, they are sufficient to carry his far point to the normal standard. But before deciding upon the choice, glasses of foci next below and next above this N° should be tried in comparison, first one and then the other glass being held before the eye; or, — 10 being placed in a frame before the eyes, a low power of + and of — glasses is alternately held in front of these, to ascertain if by thus lessening or increasing their power vision is made sharper. It is also found that if the glass is too strong vision is improved by placing it a little farther from the eye; if too weak, by bringing it closer. The lowest power which gives clear definition of objects is to be selected. Too strong glasses make objects appear smaller, and give to them unnatural brilliancy. In testing for glasses, the lower powers should be first tried, and the higher N^os compared with these, rather than the reverse.

Ophthalmoscopic examination with the erect image is also employed to determine the degree of M; but should not be solely relied on to the exclusion of actual comparison of the glasses indicated by this optometric measurement with other lenses of less and of greater power.

Slight or moderate M is scarcely discoverable by external inspection of the eyes; but in the higher degrees the elongated form of the eyeball may be readily seen by widely separating the lids with the fingers, at the outer canthus, and having the eye turned strongly inward. The curve of the sclera is perceived to be gradual, and extends far back in the orbital cavity, giving to the globe an evidently ovoid form; whereas in H the curve is very short, and the eye is obviously flattened in its antero-posterior diameter. The anterior chamber in M is often deeper and the pupil larger than natural. Where the M is considerable, the movements of the eyeball are manifestly limited and difficult, especially those of convergence.

In slightly myopic eyes, though both the far and near point are brought closer to the eye, the range of A is not affected; but in the high degrees it is materially shortened, though it is less called into exercise, unless the eyes are imprudently used for fine work, because the refractive power is above the normal. In medium grades of M, this is an absolute advantage, and such eyes read and work longer without fatigue in early life, and do not need convex glasses in old age. Unfortunately, this quality in youthful myopic eyes proves but a delusion and a snare, tempting them to excess, which has destructive results.

The myopic alterations of form, the tendency toward which is strongly hereditary, take place principally at the posterior segment of the globe. This renders the greater convergence which is required in binocular A on account of the shorter distance of the near point, exceedingly difficult, because of the altered form of the eyeball, which is no longer fitted to rotate easily in the orbital cavity, and because of the relatively disadvantageous insertion of the rectus internus and its lessened power. Where these conditions exist in a high degree, binocular vision becomes impossible, because the eyes cannot converge even to the binocular far point. One eye then gives up the attempt to converge or to see clearly, and, yielding to the impulse thus created, turns outward, in divergent strabismus, to avoid inharmonious images on the two retinæ.

The binocular field of vision is limited by these disabilities of movement, and the lateral range of sight is also lessened, when strong glasses are worn, by the disturbing refractive effects produced when looking through their edges. Therefore, the myope, instead of turning his eyes, acquires a habit of suddenly turning his head to the side, so as to enable him to view objects through the centre of his glasses.

Inasmuch as M depends on positive and permanent structural alterations of the eyeball, it is an incurable affection, and the popular belief that it disappears at a certain age is unfounded. Once myope, always myope. Nor is it true that because myopes see small objects in a dim light, and can read without glasses at an age when others require them, their eyes are stronger than those of emmetropes.

Myopia, as has been said, is to a large extent a result of hereditary predisposition. Few children become short-sighted in any considerable degree, in whose parents or relatives of a previous generation myopia had not already existed. It is very rarely congenital, but is developed during the years of study, and especially in those who inherit a disposition to it.

It may, however, be created, where there is no such inherited liability, by over-use of the eyes; while, on the other hand, the inborn tendency to M may remain dormant, unless unfortunately aroused by excessive application of the eyes to near objects. M is a disease of civilization, quite unknown among savage tribes, and of rare occurrence among the peasant classes of the European states. The reasons for these facts have been only recently apparent; but in the progress of modern ophthalmology it has been amply demonstrated that the gradual regular or irregular elongation of the eyeball backward, which constitutes one of the essential conditions of M, is a result of too continuous strain in accommodation and convergence, which, by causing tension of the recti muscles, creates a lateral pressure upon the globe, which disposes it to yield posteriorly. At the same time the ocular vessels become congested, from the position of the head when reading, writing, etc., and from the prolonged action of the ciliary muscle, and intra-ocular pressure is thus added to that from without. If the light is dim or the print blurred, as is often the case in schools, the book must be brought nearer to the eyes and the convergence yet further increased.

The ophthalmoscope has reconstructed our knowledge of M, and has revealed the pathological processes and results which give to it such grave importance. It shows us, not merely a retrocession of the posterior tunics of the eyeball, but also, in numerous cases, a progressive yielding of these parts, with gradually increasing and incurable structural changes. The most striking phenomenon revealed by the ophthalmoscope is the presence, in a large proportion of all but very slight cases of M, of posterior staphyloma. On looking at the optic disc, this staphyloma is seen as a crescentic atrophy of the choroid, nearly always at the side of the disc which is toward the macula lutea. This crescent may be nearly of normal color, though wanting in choroidal pigment; but oftener it has a whitish aspect, sometimes much more so than the disc itself. Its outer edge has a sharply defined limit, or blends by an ill-defined orange border with the normal choroid. In progressive M, this atrophied area extends itself, creeping, perhaps, by a narrow line completely around the disc, but especially enlarging toward the macula lutea. The blood-vessels of the choroid are nearly obliterated over the affected surface, and the pigment disappears or remains in scattered patches. The general direction of the axis of the crescent is toward the macula; but it follows no absolute law of development, and often branches forth irregularly above or below the usual line of progress. It only occasionally reaches so far as to involve the macula: but, unfortunately, this region is liable to be indirectly implicated, and, perhaps suddenly, is the seat of hæmorrhagic effusion or other exudation. The form and the level of the optic disc are unchanged in slight degrees of staphyloma; but when this increases, the outline of the nerve entrance often blends at the outer side with the crescent, and partakes of the disposition to atrophy and to giving way, while the rest of the disc appears of an oval form. The retinal vessels become straighter as this tissue is stretched by the intra-ocular distention, and the choroidal vessels show attenuation. When changes at the macula occur independently of direct extension of the staphyloma, or of actual hæmorrhage, they take the form of small scattered red or yellowish-gray spots, intermixed with pigment patches. Rarely, the staphylomatous degenerations of the membranes are greatest at this region. Disseminated choroiditis, in irregular congested spaces, not seldom ensues in the advanced stages. The vitreous also partakes in the morbid changes of the superlying structures, and floating opacities are often visible in its softened mass. Effusion beneath the retina, separating it from the choroid and abolishing vision, is a by no means rare sequel of these other pathological processes. The sclera, which in normal conditions is thicker at the posterior part of the globe, grows thin and bulges backward, sometimes uniformly, at other times irregularly, as we observe elsewhere in its structure, where it has come to be affected after choroidal disease. Whether the traction upon the sclera at the outer side of the optic nerve, caused by continuous convergence of the eyes, has any share in causing its attenuation and yielding is a yet undetermined question. The entire series of processes occurring in the formation of staphyloma posticum has been regarded by Gräfe and others as a sclero-choroiditis of chronic nature. In some cases, even of very considerable M, instead of the appearance of staphyloma at the border of the disc, no changes can be discovered at the fundus with the ophthalmoscope, except that the disc is redder than the normal, and smaller, as being evidently farther from the cornea.

The vision of myopes for large objects is often wanting in acuteness, particularly at night, even when the eyes are provided with the glasses which most assist them. Where, as is sometimes the case, no extreme changes are visible with the ophthalmoscope, this amblyopic imperfection doubtless depends on a uniform distention of the retina, with, perhaps, displacement of its rods and cones, so that the number of percipient elements in a given space on which rays of light impinge is less than is needed for the formation of a distinct image.

Myopes see better when looking through a small aperture, because this lessens the circles of diffusion, which otherwise, especially where the pupil is of the abnormal size so common in myopes, form a confused image on the retina. The fact that vision is thus improved by narrowing the pupillary opening, together with the slightly lessened refraction of the crystalline in advanced life, explains why it is that as the pupil grows smaller in old age some short-sighted persons see better at a distance when they reach this period of life.

Predisposition to M is almost always inherited by at least some of the children where one parent is myopic. In these children M may often be detected, if sought for, at a very early age, and is generally evident at from eight to twelve years of age. Once present, it tends to increase, and should be watched with care. If not existing, at least in some slight degree, before sixteen years of age, it is never developed, even by excessive use of the eyes ; nor does it appear, unless exceptionally, in eyes originally hyperopic.

Three conditions of M are to be recognized : stationary M, where, having reached a certain degree, no other change occurs ; temporarily progressive M, where there is for a time increase of optical and structural changes ; and constantly progressive M, where the morbid processes go on to more or less destructive terminations.

During the period of youth, which is usually also the time of closest application to study, there is a disposition to gradual development of the inherited myopic tendency ; but this may be kept in abeyance if the eyes are used principally for large objects ; and if, during this period, the M does not become very considerable, it may remain stationary during the rest of life. Temporary increase of M may take place during these years of growth and of study, from too close application ; but, provided its degree is still moderate, its further progress may be arrested at or after maturity, if the individual grows more prudent. But — and this constitutes the gravest feature of the disease — if the M has, during this period, already reached a high degree, the tendency to continued progress frequently cannot be arrested, notwithstanding the exercise, too late, of the greatest care ; and degenerative changes go on in the tissues and media of the eye, with the sad prospect of partial or even total blindness at or before middle age.

The earlier symptoms of progressive M are often a mere increase in the imperfection of distant vision, without other apparent inconvenience than the need of stronger glasses. Afterward, as the changed form of the eyeball makes accommodation for near objects less easy, the eyes are readily fatigued and irritable, perhaps hyperæmic, and sensitive to light. Photopsia and muscæ volitantes are often complained of, while as yet no actual opacities are visible in the vitreous. Strabismus divergens often follows, as a consequence of the muscular asthenopia caused by attempts at convergence, and vision becomes only monocular. The downward course of progressive myopia is accompanied by ophthalmoscopic evidences of atrophic and other changes already described: scotomata or limitations of the field of vision, of greater or less extent; much general deterioration of the acuteness of sight; effusions in the choroid or opacities in the vitreous; and, at last, by degeneration at the macula lutea, or separation of the retina, perhaps followed by the formation of an unhealthy form of cataract, irido-choroiditis, or glaucoma; with absolute loss of vision at the very period when family cares or public duties are most imperative.

Since it has been shown that it is especially by continued tension of the A in study that M with its attendant dangers is generated and increased; and as it is well known to be only preventable, and not curable; it follows that a change in our methods of education is an absolute necessity; or else this, which might be termed self-imposed, disease, will impose a more and more grievous burden on the community.

A child having an hereditary leaning toward M is expected to give a large portion of time every day to study of oftentimes badly printed books, perhaps in a dim light, and sometimes with the requirement from his teacher that he shall not take his eyes from his lesson. M is thus begun. As this augments, the child, who does not see things about him clearly, has less pleasure in the usual sports of his age, and finds more enjoyment in books. His close application to reading, writing, drawing, etc., keeps up convergence of the eyes and pressure upon them of the recti muscles, which tends little by little to increase the ellipsoid change of form and elongate the antero-posterior axis. These alterations go on during the period of growth and of most continuous study, because at this time the tissues of the globe are softer and more extensible than after maturity. If, on reaching this latter term, the structural changes are still only moderate in degree, the M may continue stationary during life. But if, at this time, great deviations from the normal condition have already been produced, the affected parts are less capable of resisting further yielding, and progressive M is thenceforward an ever-present source of danger.

As is evident from the description of the nature of the pathological changes, prevention is the sole resource at our command; restoration is impossible. And in order that preventive measures may be seasonably adopted, it is first necessary that the profession and the public should become alive to the fact that in a large number of cases M is one of the gravest affections of the eye, capable of limitation by constant care during childhood and youth; but if not thus limited, likely to be a source of future disability and misery, and to be handed down as an onerous inheritance to children. At present, the warnings inspired by frequent sad experience in the practice of every skilled observer are almost unheeded, and it is but too common to see the chances of retaining even moderately useful vision in future years recklessly sacrificed to a vain ambition for acquiring mere book knowledge, which, when gained, is often valueless to its possessor; or, if otherwise it could be usefully applied, cannot be made serviceable because of the imperfection of sight which has been created in obtaining it.

Very high degrees of M should also be recognized as an infirmity deserving careful consideration before assuming the obligations of marriage; for those in moderate circumstances may well hesitate to choose partners who, though highly cultivated, may probably at middle life become unable to provide for their households or care for their children.

It should be understood, that if these risks of future disability are to be avoided, it is imperative that when they are shown to be unmistakably present such pursuits as increase them must be at once abandoned, in whole or in part, at whatever sacrifice of preference or ambition. Parents should modify plans for their children's training, and choice of a pursuit, so as not to imperil their eyes. Older persons, who have already developed a high degree of M, but who feel obliged to continue their preparations for some avocation for which they are especially fitted, or in which they see opportunities, should keep in mind the risks to which they are exposed, and should avoid too intense or continuous application, and efforts to obtain class rank or other temporary distinctions, and if necessary should take more time than would otherwise be required for a certain amount of work. If they expect to depend for their support upon occupations which will not only tax the eyes in preparation, but in their pursuit, it is of the utmost importance to preserve these eyes in the best condition possible, and not sacrifice future prospects from disability to accomplish what they had qualified themselves to do. Those who do not study as a means of obtaining a livelihood, but merely for the pleasure of literary acquisition, should feel it a duty incumbent on them to refrain from the continuous excessive use of the eyes, to which their tastes so strongly tempt them; not only that they may prevent progressive and dangerous changes in their own eyes, but also to avoid developing a condition which will often become a baleful possession for their children.

Vision has been carefully tested in many thousands of eyes of school-children, in Austria, Germany, Russia, Switzerland, and America, with everywhere similar results. The statistics thus gathered show that, while in children at common village schools there is but 1.4 per cent. of M, the proportion rises to 21 per cent. in city schools of high grade, and to 40 per cent. in some universities. They show also that not only the numerical ratio but the degree of M is far greater in the higher than in the lower classes of the same schools, — those children who had no M, or only a moderate amount of it, acquiring or largely increasing it in their progress through the advanced classes. Other statistics have shown that in those who studied two hours out of school the proportion of near-sighted was 17 per cent., in those studying six hours 40 per cent. In America, probably on account of the greater activity and variety of life, and the less degree, as yet, of hereditary tendency, the ratio has been found to be smaller than in Europe.

These facts deserve serious attention, especially in connection with our undoubted power of modifying or arresting the progress of M, by proper management and by self-denial during the years of growth and of education. We have seen that if M does not begin before the age of sixteen it is not afterwards developed. We know also that if at the age of twenty, when the system has become matured, the M remains only moderate in degree, not more than $\frac{1}{10}$, it may remain at this point during life, unless imprudent use of the eyes is indulged in, without exhibiting progressive features. This degree of $\frac{1}{10}$ is deemed by good authorities the line of safety. If, at twenty years of age, the M is less than this, there is little danger, with reasonable care, that further changes will declare themselves; if more than this degree exists, constant watchfulness is needed to prevent further deterioration.

If succeeding generations are to be affected with M in an ever-increasing ratio, it is by no means impossible that an abnormal form of the eyeball may be gradually acquired, and its availability as an organ of vision essentially diminished.

As M progresses, the eyes during a certain period have muscular asthenopia, from a disturbance of the proper relations between convergence and A in the endeavor to maintain sufficient convergence for binocular vision, while the A is scarcely used at all. But this effort at last becomes futile, and binocular vision is sacrificed to allay the asthenopic pain. In reading, especially when this is long continued or when the person is fatigued, one eye unconsciously deviates outward, and *relative divergent strabismus* is established, which may be relieved by concave glasses so as to allow of binocular vision.

Absolute divergent strabismus exists when the visual axes diverge during distant vision. In a large proportion of cases M is the initial cause of this; but, as I have said elsewhere, divergent squint may also follow loss of sight in one eye from various causes; the rectus internus of this eye being no longer called into use for looking at near objects.

If one eye has a high degree of M, while the other is emmetropic or hyperopic, there is often slight deviation outward of the myopic eye, because its internal rectus is not used to the same extent as that of the other eye. Here, one eye serves for near, the other for far, objects, and conscious attention is given only to the image formed in one eye; monocular vision in fact sufficing, as in instances where one eye is lost, for conveying distinct sensations to the sensorium.

Myopia, as already said, is not a curable affection. We cannot expect to shorten the elongated axis, or to alter the abnormal form of the globe. Various means for changing or lessening these have been tried, without success. Among these, paracentesis of the cornea, or even iridectomy, were proposed, to mitigate intra-ocular pressure; tenotomy of both the internal and external recti, to lessen tension by giving to the muscles an insertion farther back; extraction of the crystalline, to diminish refractive power; and the use of atropia to suspend A and lull a supposed spasm of the ciliary muscle. Cases are reported where the degree of M has been apparently lessened by the continued application of this latter; but such is not the uniform result, and, in the instances of alleged success, disuse of the eyes for small objects during the course of treatment, and often-repeated trials with test letters, by which the eyes learned to recognize them at a somewhat farther distance, seem sufficiently to explain the apparent slight removal of the far point. Unless proved to have positive efficacy, this treatment is objectionable, even when blue glasses are worn to prevent dazzling. Donders says, "I have never established the fact of any diminution of M in young persons;" and the treatment by atropia appears to deserve no higher praise than other methods, which have been, to use his words, "Alas! a matter of fashion."

The antagonists of atropia, pilocarpine and eserine, appear theoretically to deserve a trial in M, as a means of lessening the size of the pupil, and of causing accommodative action without at the same time requiring increased convergence.

Some further details regarding the hygiene, as it may be termed, of M, may perhaps be useful in showing how to counteract its mischievous tendencies. Excessive and continuous use of the eyes upon small objects is especially to be avoided when these are indistinct or badly lighted. The book should be held up, when possible, to prevent congestion of the choroidal vessels by prolonged leaning forward of the head. Difficult work, in lexicons, in mathematics, etc., should be done, by preference, by daylight; and not too much of this at one sitting, because it calls for continued convergence. Much bodily fatigue before study should be avoided, as this makes A more difficult; and too violent exercise should not be indulged in, because it congests the cerebral and ocular vessels. During work, the eyes should be often turned momentarily towards distant objects, to relax the convergence. Children should not be expected, nor even allowed, to keep their eyes fixed on their books.

Our system of education has grievous faults. To show his erudition, an author often encumbers his pages with useless elaboration, or a repetition of exploded theories; wearying the learner's eyes and brain in the effort to separate the wheat from the chaff, instead of making it his duty to offer to the student a winnowed product. Books are too often printed with blurred type and on bad paper. Teachers insist too much on literal exactness in trivial details; whereas near-sighted children should rather be advised to neglect these, and be satisfied with a general knowledge, in many of the subjects. Looking out unimportant things on maps is a fruitful source of harm. Parents, ignorant of the risks incurred, encourage a precocious myopic child, fond of books, to devote himself more and more to them. Unfortunately, myopes have at first no symptoms which warn them or their friends of impending disaster. Though they see little at a distance, their vision, in the early periods, is better for near objects than it is in emmetropes; their excess of refractive power enabling them to see smaller objects more clearly, for a longer time, and with less light, without fatigue of the accommodation. They therefore regard their eyes as uncommonly strong, and are reluctant to believe that they, above all others, need to use the eyes with care. But the limitations as to excessive application and as to a choice of pursuits, to which allusion has already been made, must be recognized and conformed to by those who are highly or progressively myopic, as the price and sole condition of safety. They will be far happier at middle life if possessed of a moderate amount of knowledge and good vision, than if they find themselves more learned but with disabled eyes, and perhaps threatened with actual blindness. Already, in the German parliament, attention has been called to the fact that in certain districts, where compulsory education has been for some time enforced, more than half the population are myopic.

CHOICE OF GLASSES IN MYOPIA.

As a rule, concave glasses should be of such power as to make distant objects distinct without diminishing them, and should be too weak rather than too strong. If of too high power, distant objects are rendered smaller and unnaturally brilliant, and they have a dazzling effect. Furthermore, they render rays from objects at moderate distances so divergent that the eye cannot bring them to a focus at the retina without using its accommodation, as in H. There is no ground for the belief that the use of optical instruments, such as telescopes, eye-glasses, etc., is injurious. Assiduous work with microscopes, with the head bent forward, is objectionable for myopes, on account of the danger of ocular congestion.

Young people who have moderate M, with good range of A, may, if they desire it, also wear the same glasses as give clear definition at a distance, for reading, etc. In some respects it is an advantage to do so, as they are able to hold the book as far off as in E. They thus use their own accommodation, and avoid keeping up an excessive muscular tension in convergence, and, by so doing, lessen the disposition to progressive M and intra-ocular changes. As such persons reach middle age, still weaker glasses than those at first worn will suffice for all purposes, and will afford greater comfort. When still older, they may require no glasses for near work; or even, where the degree of M is inconsiderable, may need convex glasses for reading, while still wearing concaves for distance. As a general rule, there is a reluctance to the adoption of glasses in early life; but, when properly chosen, they have a conservative effect as to the progress of M, while they also afford great pleasure and instruction by allowing the child to see what is around him, and to estimate forms and distances.

If the A is deficient, glasses of different foci must be used for near and for far, since the power which defines distant objects clearly will be too strong for near work, and will call for too much A. Where there is a high degree of M, with lessened A and defective visual acuteness, it is best to give glasses for constant wear which do not quite correct the M for remote things; reinforcing these by lorgnettes or eye-glasses when occasionally needed for clearer definition.

For reading, sewing, etc., such glasses may be worn as make vision distinct at a convenient distance, say 14″ to 16″, so that the eyes may not be fatigued by the greater convergence which is exerted when the book is held near the eyes. If the A is very defective, glasses should not be worn for near objects, and the extremely myopic person should avoid fine work. But when these changes have reached such a degree that binocular vision is no longer practicable, moderate use of one eye for reading, without glasses, or with those of low power, may be allowed.

Where strong glasses are needed for distant vision they should not be worn for piano practice, as the notes are made small and illegible. Those of less power, sufficient for seeing at about two feet distance, should be substituted for this and similar purposes. The same rule applies when glasses are required for writing, reading in the pulpit, etc., where it is desired to keep the head erect.

Some very near-sighted persons see clearly at a distance only with opera-glasses, or with Steinheil's cones. These refract parallel rays to convergence, at their lower surface; and these are again rendered divergent in passing through the concave surface, next to the myopic eye, so as to be adapted to form an image on the retina.

Where the acuteness of sight is much lessened, persons are sometimes unable to read without wearing concave glasses and reinforcing these with a convex reading-glass of large field, held at a short distance from the print. Occasionally, refraction and vision are so abnormal that a stenopæic frame for the concave glass is needed, to cut off the lateral pencils of rays.

The question whether lenses of different power should be worn where there is a different focus in the two eyes, *anisometropia*, is not solely to be determined by scientific theory. They are sometimes serviceable, a glass only partially correcting the refractive error in the worse eye being generally chosen; but in many instances vision is more easy and natural where the lens adapted for the more nearly normal eye is used for both eyes, the less clear image on one retina being more acceptable than the accommodative endeavor to bring to a focus rays from glasses of different foci, which call for a different angle of convergence, and form images of different size upon the two retinæ. If glasses of different foci are tested upon the patient, although he sees more clearly with these when each eye is used alone, he usually declares that he wears them less comfortably than two glasses of the same focus, adapted for the better eye of the two. But if he, exceptionally, sees better with the glasses fitted for each eye, these may be allowed.

Slightly blue-tinted glasses, of the focus usually worn by the person, are sometimes acceptable and useful where, from hyperæmic conditions, the fundus has become sensitive to light.

The setting of the glasses is important. The lenses should be well and accurately ground; they should be carefully centred, and at a suitable distance apart, opposite the axes of the eyes, and as near to them as the length of the eyelashes will permit. If not thus centred the refraction will be irregular, as if from prismatic or cylindrical lenses. Generally, they are set farther apart for men than for women, on account of the greater distance between the eyes. They should be worn parallel to the plane of the iris, and not inclined at an angle, which increases but disturbs the refractive effect. They may be set as spectacles or as eye-glasses, according to the wishes of the individual or the conformation of the nose. Some pattern of eye-glasses, *pinces nez*, can be adapted for most persons, if these are preferred to spectacles. The idea that they do harm by pressure is not well founded, but the spring should not be stronger than is necessary for keeping them in position, and the lighter the frames the greater the comfort in wearing them.

CHAPTER XX.

HYPERMETROPIA.

THE antero-posterior axis of the hypermetropic eye is so short that its unaided refraction does not bring either parallel or divergent rays to a focus upon, but only behind, its retina. Its refraction is adapted to convergent rays, which do not exist in nature, but only when they have passed through a convex lens. Such rays as actually come from all objects, parallel from those at a distance, and diverging from those within eighteen feet distance, can be brought to form distinct images upon the retina in a hyperopic eye only by exercise of the power of accommodation within the eye itself, or by the aid of convex glasses placed before the eye to render the rays of light convergent before they enter it.

FIG. 36. Hypermetropia corrected by the use of a convex lens.

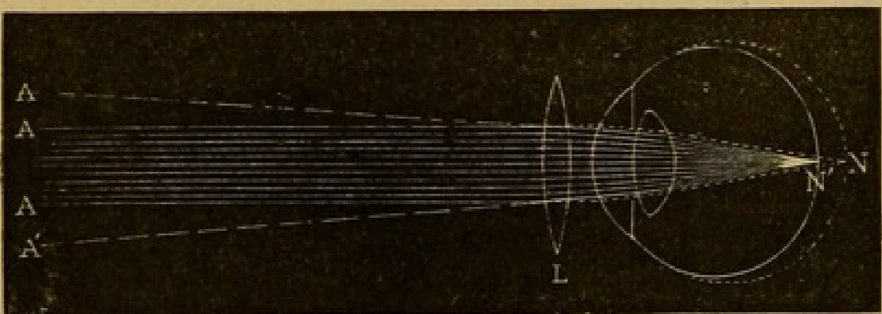


Figure 36 represents a hypermetropic eye at rest, in which condition the convergent rays A′ A′ are refracted to a focus upon its retina N′. Parallel rays A A being, under the same conditions, refracted to a focus at the normal position of the retina N. By the interposition of the convex lens L, the parallel rays A A are rendered convergent, and thus enter the eye in such a condition as permits the formation of a distinct image upon the actual retina N′.

Hyperopic eyes, therefore, are able to see distant things clearly only by employing their A, and they thus have less power in reserve for bringing to a focus divergent rays from near objects. If the A is paralyzed by atropia, even distant objects are not distinctly seen without the help of a convex lens.

The degree of H is expressed by the power of the strongest convex glass with which objects at an infinite distance can be clearly seen.

Hypermetropia is divided into *manifest*, H. m., and *latent*, H. l. The sum of these is the *total*, H. t. The manifest hypermetropia is that degree which appears on testing the eyes with glasses while the accommodative power continues in activity. The latent hypermetropia is expressed by the additional focal power which is required after the A has been completely paralyzed by atropia.

The hypermetropic, or, as he may be termed for brevity, the hyperopic person, is so accustomed to use his A in forming images of distant things upon his retina that he cannot at once give up this habit and relax the ciliary muscle. He thus unconsciously conceals, as it were, and renders latent a portion, often a large part, of his refractive disability.

The total amount of H may be latent in young subjects who have it in but slight degree, and whose A is sufficient to bring even diverging rays from a near object to a focus at the retina. It may, on the contrary, be wholly manifest, where the A has been lost or suspended either by disease, by artificial means, or by advancing age.

Professor Donders, to whom we owe most of our knowledge of this form of Am., and of the frequency of its occurrence, divides H into *absolute*, *relative*, and *facultative* H. Absolute H is present when, with full exercise of the A and the strongest convergence of the visual axes, neither parallel nor divergent rays can be brought to a focus at the retina, unless with the aid of convex lenses. Relative H exists when both parallel and diverging rays can be brought to a focus by using the A and converging the optic axes to a point nearer than the object. Vision is imperfect. In facultative H the person can see both near and far by the aid of his A, either with or without convex glasses. These subdivisions may pass into each other with age, or weakness, or too great fatigue of the eyes, the facultative H of youth becoming at length absolute in old age.

The form of a hyperopic eye is flattened from before backward, as may be seen by opening the lids widely at the outer canthus, and having the eye turned strongly toward the nose. Its antero-posterior diameter has sometimes only four fifths of the normal length. When H is of high degree the eyeball is generally smaller in all its diameters. The image of an object will be smaller in a hyperopic than in a normal eye, because from the shortness of the axis the optic centre is brought nearer the retina. The near point of distinct vision will be farther from the eye.

Hyperopia is a congenital condition, and often hereditary. It not very rarely appears as early as five or six years of age, or much later in life, according to the amount of H and the extent of A. It may declare itself suddenly, where it had been previously latent, after exhausting illness, or as a sequel of affections which paralyze the A, and in such cases vision for far and near objects is indistinct. With advancing age, the symptoms depending on the hyperopia are increased by supervening presbyopia. An apparent hyperopia is a not uncommon premonitory symptom in glaucoma, manifesting itself in a necessity for a frequent increase in the power of glasses for reading.

Fortunately, H involves none of the dangers which attend the myopic form of ametropia. Glasses may be requisite for the comfortable use of the eyes, but there is no such tendency to gradual structural and functional degeneration as that which gives to myopia, in so many instances, the character of a grave disease.

The diagnosis of H may be made in several ways. It may be quickly detected and its degree approximatively determined by my sliding measure, the person tested being found to have both his near and far point removed to a greater than the normal distance; the probable focal power of glasses which will be needed being in proportion to this removal. A practiced observer can perceive its existence when examining with the ophthalmoscope, with the reversed image. It may also be measured by using the ophthalmoscopic mirror alone for the upright image; that convex glass which, when A is relaxed or has been paralyzed by a strong solution of atropia (four grains to the ounce), gives the best defined image of the smaller vessels at the disc and toward the macula, representing the degree of H. But the glasses thus indicated require to be verified by actual test, after recovery of the accommodative power, before they are ordered for the patient. In fact, it is by no means essential to determine the total H by means of atropia, a knowledge of this being scientifically interesting rather than practically important, inasmuch as, if thus ascertained, glasses cannot at once be adapted which will neutralize it, because the extent of A existing in the eye must be taken into account in selecting the glasses. If lenses which correct the total H are given, they prove too strong; for the patient cannot at once lay aside the habit of constantly using his A, and we thus have given him an excess of refractive power which renders him virtually myopic. We therefore order at first glasses which correct the manifest H, as they are easiest for the eyes; and we afterward increase the power of these, so as to correct a portion or the whole of the latent H, when the person has learned to dispense, through their assistance, with his constant exercise of A for all objects, both far and near. Unless the power of the glasses is thus seasonably increased as needed, the A will still be unduly drawn upon, and the required corresponding degree of convergence will be so excessive as to create asthenopia. The ultimate reliance in the choice of glasses must be upon actual trial by the patient from time to time. Those should be given which enable him to read at about fourteen inches. While these are before the eyes, a low power of + and of — glasses may be alternately held in front of them, and we ascertain whether either of these improves the clearness of sight. If the added convex glass makes vision clearer, the glass before the eye is too feeble; if the concave glass gives better definition, the glass on trial is too strong. Glasses should not be chosen which magnify much or cause the patient to bring the book too near the eyes, or which oblige him to hold it too far off, as these would be respectively too strong or too weak for accurate and comfortable vision. The print should simply be rendered clear and black by their aid.

Hyperopic persons often have the eyes widely separated, and the orbital margins, as well as the nose and the cheek bones, less prominent than in E. The eye is deeper in the orbit, the anterior chamber more shallow, and the pupil smaller. There is often apparent strabismus divergens, the visual axes, in looking at a distance, passing some 8° to the inner side of the optic axis, giving to the cornea a seeming outward deviation. Actual convergent strabismus is more often present, as I have shown in treating of this subject. Hypertrophy of the circular fibres of the ciliary muscle, with less development of the longitudinal fibres, is observed in hyperopic eyes, while the contrary is the case in myopia.

The greater amount and more constant exercise of A which is required in H causes *accommodative asthenopia*, from fatigue of the ciliary muscle, after prolonged use for near objects, from which only divergent rays are received; but less complaint is made in the morning than after the eyes have been continuously used during the day, because the eyes are, for a time, capable of the requisite accommodative effort, which, however, produces lassitude and discomfort when kept up too long, and at last compels suspension of work.

Hyperopia becomes the cause of the secondary affection, convergent strabismus, which accompanies it in so large a proportion of cases, because, the acts of convergence and accommodation being unconsciously associated, the eyes perceive that if the visual lines cross at a greater angle, by stronger convergence, than when directed to the object, the sensation of strain during the accommodative act is lessened.

At first temporary, and finally permanent, squint is thus induced. But as this excessive convergence brings the near point inside the limit of binocular vision, one eye alone exercises the function of perception, and, as described in speaking of strabismus convergens, the image formed in the other eye, being inharmonious and indistinct, comes to be neglected; the eye converges yet more, and perceptive power in this eye is gradually lost or weakened. This explains how it is that in the beginning the development of strabismus may often be arrested by the wearing of properly adapted glasses, which prevent the necessity for over-exercise of the A when the child first begins to look intently at small objects. Strabismus does not occur in the higher form of absolute H, because here even increased convergence does not add to the sharpness of the retinal images. Nor is it developed after the early periods of life, rarely after eighteen years of age, because the range of A lessens, and the relative becomes more and more an absolute H. Where strabismus exists the book is often held toward the side of the deviating eye, so that the fixing eye may converge more strongly and obtain a clearer image by increased A.

As hypermetropia, like myopia, depends on a defect of conformation of the globe, oftentimes hereditary, it is not removable by treatment, but it can be relieved by the use of lenses. Through their aid, and with careful management of the eye, asthenopia is prevented, and full use of the organ becomes possible. The acuteness of perception is, however, usually less in hyperopic than in emmetropic eyes. A slight degree of H ensues as a normal condition in advanced age, because of changes in the crystalline lens.

It is by no means always necessary to give glasses to young hypermetropes, if they have such an amount of A as allows them readily to form clear images of near objects, and if they can rest their eyes in case fatigue is felt. They certainly should not use them for distant objects, as they are not needed, and if worn they tend to lessen the adaptive power previously possessed by the eye. But if these persons are obliged to constantly use their A in close study or fine work, they must give their eyes frequent intervals of repose, or else glasses will be needful to assist the refraction, so as to avoid muscular asthenopia and prevent the excessive convergence which would result in strabismus.

Asthenopic symptoms are developed at a period corresponding to the degree of H and the capability of A; according to Donders, at about the age equivalent to the degree of H, — at 10 years if it is $\frac{1}{10}$, at 20 years if $\frac{1}{20}$, etc. At about 25 years the lens begins to adapt itself less readily to its accommodative changes; and presbyopia appears, as hyperopic individuals grow older, much sooner than the age at which it manifests itself in emmetropic eyes. Such persons find themselves prematurely requiring glasses, and are obliged to use them more constantly than normal presbyopes.

If, as already advised, on first seeing a patient, we order glasses which correct the H m only, or at most a part of the H l, the asthenopia is often relieved, if these are always worn for near vision. Sometimes, after the symptoms have thus been removed, the person may carefully resume work without glasses; continuing it, however, only so long as he can do so with ease. When he is not to remain under observation, he should generally be advised to exchange these for rather stronger glasses, if the eyes, while wearing them, begin to feel strained during or after work. If tested at this time, the H m would be found to be increased from its original amount. Patients should also be advised to interrupt the use of the eyes now and then, while at work, by looking at a distance, and not keep them too constantly employed upon small objects.

The increase in power of the glasses may go on *ad libitum*, and patients may be assured that there is no danger of their ever reaching a point where no glasses will be sufficiently strong for them.

Wearing glasses for distant sight, although theoretically advantageous, is disagreeable to many persons, especially to ladies; for their vision is not thus vastly improved, as it is in myopes, since they see very perfectly without glasses. These may therefore be dispensed with in looking at far things, for a time at least, especially as disuse causes no such asthenopic symptoms as results from attempts to do without their aid in near vision. But the wearing of glasses for looking at far objects, either as a second pair, or as combined, in the upper part of the same frames, with a higher focus for reading, occupying the lower part of the frame, becomes desirable in absolute H ; or where much presbyopia has come to complicate the H, rendering objects blurred at all distances.

If a hyperope sees equally well with two different powers of lenses, the stronger of the two should be given him, as his A will be less taxed. The glasses should be carefully centred.

CHAPTER XXI.

ASTIGMATISM.

ASTIGMATISM is thus named because bundles of homocentric rays, proceeding from one point, are not brought to a focus at one point; but those entering the eye in one meridian are brought to a focus at a point anterior to the focal point of those entering in a meridian at right angles to the first. This condition exists to a trifling degree in most eyes, and is termed normal As.; but it is only where the asymmetry of the two meridians is considerable that it causes annoyance, giving rise to symptoms which the patient finds it difficult to describe, and to a lessening of the acuteness of vision which is not relieved by either convex or concave glasses.

The meridians of shortest and of longest radii of refraction are termed the *principal meridians;* the point where the rays in the meridian of shortest refraction intersect the optic axis is the *anterior focal point;* the point where the rays in the meridian of longest refraction intersect the axis is the *posterior focal point;* and the distance between these, the *focal interval.* The imperfection of vision will be in proportion to the length of this interval, the circles of diffusion overlying each other.

The vertical meridian is generally that of greatest, and the horizontal that of least, refraction, though the reverse is not unfrequently the case; and other exceptions are not rare, the greatest or least curvature being occasionally found in any meridian.

Regular As. depends on differences of radius of curvature in different meridians of the cornea, and may be corrected by cylindrical glasses. *Irregular* As. results from irregularities of surface, or construction, or position in the crystalline lens, and is little relieved by optical appliances, except such as cut off lateral pencils of rays of light.

Astigmatism was observed in his own person, and described, by Thomas Young, as long ago as 1793, but was supposed, until Professor Donders and others recently proved the contrary, to be but a rare anomaly: whereas we now know it to be a by no means infrequent form of ametropia, requiring + or — cylindrical glasses for its correction.

If an astigmatic person looks at horizontal lines when these are at such a distance that rays from them are brought to a focus in the vertical but not in the horizontal meridian, the lines will be distinctly seen, but their ends will be blurred. If, on the contrary, these lines are placed at a point adapted for refraction to a focus in the horizontal meridian, they will appear everywhere blurred except at the ends. These conditions can be transposed by placing convex or concave glasses in front of the eye, or by changing the distance for which it is accommodated. It is this impossibility of distinguishing with equal clearness horizontal and vertical lines at a given point, which makes reading difficult for astigmatic persons. On looking through a card or plate perforated with a slit, held in a proper direction, the confusion of sight ceases.

Astigmatism can be detected by observing the optic disc with the ophthalmoscope in the direct method. The disc will have an oval form, its greatest elongation corresponding to the meridian of greatest curvature. The smaller retinal vessels running in one direction will be less clearly seen, at the same distance and with the same degree of A, than those running at right angles to them. If the mirror is brought alternately a little nearer and farther from the eye, the vessels and the outline of the disc will be seen distinctly, first in one and then in the opposite meridian. In ordinary ophthalmoscopic examinations with the inverted image the object-glass must not be held obliquely, as it then produces the effect of a cylindrical lens, and makes the disc appear oval. To be sure that the lens is held at right angles to the direction of the light, we notice the reflections from the anterior and posterior surfaces of the lens, and bring them into a position where they coincide. In testing for As. we first determine whether the person sees plainly at the normal distance of 20 feet, and if at this point he can see horizontal and vertical lines with equal clearness without or with the aid of a plus or minus glass, in which case he is not astigmatic. If he does not thus see them with equal distinctness, various tests are used to determine the principal meridians of greatest and least refraction. Lines arranged as radii of a circle or semicircle are a convenient means. If no one of these lines is clearly seen at a position where they subtend an angle of $5'$, + or — glasses are successively held before the eye until some radiating line becomes defined; this line indicates one of the principal meridians, and the other is at right angles to it. Other + or — glasses are now tried, until a N° is found which renders the line which corresponds to the second meridian distinct; and the difference between the two glasses denotes the degree of As. With a set of cylindrical glasses the determination is more quickly made, the cylindrical glass being selected which renders all the radiating lines as distinct as the line most clearly seen without its aid. The glasses chosen for distance and for reading are to be carefully tested, to determine if errors caused by any latent H are duly provided for.

Astigmatism may be associated with M, with H, or with both of these forms of ametropia.

Donders gives as a classification:—

Am. Simple myopic astigmatism, where one meridian is M, the other E.

M + A. Compound myopic astigmatism, where one meridian is Am., the other M.

A h. Hyperopic astigmatism, where one meridian is H, the other E.

H + A h. Compound hyperopic astigmatism, where one meridian is H, the other A h.

A m h. Mixed astigmatism, with predominant M, where one meridian is myopic, the other hyperopic.

A h m. Mixed astigmatism, with predominant H, where one meridian is hyperopic, the other myopic.

These forms of regular As. may be increased, or they may be partially neutralized, by irregular As. existing in the crystalline, and especially by the partial and oblique displacement of this lens. *Polyopia*, or multiplication of images in one eye, often depends on irregular As. of this eye.

Astigmatism, as a rule, is congenital, and according to Donders is more frequent in hyperopic eyes. Irregular curvature of the cornea, following ulcers or operations, particularly those for cataract, where some delay or complication has occurred in the healing of the wound, may be the cause of an acquired As. In such cases a combination of a cylindrical with the ordinary convex cataract glass, or wearing the convex glasses a little inclined to the plane of the iris, or decentred, so as to look through their edges, may increase the clearness of sight. Acquired As. may also result from dislocation of the crystalline lens.

Cylindrical glasses are the sole means of correcting astigmatic refractive errors. These may be plano-cylindrical, or bi-cylindrical, which are to be regarded as combinations of two plano-cylindrical lenses, the two axes of which may be ground to intersect so as to correct the As. or ametropia in each meridian. The angle of inclination of the axis at which cylindrical glasses are to be set is to be indicated to the optician. Sphero-cylindrical glasses, one surface ground to a spherical, the other to a cylindrical, curve, are ordered thus: $+ \frac{1}{12}$ s $\supset$ — $\frac{1}{24}$c, ax. 180°; — denoting that the convex spherical is combined with a concave cylindrical form, with the axis placed horizontally.

Bicylindrical glasses with surfaces of equal curvature, or more commonly plano-cylindrical, are worn, where there is no such degree of difference in the principal meridians as to require that compound glasses should be ground for use in the particular case in question. The plano-cylindrical, of which the curved surface may be convex or concave, correct the refraction in the meridian at right angles to their axes, while in the meridian corresponding to their axes, which is already emmetropic, they do not deviate the rays. These glasses, which bring the rays in the other principal meridian to unite in forming a normal distinct image, are sufficient in a large proportion of cases.

A convex cylindrical lens should be fitted with its axis in the plane of the meridian of greatest refraction of the eye, that rays passing through its meridian of curvature may be converged as if they passed through the meridian of high refractive power in that eye. Concave lenses should be placed with their axes corresponding to the meridian of lowest refraction, so that rays passing through their meridian of refractive curvature may be dispersed before being subjected to the high refractive meridian of the eye.

Dr. John Green, of St. Louis, has devised a great variety of tests for As., no less remarkable for their scientific accuracy than for the ingenuity with which they have been adapted for the solving of every possible problem. His radiating lines, directed toward the hour figures on a clock-face chart, are convenient for testing without having to lose time in explaining to unintelligent patients what is required of them. Test letters made up of parallel lines, inclined at different angles, were also well devised for this purpose by the late Dr. Pray, of Brooklyn.

Stokes's method of testing, by plano-cylindrical lenses rotating upon each other, has been advantageously modified by Snellen. A somewhat elaborate instrument was also devised by Javal. Stereoscopic and other contrivances, too numerous to mention, have been employed by authorities in physiological optics. To many of these contrivances we may apply Zehender's remark, "Useful, but by no means indispensable."

The delight exhibited by those having a considerable degree of As., when, after being fitted with suitable cylindrical glasses, they see for the first time objects with a clearness of which they had previously no conception, is most interesting to witness.

Care must be taken, however, in adapting glasses for As., not to over-correct the defect, or too much complicate the lenses. The fact that the congenitally astigmatic eye has capabilities which enable it in youth, and up to a certain period of life, to virtually neutralize the defect cannot be questioned, and thus, by unexplained involuntary acts of accommodation, an image is formed upon the retina at the middle of the focal interval, where the section of the cone of homocentric light will be nearly round. This latent power unquestionably enables many astigmatic eyes to overcome, or to disregard, moderate degrees of this anomaly of refraction, and either to altogether dispense with glasses, or to take such as correct the greater refractive defects without demanding that minute secondary deviations should be compensated by special adaptations of glasses. Cylindrical lenses, which seem accurately to fulfill all required conditions when tried in one position only upon a test object, may prove very uncomfortable to an eye which is to be constantly and rapidly rotated in different directions, and used for various distances; and great relief is often found in exchanging too elaborate compound lenses for such as obviate the extremer defects of refraction, leaving to the eye itself the overcoming of lesser irregularities.

Cylindrical lenses must be mounted with great exactness. With ordinary convex or concave lenses slight deviations from accuracy do not materially interfere with the serviceableness of the glasses or the comfort of the wearer. It is quite the contrary with cylindrical glasses, especially those of considerable power; for, since it is only when the axis corresponds to a certain meridian that they are adapted to aid the eyes, a very trifling displacement of the axis from its proper direction prevents a neutralization of the refractive defect. The patient must therefore, if possible, make personal application to the optician, that the frames for the glasses may be carefully adapted to his nose, to the proper distance of the eyes from each other, and as regards their level in front of the pupil. The glasses are then to be fitted to the frames with the utmost care, with the axis in the direction ordered. Spectacles have the great advantage that they keep their place more steadily than eye-glasses, but the latter are preferred by most individuals. These must be put on with due regard to their axial position, and if they slip or are tilted, so that the axis becomes deviated, they must be readjusted by the wearer; otherwise he soon has a sensation of fatigue, as in accommodative asthenopia. Round glasses have this advantage over the oval forms: that if any displacement of the axis of the cylinder occurs from bending or other accident to the frames, the glass can be set right by being turned in the frame, which cannot readily be done with those of oval shape.

Irregular As. may be corrected by a stenopæic slit, inclined so as to allow rays to enter the eye in a direction which is the meridian of its most accurate refraction.

CHAPTER XXII.

TEST LETTERS.

A SERIES of standard test letters, prepared according to Professor Snellen's plan, is appended to this work. The figures placed above each line of letters denote the distance in feet at which they should be read by the normal eye. N° XX, for example, should be read at twenty feet; and this is regarded as the standard of normal vision. If this N° can be read only at ten feet, we say V, which expresses the acuteness of vision, is $\frac{10}{20}$: the denominator indicating the distance at which the letters should be read, the numerator the distance at which they can be read, by the person examined. These test letters are also largely used for examinations as to the acuteness of sight in railroad employés.

A page of reading tests and two tests for astigmatism are also included. The three horizontal and the three vertical lines, and the radiating lines of the semicircle, should be seen at the proper distance, and, if necessary, with the aid of convex or concave glasses, with nearly equal distinctness; though even a normal eye often perceives a slight difference in clearness.

If persons are unable to make out the test letters at the figured distance, we have then to ascertain whether the inability arises from abnormal focal conditions, or from a want of clearness of the transparent media, or from a deficiency of perceptive power. If from the first cause alone, we seek our remedy in adapting suitable glasses; if from the other defects, we must look to other means for relief.

APHAKIA.

The absence of the crystalline lens from its normal position, in consequence of its luxation, absorption, or extraction, constitutes aphakia. The eye may here be regarded as in a state of acquired H, being greatly deficient in refractive power; and it is wholly deprived of its function of accommodation.

On inspection, the iris is often seen to be tremulous, and the lens to be absent from behind it. This may have resulted from a blow, or other traumatic injury, or from an operation for the removal of cataract. The loss of the lens can only be supplied by strong convex glasses, one glass being usually worn for distant vision, and another, of higher power, for reading; though, as in other instances, glasses may be ground having the focus for distance at the upper part, and that for reading below. As there is no longer any accommodative faculty in the eye itself, objects at intermediate points are more clearly defined by artificial A, which consists in holding the distance glasses a little farther from the eye while looking at such objects. The refractive power of the glasses is thus virtually increased, and they define more accurately things which are at the middle positions, between far and near. By carrying them still a little farther from the eye, print may be read with the distance glasses. If the cornea is astigmatic, vision is sometimes improved by slightly inclining the glasses. Glasses of about 4 or 4½ inches focus are generally chosen for distance, those of about 2 or 2½ inches for reading; but there is considerable variation in this respect, according to the previous M or H of the eye. As a rule, however, the acuteness of vision is somewhat less than the normal; and, on account of the high refractive power of the glasses, it is necessary, for most distinct vision, to look directly through their centre, and for lateral vision the head must be turned rather than the eyes. Where only one eye has been operated on, and the other has no sight, the far and near glasses may be set in the two sides of the same frame, where the conformation of the nose will allow of this, so as to be reversed at will before the eye, and thus to serve for distant or for near vision.

CHAPTER XXIII.

ANOMALIES OF ACCOMMODATION.

PARALYSIS OF ACCOMMODATION.

THIS condition, which may have various initial causes, gives rise to defects of vision corresponding to the refractive construction of the affected eye. In myopes, who have an excess of refraction, the formation of retinal images is least disturbed by the loss of accommodation. Emmetropes see only distant objects clearly, while hyperopes, who use their accommodative faculty in every act of vision, do not see distinctly either at far or near distances.

Paralysis of A is usually associated with dilatation of the pupil, but may exist independently of this ; as, on the other hand, mydriasis may be present without paralysis of A. Suspension of A, from the use of atropia or other mydriatics, usually subsides spontaneously ; but its subsidence may be hastened, when desired, by the use of myotics. Mydriasis, with its accompanying paralysis of A, also generally disappears slowly when it has resulted from rheumatic paralysis of the ciliary branch of the oculo-motorius, caused by exposure to cold, and when it occurs as one of the sequelæ of some exhausting or other diseases ; but the time required for recovery varies greatly, and the prognosis in this respect must be guarded. When the paralysis results from a blow upon the eye, and does not soon decrease, or if it comes as a secondary symptom of cerebral lesion, the prognosis is unfavorable.

Pilocarpine and eserine are sometimes useful as curative means ; and in cases where such a result is not attainable they palliate the symptoms, giving temporary power of A, and lessening the discomfort caused by the excessive influx of light through a dilated pupil. Convex glasses are useful in compensating for the loss of A, as they are also where A is diminished, as in presbyopia, from senile changes in the structure of the crystalline.

SPASM OF ACCOMMODATION.

In this rare affection an excessive but varying convexity of the lens appears to be kept up, so as to greatly interfere with the normal exercise of the accommodative function. Distant things are seen indistinctly, and close application of the eyes to near objects soon becomes fatiguing.

Accommodative spasm is oftenest seen in eyes which have been employed immoderately upon fine work, and may come on suddenly. Reflex irritation proceeding from the facial or other nerves seems to be an occasional cause. It is also one of the characteristic signs of progressive locomotor ataxia. Temporary spasm of A, with myosis, may occur from the effect of irritating applications to the eye, or the presence of foreign bodies, in which case it subsides as the local irritation is removed.

As paralysis of A and mydriasis can be artificially produced by atropia and other drugs, so may the opposite condition of spasm be excited by the two myotic agents recently placed at our command. In 1863, Drs. Fraser and Robertson, of Edinburgh, announced to the profession the very important discovery that an extract of the Calabar bean, *physostigma venenosum*, was capable of causing contraction of the pupil and increasing the accommodation. A few years later, jaborandi, *pilocarpus pinnatus*, was found to possess similar powers. These invaluable myotics have been made more conveniently available by means of their alkaloids, eserine and pilocarpine. Myosis and active contraction of the ciliary muscle are induced within a few minutes after the instillation of a drop or two of a two or four grain solution of either of these alkaloids upon the conjunctiva. The effect on the pupil continues a much longer time than the contraction of the ciliary muscle.

If spasm is caused by excessive strain of the eyes, rest is often sufficient for relief. If necessary, the ciliary accommodation may be placed completely in repose by paralyzing the muscle with a solution of atropia; and the use of convex glasses may be advised for a time, to supersede the necessity for any accommodative efforts.

CHAPTER XXIV.

OPHTHALMITIS.

INFLAMMATION of the entire globe, succeeded by purulent or sloughy degeneration, may occur where a staphylomatous or otherwise disorganized eye has received a blow or some other injury; or it may follow operations, especially such as are done upon an eye already much diseased, as, for instance, the ablation of a large staphyloma. The presence of a foreign body, such as a bit of gun-cap or steel, in the deeper parts of the eye, often causes suppurative choroiditis, with a tendency to a gradual bringing forward and final elimination of the foreign substance through the cornea, usually without exciting symptoms of sympathetic ophthalmia; the choroiditis thus induced being generally sluggish in its form, and rarely becoming an ophthalmitis. This general inflammation may also happen, in rare instances, in puerperal or other cases, from metastasis or septicæmia, in eyes previously healthy.

At the outset the globe is very tense, and if the cornea is still transparent the pupil is seen to be dilated and fixed. Turbidity of the transparent media, and soon after of the cornea, follows, with phlegmonous chemosis of the ocular conjunctiva and great tumefaction of the lids. If vision existed, it is entirely lost. The tension of the globe, causing extreme and often pulsative pain, distinguishes this panophthalmitis from abscess of the orbit. The globe is immovable. General febrile symptoms are marked. The contents of the globe sometimes become purulent; in other instances they are transformed into a mass of sloughy tissue resembling that of anthrax. The indications for treatment are, the early evacuation of the contents of the globe; by free incision if the accumulation is purulent, and by scooping out of the material when it is of firmer consistence, leaving only the sclera. The great suffering is thus quickly relieved, and the danger of even a fatal termination is averted. Enucleation should not be done in these cases, as it has been followed by cerebral septicæmic symptoms, and it has no advantages over the outscooping above advised, which allows of the preservation of a very useful remnant of the globe. Some little time is needed for recovery, the secondary inflammation of the orbital tissues subsiding only slowly. Only fomentations are called for as local treatment, but the general condition of the patient often urgently needs attention, a large proportion of these cases occurring in decrepit or debilitated subjects, and requiring stimulants and tonics.

After the results of inflammation are fully recovered from an artificial eye may be worn.

INFLAMMATION OF TENON'S CAPSULE.

This affection of the fibrous capsule in which the eye rotates has more resemblance to ophthalmitis, where the entire globe is disorganized, than to inflammation of the orbital cellular tissue. It is marked by chemosis of the ocular conjunctiva, protrusion of the eyeball, a certain amount of œdema of the lids, and much pain.

If the eye is examined with the ophthalmoscope early in the disease, it is evident that the origin of the inflammation is not within the globe; but, where the disease results in purulent formation within the capsule, vision is lost, and the posterior tunics and media of the eye become affected by the pressure and the change of intra-ocular circulation which is thus produced.

A rheumatic form of this affection, which may subside under the use of iodide of potassium, without loss of sight, is described by Ferrall, Mackenzie, Meyer, Wells, and others. In my own experience the cases never had this milder form, or when first seen had passed beyond any such favorable stage, and resembled panophthalmitis in the severity of the pain, the marked chemosis, and the loss of vision, though differing from this in the greater protrusion of the globe, and in the absence of suppuration within the eye. The results have also been different: ophthalmitis terminating in sloughy or purulent alteration of the ocular contents, while inflammation of the capsule ended in discharge of pus through the conjunctiva at a space between the insertions of the muscles, without any evacuation of the contents of the globe, though in some cases a slow process of partial atrophy of the eyeball ensued.

Anodynes at first, and the earliest possible evacuation of the pus as soon as it can be discovered beneath the conjunctiva, followed by warm fomentations, are the proper measures to be employed.

CHAPTER XXV.

DISEASES OF THE ORBIT.

ORBITAL TUMORS.

ORBITAL growths encroach so early upon the space belonging to the eyeball that the first symptoms of their presence are usually a limitation of the movements, and perhaps a forward displacement of the globe, which is accompanied by double vision when looking in some direction, on account of inability of this eye to follow the movements of the other, and by difficulty in closing the lids. These phenomena may reach an extreme degree, the eyeball being even pushed out of the orbit, so as to rest upon the cheek, and all motion of the globe prevented by tension of its muscles. Even in this degree, although the optic nerve is stretched to a great extent and for a long time, the visual function is not lost, though the pressure from behind may lead to a certain amount of flattening of the globe and hypermetropia. The upper lid, having great extensibility, continues capable of covering the eyeball more or less completely. The lower lid is often crowded outward, till ectropion is produced, and the conjunctiva, being exposed to the air and dust, becomes inflamed and thickened; but its structure is not degenerated, and it gradually regains its normal state if the protruding force is displaced.

The prognosis depends much on the acute or chronic development of the growths. If slow, the globe gradually adapts itself to the extruding pressure, and may wholly recover after this is removed; if rapid, serious intra-ocular changes may occur. Where the protrusion reaches such an extent that the cornea is constantly exposed, there is danger that it will become ulcerated and perforated, and the eye be lost.

Continuance of sight in the eye is a favorable diagnostic sign, as the more malignant forms of disease have a tendency to invade the globe and destroy vision.

The possibility of syphilitic infection is not to be lost sight of in making a diagnosis of the nature of orbital enlargements. In such case specific medication rather than surgical treatment may be indicated.

Cystic growths from deeper parts of the orbit, or developed from the follicles of the lids, are perhaps the most common of all orbital tumors. Their contents vary, being cheesy, oily, curdy, or serous, sometimes including hairs. They may extend to the very bottom of the orbit, and cause exophthalmos, but are rarely accompanied with pain. As much as possible of the cyst should be excised, any remaining portion being left to suppurate without the introduction of irritants.

Tumors of the optic nerve or of its sheath cause less protrusion and immobility of the globe, but affect vision more rapidly and fully, than most other orbital growths. These may be removed without excision of the eyeball, but with no hope of restoration of vision.

Ecchinnococci and cysticerci have in a few instances attained a considerable development in the orbit.

Degeneration of the lachrymal gland is of very rare occurrence. It may be removed by an incision through the skin along the orbital ridge, near its outer border. Pulsating tumors of the orbit can usually be traced to a traumatic cause, which has ruptured or obliterated some vessel ; the pulsation and aneurismal murmur often extend to the temples and forehead. Digital compression may be tried, but in the greater part of the reported cases, where the symptoms ceased during compression of the common carotid artery, ligature of this vessel has been the means employed, nearly always with success, for the relief of the patient, only one death occurring in forty-one cases of this operation.

Fibrous tumors, originating in the periosteum, may be of greater or less extent and firmness. They are generally formed near the edge of the orbit, and, if attached by a small pedicle, may be extirpated with little difficulty and with a favorable prognosis, zinc paste being applied, as a precaution, to their point of origin. If extensively attached to the orbital parietes, the removal is attended with more danger of secondary consequences, from the proximity of the thin orbital walls to the brain; and for this latter reason the operation must be done with great care that no perforation of the wall shall happen.

Sarcomatous fibro-plastic growths are mostly made up of cells, of spindle-shaped and various forms, and, being developed from the orbital cellular tissue, may, after pushing the globe forward, appear in lobulated masses beneath the conjunctiva; or they may erode the bony parietes, and invade the cranial or other cavities. If pigment cells abound, the tumor has the nature of melanotic sarcoma, and has a tendency to recur after operation, which should therefore be performed with great care to remove all morbid tissue and diseased periosteum. The periosteum may be peeled up from the orbit with considerable ease, but care must be taken not to penetrate the thin walls in using instruments. A hot iron, followed by zinc paste, may be carefully applied to destroy every suspicious particle which was not excised.

Scirrhous and medullary growths are exceedingly rare, but cases are cited by Wells where the patients continued healthy for some years after these had been removed by operation.

Fatty tumors occur, which from their softness may give a sensation of fluctuation, or may be mistaken for the more common cystic growths.

Osseous tumors, especially ivory exostosis, are now and then met with. If of slow growth and not inconvenient size, they may be left untouched. Their cutting away by means of the instruments formerly in use, the chisel and mallet, was a matter of great difficulty, from the extreme hardness of the mass and the fragility of the bones about its place of origin. The application of the "dental engine" enables this to be done with far more facility and safety. Osseous enlargements of syphilitic origin may be treated with iodide of potassium.

In the ablation of orbital tumors, where sight remains in the eye, its preservation is of the greatest importance; and even if vision is lost, provided the eyeball is not actually implicated in the disease, it is most desirable that it should be spared. This may often be done, even where the diseased mass is so voluminous that its removal is difficult, by gaining more space for operating by dividing the external commissure and widely separating the lids. Even if the optic nerve and some of the muscles must be severed to allow the globe to be drawn to one side, and thus obtain access to the tumor, it is desirable to leave the globe in the orbit rather than excise it; for even a sightless eye is worth retaining for cosmetic effect and for greater comfort, rather than to have in its place an artificial substitute. It has been already demonstrated, in the operation for enervation, that the vitality of the globe continues unimpaired, though the cornea loses its sensibility, after section of the optic and the posterior ciliary nerves. But where the eyeball is actually involved in the morbid transformation, it must of course be sacrificed. Happily, it is comparatively seldom that the eyeball becomes the seat of grave disease extending to it from the orbit.

HÆMORRHAGE IN THE ORBIT.

This may occur after traumatic injury, and it takes place to a copious extent after the recently devised operation for enervation of the eyeball, where the optic and ciliary nerves are divided, in injured or already disorganized eyes, as a security against sympathetic inflammation of the opposite eye, or to relieve pain, instead of removing the globe by enucleation. This division of the nerves involves section of the retinal and other vessels, and the globe is sometimes protruded by the suddenness of the effusion which follows, which also gives rise to a sensation of pressure in the orbit.

A portion of the blood oftentimes subsequently makes its way forward in the loose cellular tissue of the orbit, and the lids become infiltrated and ecchymosed. But these symptoms, which look formidable for the moment, subside in a few days under the use of cold compresses, without other treatment. This hæmorrhage may, however, be in a measure prevented by the use of Warlomont's recently and ingeniously devised scissors, which have an attachment by which the vessels are simultaneously severed and crushed, so that less bleeding follows the operation.

ABSCESS IN THE ORBIT.

Inflammation of the cellular tissue of the orbit is attended by more acute symptoms than those accompanying the sluggish development of morbid growths. There is much subjunctival injection and chemosis, infiltration of the lids, considerable pain, and loss of mobility of the eye. This sometimes occurs in children without evident cause. When caries of the orbital bones has given rise to purulent formation, the symptoms are less severe, and are localized near the seat of the primary disease.

There is a resemblance between the symptoms of orbital abscess and those of inflammation of Tenon's capsule; but the latter is more painful, and the prognosis is unfavorable as regards vision, on account of the pressure on the globe and the obstruction of the intra-ocular circulation by the closely retained matter between the eyeball and the capsule.

Pus may sometimes be detected by means of a small exploring trocar, before fluctuation can be made out, and before matter shows itself beneath the conjunctiva, at the usual place for pointing, between the insertions of two of the recti. As soon as it can be discovered its evacuation should be at once obtained; otherwise the cellular tissue is rapidly destroyed, and subsequent adhesions may limit the movements of the eye. The earliest possible evacuation of the purulent accumulation is, especially, urgently important in deep-seated abscess of the orbit occurring in the course of phlegmonous erysipelas. Instances of this are rare; but the danger that, if not provided with an outlet toward the surface, the pus may make its way through the optic foramen, and cause fatal results, makes the utmost watchfulness necessary, inasmuch as the patient, when attacked with erysipelas about the head, is not always able to assist the physician in localizing his symptoms with precision. In the only case I have seen, I was able with great difficulty to discover and evacuate the pus, and thus avert danger; while, of five cases which are reported, four were fatal.

If caries exists in the wall of the orbit, a discharge of matter continues after the evacuation of the first accumulation, and a fistulous passage may persist for a long time, the carious bone being either gradually broken down and discharged with the pus, or eventually thrown off as a necrosed fragment. If an opening spontaneously forms through the skin at the border of the orbit, a drawing in and adhesion of the skin to the spot from which the sequestrum separates is a very usual sequence in the healing process.

TUMORS OF THE ANTRUM.

Polypoid, fibrous, enchomdromatous, sarcomatous, and other growths may originate in the antrum and develop slowly, eroding the bony walls, and invading the nasal, orbital, or buccal cavities. They seldom cause severe pain except in their latest stage. When they extend into the orbit they produce displacement or protrusion of the eye, without necessarily involving the sight. Removal through an opening in the anterior wall of the antrum, including, if necessary, a large part of the bony parietes, is the only resource, and, in the more malignant forms of disease, even this is not always a security against relapse.

Pus sometimes accumulates in the antrum, accompanied by acute pain, and generally originating from a decayed tooth. It may be discharged by extracting this or some other tooth, and plunging a trocar through the alveolus into the antrum.

TUMORS OF THE FRONTAL SINUS.

Like forms of morbid growth to those found in the neighboring bony cavities, or accumulations of fluids, are also met with in the frontal sinus, whence they may invade the orbit or the cranial cavity. Operative interference is the only reliable means of treatment.

ANÆMIC EXOPHTHALMOS.

This term, given by Mackenzie to a special combination of morbid conditions, conveniently designates a peculiar chronic protrusion of the globe without inflammatory symptoms, which is nearly always associated with other evidences of disordered health. The affection is also known as exophthalmic goitre, or as Basedow's or Graves' disease. The orbital changes occasioning the protrusion are accompanied with irregular palpitating and often greatly accelerated action of the heart and a feeling of oppression, and with enlargement of the thyroid gland. The violent heart action may sometimes be felt in the carotids and other large arteries.

The subjects of this affection are usually young women, and it is often combined with anæmic symptoms or with deranged menstruation. The bronchocele is generally firm; and it may be so slight as to be scarcely perceptible, or may have very considerable dimensions. Exceptionally this condition is absent.

Usually both eyes protrude, to an equal or unequal extent: in some cases only slightly; in others to a degree which, together with the want of mobility of the globe, constitutes great deformity, which is noticed by every one who sees the person. Closing the lids is difficult, and their movements, especially those of the upper lid, are much impeded. A special retraction of the upper lid exists in some instances, and in extreme cases I have seen this lid dislocated behind the projecting globe on attempts of the patient to open the lids widely, so that it was necessary to reduce the dislocation by searching for and drawing the lid from beneath the orbital ridge. The same startling retraction may also happen if the physician raises the lid a little with his finger to inspect the eye. When the lids can no longer be closed sufficiently to protect the cornea, this must be carefully guarded against irritation from external agents, which might induce ulceration; though this does not often occur, because there is no disturbance of the corneal nutrition or inflammation of neighboring parts. It takes place, however, oftener in men when they are, exceptionally, subjects of this disease, because their avocations expose them more to external irritants, such as wind and dust. The best means of avoiding corneal ulceration are the frequent use of a ten-grain solution of borax as a lubricant, or bathing with a solution of salt and water, about two teaspoonfuls to a pint. The eyes should be protected by glasses or otherwise when needful.

Secondary functional defects, from want of mobility of the globe and of A, may arise in severe cases.

The nature and causes of this exophthalmos, and its connection with the thyroid enlargement and the disturbance of heart action, are as yet unexplained. An abnormal action of the sympathetic nerve has been suggested by some authors.

The local morbid changes in the orbit consist in hyperæmia or hypertrophy of the cellular and fatty tissues. The disease is usually of slow development and of long duration. Cases have occurred where structural disease of the heart and dropsical conditions have supervened, and if the heart thus becomes permanently affected relapses of the orbital disease may take place.

As chlorotic symptoms are often present, tonic general treatment, with good diet, and sometimes change of air, are beneficial. The disease and its complications in the heart and the thyroid do not seem to be relieved, but are rather injured, by means which might be of service in other circumstances, such as preparations of iodine or digitalis.

No local curative measures are of any avail. Pressure bandages, or uniting the lids by means of sutures, are especially to be avoided. Nothing could be more adapted to produce ulceration and destruction of the cornea, which has actually occurred in some reported cases where these means had been employed.

Recovery, though always very slow, requiring months or even years, may be expected in most cases. In my own experience I have never known other than a favorable termination. But gradual deterioration of the system, and even death, are mentioned by authors as having resulted in some rare instances.

CHAPTER XXVI.

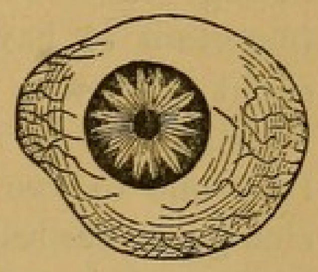
ARTIFICIAL EYES.

ARTIFICIAL eyes have been brought to great perfection as a substitute for one of the most expressive of the human features. They are worn for two reasons: first, and chiefly, to remove deformity; and also as a means of supporting the eyelids and preventing their inversion, and to aid in a proper conducting of the secretions toward the lachrymal puncta, thus greatly increasing the comfort of the patient by avoiding their outflow upon the cheek.

Such eyes can be worn with most advantage when the eyeball is only slightly lessened in size, as the substitute is then better supported and has more of the natural motions of the globe than when the eye is too much atrophied, or when enucleation has been performed. Should the eyeball have become disorganized and enlarged, or irregularly staphylomatous, it is necessary first to remove a portion of the globe by excision, bringing the edges of the wound together by sutures, so as to reduce its dimensions sufficiently to allow of the wearing of the artificial eye. If bands of adhesion exist, connecting the remains of the eyeball with the lid, these must not be divided, however earnestly the patient requests it, in the hope of making the orbital cavity more regular; for if thus divided the cicatricial scars are certain to limit, even more than before, the space required. Instead of this attempt to improve the conditions by operative measures, the artificial eye must have its edge notched at the point or points corresponding to the fibrous bands; or perhaps a smaller eye may be worn at first, and the adhesions stretched. No attempt should be made to adapt an artificial eye before the conjunctival surface is quite free from inflammation and the parts have shrunken to nearly the state in which they are to remain ; otherwise there is either irritation of the conjunctiva, or, contraction going on in the tissues, the eye previously chosen does not fit the cavity when the contraction is complete.

Artificial eyes are thin shells, very light and movable, made of a kind of glass called enamel ; the sclera, cornea, and iris, with the size of the pupil, being as nearly as possible imitations of the other eye of the wearer. They are of various forms, and in selecting them, which can only be done by putting in one after another, it is of the first importance that they should properly fit the outlines of the surfaces upon which they are to be worn. A slight projection at any point soon becomes a source of great annoyance, and a good fit as regards form is of more importance than a slight variation in color of the iris or size of the pupil. As a rule, the shell should be a little too small and too little prominent rather than too large ; as it causes less irritation, moves with more freedom, and does not give the staring look which is observed when the eye is too large. If well adapted it produces no discomfort, and greatly improves the expression of the face. It should be removed at night, and in fact it is well to take it out at times when the person is to be alone ; for if too constantly worn the conjunctiva of the cavity may become irritated, and the eye sooner loses its polish by constant contact of the secretions. After this change of its surface, the roughened eye, like a bit of ground glass, frets the conjunctival surface ; and if it continues to be worn too long the cavity begins first to secrete mucus in large quantity, then to be covered with granulations, and at length is completely filled with fungous masses, which crowd the artificial eye from the orbit and at last prevent its introduction. Should these fungous growths be excised by a zealous but inexperienced operator, the cavity

FIG. 37. Artificial Eye.



is often so far contracted that the wearing of an eye is impossible. The only proper treatment, where this granulated or fungous state has been induced, is to omit wearing the false eye, to use cold fomentations, and allow the parts to recover their normal state, which they do oftentimes with surprising rapidity; after which the eye should be worn, for a time, less constantly. If its polish is destroyed, or if its edge does not fit the outline of the cavity, it must be exchanged for a new one. There is no danger that an eye will be broken by violence while in the socket.

An eye must be worn for a few days before its exact adaptability can be fully determined, because the lids and the opposite surfaces gradually fit themselves to the edges of the shell, and it then becomes more comfortable and more mobile than at first. Unless the eye is made to fit the individual, — which can only be done where workmen in large cities understand the manufacture of them, — it is important to have a large number to select from, as even slight differences of form cause much difference of effect in wearing. It is rarely possible to wear an eye more than from one to two years before it so far loses polish that a change is desirable; though in a few cases they last much longer. It is well, therefore, to be provided with more than one eye, if others are found at the time of selection which are a good fit, since it often happens that if an eye is broken or becomes rough it is difficult to replace it at a given moment with another which is equally well fitted in form and color.

In putting in an eye, after it has been dipped in water it is taken hold of at its temporal end with the thumb and finger of one hand and pushed vertically under the upper lid, which is drawn slightly forward with the thumb of the other hand, the fingers being supported on the brow. As this is done the nasal end is turned inward, bringing the eye to the proper horizontal position, its edge being kept under the upper lid; the lower lid is then drawn down with one finger, and the lower edge of the eye slipped inside it. To remove the eye, the lower lid is drawn a little outward and the head of a pin or a notched tooth of a tortoise-shell comb is introduced beneath the margin of the artificial eye; this is then drawn forward and drops out, to be caught in the hand. Until persons have acquired dexterity in these manipulations it is best to insert and remove the eye while leaning over a bed, so that if it slips from the fingers it may not be broken by a fall on a hard surface. It should be washed and wiped, but not left in water during the night, as it thus sooner loses its polish.

CHAPTER XXVII.

AFFECTIONS OF THE LACHRYMAL ORGANS.

THE secreting lachrymal gland is made up of two portions, of which the larger is situated in a depression of the roof of the orbit, behind and near the temporal end of the orbital ridge; the smaller division is near the former, in the upper and outer part of the upper lid. These discharge the tears through the conjunctiva by several minute ducts, the openings of which can be seen on the inner surface of the lid, near the outer canthus, from whence they flow over the globe.

The tears and other excretions of the eye are conveyed by the movements of the lids toward two minute openings, the puncta lachrymalia, situated one in each lid, where its edge curves a little near the caruncula. Taken up by these puncta they flow through the canaliculi to the lachrymal sac, entering it by one, or by two distinct outlets. For a very short distance the canaliculi are vertical to the edge of the lid, and then turn at a right angle toward the sac. A small fasciculus of muscular fibres, Horner's muscle, arises from the posterior lachrymal ridge, and is so distributed as to compress these canals and assist the onward flow of the secretions. The upper part of the sac extends a little higher than the point of entrance of the canals, its outermost parietes being here membranous, while its inner wall is in the bony fossa of the lachrymal sac. Below, it is wholly surrounded by bony walls, the nasal canal, through which it is continued by the nasal duct to the posterior nares. Where the duct begins there is a constriction of the sac, and sometimes an almost valvular fold of its lining membrane. At the lower extremity of the duct a fold of the membrane acts as a valve against the entrance of air or fluids from the nose.

The direction of the duct varies with the conformation of the nose in different persons, but usually is slightly inclined from within outward and from before backward.

DISEASE OF THE LACHRYMAL GLAND.

Acute inflammation of the gland, followed by abscess; or its enlargement or alteration by morbid growths; is of exceedingly rare occurrence, and should be treated in the same manner as other similar affections of the orbital cavity already referred to.

EPIPHORA.

A constant flow of tears upon the cheek, increased by exposure to cold or wind, is termed epiphora, and usually depends on displacement, contraction, or obstruction of the excretory puncta. Displacement often occurs outward, either from thickening of the conjunctiva near the punctum, which pushes it away from the eye, or by traction from a scar of the external skin of the lid; thus preventing the secretions from being properly taken up by the punctum. When this state has become chronic, the accumulation of the secretions about the caruncle tends to press the lid and its punctum farther from their normal position, causing yet more thickening of the lining of the lid, and not seldom a contraction or closure of the disused punctum. Where this eversion is but slight or temporary, the punctum may be stretched or reopened by a conical probe having a fine but rounded point, and gradually increasing in size.

When it is more chronic, and likely to continue, it is best to enlarge the punctum, and the canal for a short distance, so as to carry the opening farther back toward the caruncle, and allow the tears to reach it. This may be done, after the punctum has been a little dilated with the probe, by introducing the point of fine scissors and dividing to the extent of a twelfth or an eighth of an inch, as required. Generally, when the firm tissue which forms a ring about the punctum is cut through, the tendency of the little wound is to gape and remain sufficiently open. If in two or three days it is found to be contracted, it may be reopened with the probe. It is not necessary nor desirable to continue the incision more than an eighth of an inch along the canal. Obstruction of the punctum or canal by an eyelash which has entered it, or by a polypoid growth, or by small concretions, termed dacryolithes, within it, is now and then seen, and is easily remedied.

INFLAMMATION OF THE LACHRYMAL SAC.

The sac is exposed, from its position, to cold, and from the continuity of its lining membrane with the conjunctiva and with the lining of the nose is predisposed to share in their diseases; so that it is frequently the seat of acute or chronic inflammation. This may have a catarrhal or a purulent character, and may be excited by mere contact of altered and irritating secretions from the neighboring mucous surfaces. As a consequence, the entire lining of the sac, and especially of the duct, which is of less calibre, grows congested and thickened, and its own proper secretion is increased while at the same time its free discharge toward the nose is impeded. At first this secretion is transparent and slightly viscid, and either finds its way slowly through the duct, or may be readily pressed downward by placing a finger upon the sac. This condition remains for a long period unaltered; or, at any time, after exposure to cold or other irritation, the secretions become more copious, and assume a more purulent form, or the ductus ad nasum may be nearly or completely closed. In the latter case the sac may still, oftentimes, be emptied by pressing with the finger, so as to cause its contents to be discharged upward through the puncta; this being done, if necessary, several times daily, as often as discomfort is felt from the accumulation. But at this stage the affection is liable to be suddenly aggravated, and the sac, which previously had been prominent only when filled with secretion, becomes greatly and painfully distended, and cannot be emptied by digital pressure. Even now, relief is sometimes at once obtained by introducing a fine Anel's probe through one of the puncta into the sac, thus bringing the canal, which had become displaced by the tumefaction, into a straight line, and allowing its contents to be discharged by gentle pressure, either along the side of the probe or after its withdrawal. The severe pain from tension is thus at once relieved, and the formation of a lachrymal abscess often prevented. Warm compresses should be afterwards applied, and care taken to frequently evacuate the contents of the sac. Should it be impossible to accomplish this relief, the sac should be punctured with a narrow knife, either through the conjunctiva at the upper part of the sac, or through that part of the skin where the abscess tends to point. If the sac has been already ruptured by the distending fluids, an opening should be at once made for their discharge through the skin; otherwise they are often extensively diffused into the neighboring cellular tissue before finding an outlet. The fistula thus connecting the sac with the skin may close at the end of a few days, or after a longer interval; or it may contract to the size of a pinhole, without closing entirely, allowing of the occasional escape of a drop of secretion. As this last condition is little conspicuous it may be suffered to remain as a sort of safety valve. But it may be readily obliterated, whenever desirable, by slightly irritating the small fistulous tract, so as to set up adhesive inflammation.

Acute inflammation of the sac, dacryocystitis, is exceedingly painful, on account of the resistance offered by its firm fibrous walls. The phlegmonous redness and infiltration extend to the lids, and the eye, or even both eyes, may be closed, so that the condition is often mistaken for erysipelas. From this, however, it may be readily distinguished by the absence of a well-defined border of the affected tract, and especially by the extreme tenderness on pressure in the region of the sac.

Certain conformations of the nose seem to predispose to affections of the sac, and several instances sometimes occur in one family, probably because of some abnormality in size or direction of the nasal duct.

Inflammation and fistula of the sac may be followed, or sometimes caused, by caries of adjoining bony parts. In such cases the fistula continues for a long time.

As I have elsewhere described, chronic inflammation of the lachrymal passages, delaying the free conveyance of the secretions from the eye, sometimes causes a special form of conjunctivitis, which disappears after free discharge of the secretions is reëstablished. If, on the other hand, a chronic conjunctivitis has led to an extension of inflammation to the lachrymal canals and sac, the original disease must be made the subject of treatment, to improve the quality and lessen the amount of the secretions. The collyria and other means thus used will find their way into the lachrymal passages and have a good effect. In the early stages of lachrymal inflammation, where there is no conjunctival complication, mild collyria may be dropped into the eye, to be carried with the secretions to the affected parts, and, if frequently used, are often more beneficial than when employed as injections into the canals; assisting nature by keeping up a mild influence on the diseased membrane. They can, moreover, be applied by the patient himself. Solutions of ten grains of borax, or where a stronger astringent is needed half a grain of sulphate of zinc, to the ounce of water are useful, and in chronic cases may be employed of greater strength.

Injections of warm water with Anel's syringe are often of service as a means of exploration to ascertain whether and how much obstruction is present. If the punctum is too small to admit the fine curved tube of the syringe, it may be dilated a little with the conical probe. When no impediment exists, the water flows through the duct as freely as it leaves the syringe; passing into the patient's nose if his head is leaned forward, into the throat if it is inclined backward. If the lining of the duct is much thickened, the water may not pass through it readily, but only if the sac is afterward pressed upon with the finger. If the duct is occluded, the water will flow back from the sac through the puncta. As long as communication with the nose still remains, there is reason to hope that this may be kept up, and gradually made more ample by the frequent use of mild collyria, without medicated or other injections and without surgical interference. If the duct is closed, we must then decide whether to allow the sac to fill and to be emptied upward from time to time by the patient, or whether to attempt reopening of the duct by means of probes or otherwise. The probes of Anel were too small to establish a sufficient passage, and endeavors were made for a long period and by many operators to maintain permeability of the duct by tubes or by styles inserted into it through an opening in the skin, and left in place or worn for a long time. But it has been only since Bowman proposed division of the punctum, so that probes of considerable size could be introduced through the canals into the sac, and thence pushed through the duct, that the treatment of lachrymal obstructions has been really effective for permanent relief. To introduce these probes, it is only necessary to divide the ring about the punctum, and for an eighth of an inch at most along the canal; the canal itself having sufficient size or distensibility to allow of the passing of the probes after the punctum has been sufficiently enlarged for their admission. They are often arrested, however, at the point where the canal enters the sac; and if the probe selected does not find its way into the sac with the aid of gentle pressure, smaller sizes should first be used, and the orifice dilated until a probe of the desired size can be passed. The practice of at once incising the entire length of the canal and the fibrous wall of the sac, so as to gain immediate free access to the latter, and thus greatly facilitate the entrance of the probes, looks at first glance unobjectionable; but though apparently so easy and simple, and giving seemingly good results so long as the use of the probes is kept up, it is found that division of the fibrous wall of the sac at the entrance of the canaliculi is often followed by traumatic stricture and complete obliteration of all communication with the sac, after treatment has been discontinued for a short time; and the patient, who as long as the large probes were passed, perhaps daily, had appeared to be relieved of his affection, finds obstruction reëstablished. The forcing of very large probes or the wearing of very large rubber styles in the duct is also frequently followed by subsequent stricture or closure of the duct, which no means are able to overcome. Similar objections apply to the methods of incision of strictures of the duct. These disappointing experiences are in fact only a virtual revival of the former methods, the insertion of the gold canules of Dupuytren, or the silver or leaden styles of Scarpa, which gave relief in many instances while worn in the duct, but were in the end so unsatisfactory that they have been long abandoned as practically useless.

The probe, lightly held with the thumb and finger, is introduced along the canal in a horizontal direction until it reaches the outer wall of the sac, where it is arrested if of too large size. If it does not readily enter the sac upon moderate efforts, a smaller size should first be used, to be followed by others of greater dimension. Sometimes, however, it is found that a large probe, with a little gentle pressure, passes better than a smaller one, the larger instrument pushing aside any fold of the lining membrane in which a smaller one would be entangled. No violence, but only a careful persistence, with perhaps slight changes of position of the end of the probe, is needed. After the entrance into the sac has been effected with one size of probe others will often pass with little difficulty, until we have the wished-for dimensions. As long as the probe is still outside the sac we feel an elastic resistance; when this is overcome, the probe advances a little farther, and gives to the fingers a sensation that the end of the probe touches the bony parietes at the opposite wall of the sac. Until thus certain of its being in the sac, the probe must not be carried downward: otherwise the end of the probe will make a false passage through the side of the canaliculus. When sure that the probe touches the inner wall of the sac, it is to be brought to a vertical position and its end pushed carefully downward through the sac and into the duct. We here endeavor to assure ourselves that the extremity of the probe is following the course of the duct, and this once determined sufficient force may be used to overcome the obstruction. I have made a serviceable improvement, in using probes formed with olive-shaped extremities, of the size of Bowman's six numbers, but having the shafts made smaller for some distance from the end, so that at this neck, as it may be termed, the probes shall have a certain elastic flexibility; allowing the extremity to adapt itself to any inequalities or variations of direction of the duct without tearing the lining mucous membrane, as is liable to happen when the probe is rigid and is merely bent to fit the supposed outlines of the passages, of which it is impossible to judge exactly from external indications. All treatment of chronic obstructions of the tear passages requires time and patience. It is not sufficient to merely overcome the obstructions and restore the permeability of the whole length of the canals as far as the nose, but these must be kept open until the lining of the parts has had time to regain at least, in a good measure, its normal condition. To accomplish this, too frequent use of these mechanical means is not desirable, as in so doing, irritation, rather than a healthier state, of the delicate mucous membrane is set up. Nor should the probes be so excessively large as to contuse and injure the membrane. The probe should be introduced at intervals of two or three days at first, being allowed to remain in a little time; and as the obstructions appear to yield the probes should be used less and less often. But if this can be conveniently done, it is well that the probe should still be occasionally passed down, even for some time after entire relief seems to be obtained, so as to remove any tendency to contraction which may exist in consequence of long duration of the disease.

Frequent use of a mild collyrium should be continued not only during, but after, treatment, to assist in restoring healthy conditions. The patient should avoid much exposure to cold and inclement weather without protection of the face; those who are unable to protect themselves from atmospheric vicissitudes forming a large proportion of the subjects of lachrymal disease.

Where a fistulous opening has already formed this may be temporarily made use of for passage of the probe through the duct, and kept open for a time for this purpose. Probes made of sea tangle, laminaria digitata, which swell when moistened with the secretions, were tried as a means of dilatation, but they often remained unenlarged where the stricture existed, while becoming so expanded beyond this point that they cannot be withdrawn without laceration of the mucous membrane. The introduction of Gensoul's large probes from the nose into the nasal duct was very painful, and the ultimate results were not favorable, though theoretically they seemed to promise well.

CHAPTER XXVIII.

AFFECTIONS OF THE EYELIDS.

THE lids, which serve for purposes of protection and lubrication of the eyeball, comprise a great variety of tissues. Their outer surface, a delicate skin, is so light as to require little muscular power for its movement, and so loosely attached by fine cellular tissue that it is readily spread, or thrown into folds, by the action of the muscles beneath it. Fine hair follicles, sebaceous and sudorific glands, are found, as in other parts of the cutaneous system.

The frame-work of the lids is made up of fibro-cartilages, the tarsi, which are supported and attached to the orbital margin by the tarso-orbital fascia and the palpebral ligaments. Both the tarsal cartilages are slightly concavo-convex, so as to adapt them to the form of the eyeball. These are thicker at the border of the lid, and become very thin at their orbital edge, where the tarsus of the upper lid is connected with the orbital fascia and the levator muscle. The tarsus of the upper is much broader vertically than that of the lower lid, and has a triangular form.

The orbicularis muscle arises from the os unguis and crista lachrymalis and the internal palpebral ligament, at the inner angle, being divided into two portions, the orbital and palpebral. Its fibres surround the lids, forming some loose connections with the neighboring muscles and tissues and with the external palpebral ligament and the temporal fossa, and, in completing the circuit, returning to be attached at their point of origin. The outer circular fibres spread beyond the orbital border at the outer angle. A portion of this muscle, Horner's muscle, arises from the crista lach. post., and divides into two portions, one for each lid, which seem to act in accelerating the flow of secretions along the canaliculi and through the lachrymal sac.

The special office of the orbicularis is to close the lids. The levator palpebræ superioris arises from the border of the optic foramen, and, passing along the roof of the orbit, supported upon an aponeurosis from the trochlearis to the external angle, is attached to the upper border of the tarsal cartilage. Its function is to draw the cartilage upward beneath the orbital ridge, and thus raise the lid.

The inner surface of the lids is lined with a mucous membrane, the conjunctiva, which is reflected, at the palpebral fold, upon the anterior portion of the eyeball. The edge of the lid has a sharp inner border, formed by the margin of the tarsal cartilage, and a rounded outer margin, where the skin unites with the mucous membrane. At this inner border are the openings of the Meibomian glands, thirty or more in number, which extend vertically to almost the border of the cartilages, and secrete a fatty, lubricating fluid. At the outer margin are found the cilia, or eyelashes, arranged in three or four rows. These are constantly renewed by fresh growth, to replace those which are thrown off from time to time, the period of existence of an eyelash being, it is said, about three months.

ŒDEMA, ETC., OF THE LIDS.

Serous infiltration beneath the skin of the lids occurs under various circumstances: as a symptom in some diseases, as, for instance, in kidney affections; as an indication of the constitutional effect of medicines, as after continuous administration of arsenic; as a result of traumatic injury, or of the application of leeches in the vicinity of the lids; or as an effect of inflammation of contiguous parts, as in the formation of boils about the eyebrow, or facial erysipelas. The essential treatment consists in removal of the causes. Mild aromatic or astringent applications of arnica, or other harmless means, may be advised, if thought desirable.

Emphysema may follow fracture of the nasal or ethmoid bones, where the mucous membrane has also been torn allowing of the passage of air from the nasal cavity. Emphysematous crackling is heard if pressure is made with the finger. In most cases, this spontaneously subsides in a few days.

Erythema of the lids is often observed after exposure to a hot sun or other local irritation, but is of short duration.

Ecchymosis, in the well-known form of "black eye," is produced by blows, by fracture or other injury in the vicinity of the eye or at the base of the brain, or by some surgical operations about the lids or orbit. Evaporating or other lotions, with ammonia chloride, arnica tincture, or spirits of rosemary or camphor, may be advised, and perhaps lessen the duration of the discoloration. The popular remedies, beefsteak, oysters, scraped potato, poultices, etc., are better avoided. Puncture or incision is not required, even when the hæmorrhage has suddenly occurred to such an extent as to form a projecting clot of the size of a walnut beneath the skin. Time is the most efficient restorer; but if the case is seen soon after the accident, cold compresses should be applied to prevent an increase of effusion.

WOUNDS AND INJURIES OF THE EYELIDS.

Lacerated wounds may involve only the integument, or extend through the cartilage and the entire thickness of the lid. The parts must be at once carefully adjusted to each other and retained in place, if the wounds are ragged, by many fine sutures; those required for the conjunctiva being first inserted; so as to prevent irregular cicatrization, and especially such scars as might be prominent on the inner surface of the lid, or as would allow adhesions to form between the conjunctiva of the lid and the globe, or as would cause deformity, with inversion or eversion of the tarsal border.

If burns or chemical injuries have resulted in extensive destruction of apposed surfaces of the ocular and palpebral conjunctiva, an endeavor is to be made to cover the bare surface upon the globe by sliding and securing over this space a portion of the neighboring conjunctiva.

Ecchymosis, as a result of blows, is referred to in the previous section.

BLEPHARITIS.

The most usual form of inflammation of the lids is of an erysipelatous character, showing phlegmonous swelling with great redness and tension of the skin, closing the lids, and frequently involving the neighboring parts. Feverish symptoms, pain, and rigors are not uncommon. If the attack is mild, it may subside without structural changes; if severe, vesication of the skin and purulent collections beneath it soon occur, and the accumulated matter tends to diffuse itself extensively in the lid, destroying the delicate cellular tissue, and causing subsequent adhesion of the skin to the muscles and the tarsal cartilage. The purulent infiltration may, though very rarely, extend to the orbital, and even thence to the cranial, cavity; and this possible complication should be kept in mind in severe cases. The external appearances of the lid bear a resemblance to those seen in gonorrhœal ophthalmia; but the absence of the abundant purulent secretion from the conjunctiva suffices for the differential diagnosis. There is much chemosis, and the cornea may even be threatened, in consequence of the pressure of the swollen lids. Should this be the case, the tension of the lids should be lessened by dividing them at the outer commissure.

When the ocular chemosis is persistent, instead of subsiding after the formation and evacuation of abscesses in the lids; and especially if accompanied by protrusion and immobility of the eyeball, and with sensations of tension and obscure pains; great watchfulness is called for to detect any formation of pus behind the globe; its prompt discovery and evacuation when deep in the orbit being essential to the patient's safety. Vision is generally lost, as the effect of pressure on the vessels entering the globe through the optic nerve; but the appearance of the eyeball continues normal.

The strength of the patient should be supported by good diet, tonics, and diffusible stimulants, if needed, in cases of blepharitis. Anodynes are often required. At the outset, cold compresses may be used, in the hope of arresting the symptoms; but if it is evident that these are not to be thus controlled, warm fomentations should be substituted. Early evacuation of abscesses is important, before the skin of the lid has been largely undermined; but these must be opened with great precaution, as the cornea, in these circumstances, lies very near to the skin, pushing the purulent matter aside; and a case is on record where both corneæ of a physician were laid open by the too eager bistoury of a *confrère*. It is safer to glide a spatula of horn or the handle of a spoon between the lid and the globe, and thus protect the eye against a too deep penetration of the knife or lancet. After opening the abscess, warm fomentations are to be used. Erysipelatous blepharitis may be distinguished from abscess of the lachrymal sac by the existence of a more defined border between the affected and the healthy skin, and by the absence of the acute sensitiveness on touching the region of the sac, which is felt where this is the original seat of disease.

Furuncles of the lid, apart from the mild form termed hordeolum, are now and then seen, causing considerable œdema and pain, but soon relieved by evacuation.

Anthrax, with extensive gangrenous degeneration of the cellular tissue of the lid, may occur in old and feeble persons. These cases require sedatives and general support.

Malignant pustule, charbon, due to inoculation of the lids from animals, or from the hides or carcasses of cattle, affected with farcy, is nearly always fatal. Incision and destruction with the actual cautery is advised by Mackenzie and others.

ECZEMA OF THE LIDS.

Eczema of the eyelids, like that of the lip, may occur independently of any similar eruption upon other parts of the face, or it may be associated with this. It is also a very frequent secondary symptom in children affected with ulcer of the cornea or phlyctenular conjunctivitis; where the copious flow of irritating secretions from the eye, rubbed by the child's hands over the surrounding parts, gives rise to eczematous pustules and crusts. The diseased surface and the surrounding skin should be protected from the scalding discharges by oxide of zinc ointment, which has also a healing effect. The parts where the eruption exists may be dusted over with rice powder, potato starch, or other simple powder, combined, perhaps, with a little zinc oxide, to absorb the exudations from the pustules, and should be kept as dry as possible. In eczema of older persons, benzoated zinc ointment, or a little diluted citrine ointment is usually serviceable; or an ointment made up of equal parts of tar ointment and rose-water ointment may be applied at night. If the latter preparation is not readily removed in the morning, it may be first softened by rubbing over it a little simple or rose-water ointment.

ZANTHELASMA PALPEBRARUM.

Superficial yellowish patches, of irregular form and size, sometimes termed vitiligo, may be gradually developed beneath the epidermis of the lids, the subjects affected being mostly women of middle age. These are generally first seen at the inner canthus, and they have a peculiar disposition to form a chain or series of spots, not by continuity, but by contiguity, which at length encircle the lids. They are often slightly raised above the surrounding level, but are not attended with inflammation or pain. They seem to result from obstruction and peculiar transformation of sebaceous follicles. When numerous and of considerable size, perhaps as large as the finger-nail, these yellow spots are cosmetically objectionable. They can readily be removed by raising them with forceps and excising them with curved scissors. Should the space uncovered be very large, its edges may be drawn together with a fine suture. No inflammation or perceptible scar follows their removal, and the pain of the excision is insignificant.

MOLLUSCUM.

Whitish accumulations, like firmly coagulated albumen, in the hair follicles or sebaceous glands, of considerable size and umbilicated at their centre, are termed molluscum. If small and round, like pin heads, they are called milium. One or several may be seen in the same eyelid. To remove them it is only necessary to divide their epithelial covering and squeeze them out by compressing them between the branches of a curved iridectomy forceps. Other glandular accumulations show themselves as black dots, which may be numerous in the lids and surrounding parts. If these have a disposition to renewed appearance after being squeezed out between two thumb nails, the state of the glands may be modified by the use of a lotion of ammonia, sublimed sulphur, and spirits of camphor, or a strong alkaline soap, applied at bed-time. Face powder should not be used where these conditions of the follicles exist, as they increase the black accumulations.

SYPHILITIC ULCERATION OF THE LIDS.

This is now and then seen at the border of the lids, and tends to erode and leave a permanent notch at the tarsal edge, sometimes spreading so as to destroy a considerable extent of eyelid. It is generally a secondary, though possibly a primary, symptom. The ulcer has an indurated base and margin and a dirty dark color. It has a certain resemblance to lupus, but is less amenable to merely local treatment. Very light stimulation with a fine-pointed crayon of silver nitrate, and the use of diluted citrine or red precipitate ointment, with alternations of the ointment of zinc oxide, should be combined with internal alterative means.

Ulceration of the lids may occur in infants as one form of inherited syphilis; coming on a few weeks after birth, and usually complicated with similar ulcers of the skin at the angles of the mouth and about the anus. It is also frequently accompanied by plastic iritis. The child is puny and cachectic. The local treatment of the ulcers should be combined with tonics and mild alteratives. Care should be taken that the nipples of the nurse do not become inoculated with the discharge from the sores.

EPITHELIAL GROWTHS.

Cancroidal growths in or near the lower lid are not infrequent. These assume one of two forms: a small, sometimes slightly lobulated swelling at the border of the lid, where the skin unites with the mucous membrane; or a flattened excrescence on the skin, a little way from the margin of the lid, and almost always near the inner canthus or upon the side of the nose. The first of these forms slowly extends itself in depth and size, and after a while becomes ulcerated, with a disposition to bleed and to form crusts, which are thrown off and renewed from time to time.

If seen early, these growths can be successfully treated by light touches with a crayon of silver nitrate about twice a week, continued, if need be, for several months. The cure is tedious; but the situation of the morbid growth being such that it can neither be excised, nor destroyed by strong caustics, without creating an unsightly indentation of the margin of the lid, which it is difficult to remedy, the slow restoration of the healthy condition which can be obtained by persevering use of the milder means above mentioned is preferable to any attempt at immediate extirpation. The crayon should not be used too often or too freely, as an increased growth rather than absorption may thus be excited.

But where morbid changes have extensively involved the tissues throughout the entire thickness of the lid, excision is the only resource. Excision is to be preferred to destruction of the growth by caustics, as being safer, and as allowing of such an adaptation of the parts as will largely obviate any deformity. A V-shaped portion of the lid, including all suspicious-looking tissue, is to be cut out, and the edges both of the skin and the conjunctiva are to be carefully approximated by several fine sutures, the border of the lid being so adjusted as to leave the least possible irregularity after healing.

The other form of epithelioma appears in the skin, near the eye, as a warty-looking growth, or as a pimple covered with a crust. It may remain sluggish for weeks, months, or years, giving little pain, but sometimes showing an ulcerated appearance beneath the crusts. At length it assumes a more rapid development, becomes the seat of pain, and involves and erodes the surrounding parts.

Excision — the sooner the better — is the proper means of treatment. If completely removed, there is no tendency to recurrence in either of these two forms of disease.

Lupus, which also selects the inner canthus or the nose for its manifestation, extends to the surrounding skin, causing a redness and induration quite disproportioned to the amount of ulceration; differing in this respect, and in the nodulated aspect of the parts, from epithelial cancer. Deep and frequent cauterization with silver nitrate may here be effectual.

Rodent ulcer, of a malignant type, with a slowly destructive tendency, may also arise in these situations near the inner canthus. If excised early, there may be a chance of its non-recurrence, but this favorable result is the exception, and not the rule.

Warts of the lid should be removed to such a depth that they may not reappear; taking care not to notch the tarsal border, if they happen to be at the edge of the lid.

Horny excrescences are now and then seen projecting from the lid. In their extirpation, the gland in which they originate should be included.

Pediculi sometimes establish themselves about the cilia in children, from the carelessness of nurses. A touch with a solution of the bichloride, or with a little of some mercurial ointment, removes the interlopers, *tuto*, *cito*, *et jucunde*. This may often be done without horrifying the mother with the announcement of the true nature of the apparent crusts which are along the lid border.

Chromidrosis, an appearance of blue or dark coloring matter upon the lids, asserted to be secreted from the skin, has been seen in some cases of hysterical girls, who declared that it occurred during religious trances. In this way they obtained a wide notoriety, until so closely watched by medical men that their imposture was detected and exposed. Prussian blue and other pigments have been the means employed in carrying on the fraud.

ERECTILE AND OTHER TUMORS OF THE LIDS.

Erectile tumors, often congenital, or appearing in early infancy, have been treated by subcutaneous irritation or ligature, by electrolysis, by introducing threads saturated with perchloride of iron, by actual or galvanic cautery, or by excision, according to the extent or situation of the enlargement.

Fatty tumors are rare, and easily excised.

Cystic enlargements are sometimes seen congenitally, having various fluid, sebaceous, or other contents, causing no pain. They require excision of the sac, with its contents; the incision being made in the direction of the muscular fibres of the lid or of the orbital ridge.

CHALAZION.

This enlargement, produced by obstruction of one or more Meibomian glands, is so frequently met with that it deserves special mention. Slight occlusions of their orifices may occur at the edge of the lid, causing the projection there of a thin film, like a minute blister, no larger than the head of a small pin, but creating considerable temporary irritation by friction on the globe. The fragile covering soon gives way, or the transparent vesicle can be scraped off with an instrument or a pocket knife, with immediate relief to the sensation of having something in the eye.

More permanent obliteration of these ducts causes an enlargement of some part of the lobulated gland cavity into a rounded sac-like protrusion, termed chalazion. It may be nearer the anterior or the posterior surface of the tarsal cartilage, in which these glands are imbedded ; and it slowly attains the size of a pea, or even larger, without exciting in most cases much irritation of the contiguous parts. In a few instances, this enlargement begins with acute symptoms, pain and redness, like those attending hordeolum ; but, instead of the expulsion of a little pus and a small slough, with immediate return to a healthy condition, there is here no discharge, and the subsidence of the active symptoms leaves behind it a chronic enlargement. The small rounded tumors project beneath the skin of the lid at more or less distance from its border ; but when their origin is evidently nearer the conjunctival than the external surface, they do not have the same prominence internally, because they are compressed against the eyeball. If they become as large as a hazel-nut, they often burst through the conjunctiva, and nearly disappear for a time ; but they generally refill. Sometimes this perforation does not close, but fungous granulations protrude from the conjunctival opening.

Chalazion rarely inflames, and it never degenerates to a more serious form of disease. Its contents may be granular, sebaceous, or fluid.

Seen from within the lid, its position is generally indicated by a red or grayish spot, where the conjunctiva is thinned by pressure of the sac upon it.

As a rule, these small enlargements give rise to no other inconvenience than the slight deformity. But in the upper lid, where they are most frequent, their weight, if large or if they are several in number, induces sensations of fatigue and a disposition to drooping of the lid. Where they increase anteriorly they sometimes cause redness of the overlying skin, and this grows adherent to the tumor. Chalazion is more common in young women than in other persons, though the largest number I ever met with was in a gentleman of middle age, from whose lids I removed thirteen at one sitting. It is not rare to find three or four at a time. After these have been excised, others may be developed at a different part of the lid.

Applications to the skin, such as iodine tincture, ointments of potassium iodide, and the like, are rarely of any avail in causing absorption of these tumors, and merely give useless annoyance to the patient. If the person desires to try some local remedy, a painless and possibly useful stimulation may be obtained by bathing the eyelids, at bed-time, with a saturated solution of common salt. It is only very exceptionally, however, that any means, other than excision or complete outscooping of the contents of the sac, is effective. The pain thus given is generally but slight, though occasionally the distribution of nerve filaments is such as to cause considerable momentary suffering. The operation is much facilitated by the use of Desmarres' forceps, one branch of which has a smooth metal plate, the other branch a thin ring of corresponding outline. It is applied so that the ring includes the chalazion, upon the surface where the excision is to be done, the plate being beneath the opposite surface of the lid. The ring and plate being approximated by a screw, the circulation is cut off from the area within the ring, and the chalazion may be quickly removed without the hindrance to the operation caused by bleeding; the sensitiveness of the parts seems also to be at the same time lessened. With the aid of this forceps, the operation may be done without an assistant.

As a rule, it is best, even when the chalazion projects most toward the skin, to attack it from the inner side of the lid. It is so imbedded in the tarsal cartilage, which is thinned, that it cannot be dissected from this without a tedious lengthening of the operation, and its complete removal through the skin is very difficult without penetration of the conjunctiva and perforation of the lid. On everting the lid, the outline of the tumor is generally clearly discernible, and it is seen that the inner layer of the cartilage, and even the conjunctiva, are affected. It is therefore best to make the incision through this inner wall of the small tumor, when the whole cyst can be readily enucleated. No harm is done by the loss of a small portion of the cartilage. When the skin external to the chalazion has become red and adherent, the operation is more prolonged on account of the adhesions, but it is still usually best to exsect the chalazion from the inner side. Desmarres' forceps being applied, a semicircular incision is made with a Graefe's or other very narrow knife, so as to include about half the cyst in this single cut. The sac is then seized with fine forceps, and excised by clipping around its other half with small scissors, curved on their flat. If the sac is opened in doing this, its halves should be in great part removed, for better security against relapse; though it is not necessary to take away every particle, nor is it desirable to cauterize the cavity. Thorough outscooping of the contents of the sac may be substituted in many cases for ablation. The operation can be done without Desmarres' forceps, or without very delicate instruments, if the surgeon does not have these at hand; but the forceps make the performance easier and shorter, — an important consideration when the patient has not been etherized, which is rarely necessary. No after-treatment is needed, unless, as sometimes exceptionally happens, where the chalazion is large, granulations form in the cavity, instead of its immediate contraction and closure. In this case, it may appear after a few days as if the tumor had not been effaced, the prominence still remaining; and, on everting the lid, flattened granulations are seen to project from the cavity. These are generally pedunculated, and may be excised without pain by a stroke with the scissors, which usually effectually disposes of them.

Simple incision, incision with the breaking up of the contents of the sac, or incision with cauterization, have been advised by some authors; but these means are nearly as painful as excision, and they are often insufficient, so that the patient is subjected to a second operation. Cauterization, moreover, is often followed by troublesome fungous granulation from the interior of the sac.

Yellowish aggregations as large as a pin-head sometimes form in the Meibomian ducts. If these become so hard and prominent as to fret the eyeball, they should be picked out from beneath the conjunctiva with a fine-pointed instrument.

BLEPHARITIS CILIARIS.

Inflammation of the borders of the lids, known as ophthalmia tarsi, blepharitis ciliaris, tinea tarsi, affects more or less extensively the edges of the lids and the ciliary follicles. It is often chronic, with more or less frequent exacerbations. The whole thickness of the lid is sometimes involved, and a hard red ridge is formed, extending a little distance from the border. The secretions from the glands are increased, and there is a special disposition to the formation of scaly crusts encircling one or more eyelashes. Ulcers may form beneath these crusts, or follicles be inflamed at different spots along the margin, discharging purulent matter, and readily bleeding if the lid is rubbed or scraped with the finger-nail to remove the crusts. The presence of these crusts and ulcerations causes itching and heat of the lids and of the eye itself. The ciliary bulbs becoming affected, the lashes drop out, and, if the disease exists too long, these are either not reproduced, in which case the margin of the lid after a time grows rounded, like the lips, forming the incurable condition termed *madarosis ;* or, if they continue to grow, the lashes are dwarfed and pale, perhaps distorted in their direction so as to turn inward and irritate the eyeball,—*trichiasis.* The lachrymal puncta are often everted, and perhaps obliterated ; and the accumulation of tears and their outflow upon the cheek causes still greater palpebral thickening and excoriation.

This affection is exceedingly common in children, especially of the poorer classes, and often accompanies corneal ulceration. When seen in adults it usually has a chronic form, and shows much disposition to recur, requiring long persistence in the use of remedies.

Directions should be given for the daily removal of the crusts, after softening by fomentations with warm water or milk and water, until they can be easily detached ; as, unless the diseased surface is thus kept free, remedies do not effectively reach it. About the size of a pin-head of an ointment made up of one part ung. hydrag. nitratis (citrine ointment), and six parts simple ointment or rose-water ointment, is to be melted on the end of a finger, and applied along the edges of the closed lids at bed-time, three times a week. Thus used, it remains in contact with the affected parts without getting into the eye, and gradually improves their condition. Sometimes simple, or rose-water, cucumber, or zinc ointment may be used with advantage on the intervening nights. After the disease has been long established, remedies must be continued, even when the symptoms have been relieved, so as to confirm the cure and avoid relapse; but once or twice a week is then sufficiently often to use them. Other ointments, of red oxide or yellow sulphuret of mercury, are also effective, and these may be tried as alternatives, so as perhaps to obtain a fresh effect; but the diluted citrine ointment appears to be the best of all, if prepared as officinally directed, with careful attention to the temperature of the mixture and to the strength of the acid employed. If some other vehicle, vaseline for instance, is selected for preparing these ointments, instead of that ordinarily used, it should have a somewhat firm consistence, in order that the ointment may be retained where its effect is needed, and not flow too readily into the eye, or become absorbed by the skin.

If the eyelashes are already loosened, or are distorted, they should be plucked out with cilia forceps; and are reproduced in healthier conditions. The cilia forceps should have at their ends flattened opposing surfaces, so as to seize and firmly hold the eyelash without cutting it off. The evulsion is done by a quick pull in the direction of the eyelash. Where there are ulcers along the edges of the lids, an occasional very slight touch of one or two of these with a pointed crayon of silver nitrate has a good effect in hastening the cure, but too many spots should not be touched at one time. This and the above-named remedies should be continued until and after ulcerations and crusts have ceased to form, and till the thickened ridge beneath the skin has disappeared. Should there be at any time a return of symptoms the remedies which had previously proved serviceable should be early employed.

HORDEOLUM.

Hordeolum, or stye, as it is sometimes termed, is a miniature furuncle near the margin of the lid. It renders the part very tender and painful, and the skin red and tense, with more or less œdema of the adjoining tissues. It may terminate by resolution, or in a few days a small yellowish slough forms, and is eliminated with an immediate subsidence of all the symptoms. If a patient who has already had similar experiences observes a beginning of redness and pain, and applies early for advice, we may often prevent the formation of a slough, and spare him some days of discomfort, by touching the central part of the swelling with a crayon of silver nitrate. Should the morbid process go on, warm fomentations to the part during the day and a little simple ointment at night favor the separation of the slough and lessen the tension of the skin. As soon as pointing is evident the thin wall of the hordeolum may be punctured, to allow of the escape of a portion of the degenerated tissue. Gentle pressure only should be made, as it is useless to attempt to expel the core until it is separated from its connections with the healthy parts. These annoyances seldom last more than three or four days, but if there appears to be a disposition to a repetition of the troublesome affection dilute citrine ointment should be used locally twice a week at bed-time, and perhaps potass. iodide given internally.

BLEPHAROSPASM.

Spasmodic closure of the lids, with increased lachrymation, may occur as a symptom of the presence of a foreign body, or of inflammation of the cornea or conjunctiva. It may also appear, with less intensity, as a reflex action excited by the presence of worms in the intestines, or as an hysterical manifestation.

Where local causes exist these must be the object of treatment. When the patient is of a nervous and hysterical temperament, tonics, together with sedative or mildly stimulating applications to the exterior or to the inner surface of the lid, are indicated. Cooling aromatic lotions externally, or steaming the eyelids with a hot infusion of hops, or with a teaspoonful of the tinctura saponis et opii poured into a wineglassful of boiling water, are often useful. A solution of ten or twenty grains of iodine in an ounce of chloroform, kept in a glass-stoppered "eye-bottle," and held against the *closed* lids until a sensation of heat is complained of, may be used two or three times weekly.

Mere nictitation or twitching of the lids is not uncommon in nervous children who have overworked their eyes, or who have optical defects requiring glasses. A soothing collyrium of borax, with moderate use of the eyes, and having the attention of the child diverted from them by those around him, generally removes the habit within a short time, except where it depends on defects of refraction, which should be corrected by glasses, if necessary.

CONGENITAL PTOSIS.

Falling of the upper lid may occur as a congenital defect from insufficiency of the levator muscle. The child can open its eyes but a little way, and can see only when the head is thrown far backward. An operation for removing a portion of the tissues of the centre of the lids, and bringing them to some extent under the control of the frontalis muscle, is the only resource; but it is well to delay this in most cases till after the period of infancy.

SYMBLEPHARON.

Adhesion between the conjunctiva of the lids and of the globe is a frequent result of burns, or of chemical or other traumatic injuries, which have destroyed a part of two opposite surfaces of the mucous membrane. If the bands of adhesion are small, these may be divided, and the ocular portion of the conjunctival wound drawn together by fine sutures; so that the mucous membrane over the surface of the eyeball is made intact. Reunion with the opposite raw surface, which is sure to take place if the band is merely divided, is thus prevented. Fastening the lid temporarily in forced eversion by means of a suture may aid in gaining a good result. To accomplish this object, the healthy conjunctiva may, if necessary, be dissected up a little, and slid over the sclera for the required distance. Where the raw space is too large to be thus filled up, a flap of conjunctiva from the other eye, or some part of the same eye, may be transplanted and secured in place by sutures. Operations for symblepharon must be done with great care, as, if unsuccessful, the subsequent condition may be worse than the former state. If the adhesions are very extensive, surgical intervention is of doubtful expediency, as it also is where this deformity has been congenital.

ANCHYLOBLEPHARON.

Adhesion of the border of the lids in more or less of their extent is sometimes congenital. If, on passing a probe, this is found to be complicated with extensive symblepharon, and especially if this implicates the cornea, an operation would be futile. If the abnormal contact is of small extent, the edges of the lids may be carefully separated from each other, and to prevent reunion the lower lid may be everted and fastened for twenty-four hours to the skin of the cheek by a point of suture.

Similar rules to those laid down for symblepharon, as to the expediency of operating, apply to those cases where blepharo-phymosis has resulted from burn or other injury.

EPICANTHUS.

A fold of skin is sometimes congenitally extended across from the upper to the lower lid at the inner canthus, so as to obliterate the inner angle and double the width of the root of the nose. Early interference is not required, but if the deformity remains unimproved as the child grows, and especially if the lids cannot be opened to their full extent, excision of a vertical oval flap from the skin at the centre of the bridge of the nose, with bringing together of the divided parts horizontally, is generally sufficient to greatly lessen, if not to wholly remove, the defect.

TRICHIASIS.

Abnormal inward direction of the cilia, so that they scratch the eyeball, is termed trichiasis. This inversion may be limited to a small part of the lid, or may affect only a single row of the eyelashes, or a group of but a few cilia. It is often the result of previous traumatic injury, or still more frequently of marginal disease, involving the ciliary bulbs. The distorted eyelashes may be of normal size, or may be thin and pale, from defective nutrition and from being constantly bathed in the secretions, so that they are scarcely to be seen without the aid of a magnifying glass. It occasionally happens that very fine hairs grow from the caruncle and irritate the eye, where there is no other morbid condition of the parts; these may easily escape observation on account of their minuteness. Trichiasis may be not only the consequence, but may also constitute a cause, of inflammation of the external membranes of the eyeball, its persistent irritation giving rise to certain forms of pannus and of corneal ulcer.

If only a few cils are distorted, their repeated removal, with cilia forceps, or with common tweezers if these fit squarely at their ends, is a palliation of the evil, and if carefully followed up will prevent serious harm to the eye. A trial should first be made of this plan, when convenient, in preference to any operative procedure, as the number or the misdirection of the deviated cilia is often at least greatly lessened by repeatedly plucking them out; their secreting bulbs being either destroyed in the process, or turned to a more normal position, especially where the neighboring parts of the lid are also improving in condition. Touching the bulbs of the cilia with a fine needle employed as a weak galvano cautery destroys their vitality. The method of destruction is as follows: a needle similar to those used by dentists for destruction of the nerve in a tooth is fastened in a holder, which is connected with the pole of a galvanic battery of very moderate power. It is then passed along the eyelash into the bulb. A bit of moistened sponge united with the opposite pole is then applied to the cheek or forehead near the eyelid. A slight appearance of frothing at the side of the needle indicates the completion of the process of disorganization, and where this has been effectual the eyelash can at once be plucked out without resistance. This method is lauded as successful in a very large proportion of cases at the first trial. Should it not destroy the bulb of the distorted cilia, the attempt can be repeated as soon as a renewed growth of the hair indicates the failure. Care should be had that the cauterization is not carried too far, so that other cilia become misdirected as the resulting cicatrization is accomplished. Extreme delicacy of manipulation is essential.

Where but a few cilia are implicated, a minute bit of skin above them may be excised and a suture so placed as to draw the cils outward; or they may drawn through the skin in a noose of doubled thread, so that their points project in the direction in which the noose is carried by the needle.

Destruction of the bulbs of distorted cilia with a hot needle, or with caustic, is of uncertain effect; other contiguous cilia sometimes being distorted. In many chronic cases, where trachoma has been complicated with blepharitis ciliaris, the tarsal cartilage is curved inward by contraction of its conjunctival lining, and the lashes deviate along the entire border of the lid.

If operative measures are attempted for this general trichiasis, they must be more extensive than where the changes are less considerable; and as these are long and painful, the patient should be etherized. Several methods have been proposed. An incision is made with a narrow knife along the entire border of the lid, so as to split it into an outer and an inner layer: the outer including the skin and the ciliary bulbs; the inner the tarsal cartilages with their Meibomian glands, and the conjunctiva. This incision should extend to two lines from the tarsal border. A second incision, parallel to the first and two lines above it, is made through the skin of the lid as deep as the cartilage, and a line or two longer than the marginal incision. A third incision, of crescentic form, parallel to the orbital margin, is extended from one end of the second incision to the other, including the skin only, and not the muscular fibres. The piece of skin comprised between the second and third incisions is now excised, and the edges of the wound brought together with sutures. Or, instead of excising this flap, it may be raised with forceps, three armed needles passed vertically through it, and the ligatures tied and left to cut their way out. Vertical incisions are sometimes made to connect the ends of the marginal and its parallel incision. The border of the lid, with the ciliary bulbs, is thus drawn up, and the marginal cut is left to cicatrize.

Scalping the edge of the lid by excising the skin and the ciliary bulbs, after separating these from the tarsal cartilage as above described, is practiced by Jaeger.

Graefe made vertical incisions through the skin and muscle of four lines in length at each extremity of the lid, and united these by the marginal splitting already mentioned. The border of the lid was then everted by excising an oval horizontal portion of skin from the centre of the lid, and uniting the edges of the wound with sutures; or an oval portion of skin was included in ligatures, without excision.

ENTROPION.

Incurvation of the entire border of the lid, without other deviation of the cilia than that thus occasioned, may result from temporary spasm; or may result, especially in old people, from absorption of the cellular tissue, leaving the skin loosely supported and readily turned in by the action of the errant fibres of the orbicularis which are distributed to it.

Where this occurs in the lower lid the inversion may often be rectified by carefully fastening strips of isinglass or adhesive plaster, vertically, to the skin, near the border of the lid, and then, after drawing this downward, securing it upon the skin of the cheek. The same effect may sometimes be obtained by painting the skin of the lid, and its neighborhood on the cheek, with collodion, which exerts a contractile action. Should these appliances become detached they must be renewed, and continued for a few days. If in aged people these prove ineffectual, on account of the laxity of the parts, excision of an oval bit of skin, with fibres of the orbicularis, and suture of the edges of the wound is a sure relief; or, in lieu of excision, three vertical sutures may be passed through a fold of the skin and tied. The amount of skin to be thus removed or tied may be measured by raising folds of different size with forceps till the proper effect is seen to be obtained. This slight operation is almost painless, and gives great satisfaction.

In chronic entropion, resulting from injury, or from contraction of the tarsal cartilage by trachoma, numerous operations have been recommended, none of them completely satisfactory as being a permanent benefit. An expedient which may suffice in the simpler cases is *canthoplasty*, or division of the external commissure of the lids. One blade of strong scissors is passed as far as possible inside the outer canthus, and the skin and conjunctiva are divided at one stroke. The edges of the wound are now to be stretched wide apart without further dissection, and the skin and the mucous membrane are then to be united to each other by three or five sutures in the upper and the lower lids; so as in fact to lengthen each of these, and relax the pressure on the eye.

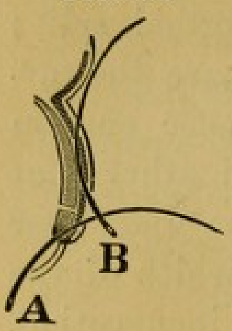
But when the tarsal cartilage is strongly incurvated, it is necessary, if interference is deemed advisable, to devise means by which it shall be bent outward.

Snellen, Streatfeild, Wells, and others have proposed methods for longitudinally grooving the anterior surface of the cartilage, and thus obtaining a change of its abnormal incurvation. Horizontal incisions are made, either as in Arlt's operation for splitting the border of the lid, or through the skin near the roots of the cilia, without the marginal split; other incisions, parallel to these, follow, to lay bare the tarsal cartilage, from which a longitudinal prismatic portion is removed by two incisions, so inclined to each other that the base of the prism is towards the skin, and the apex near the conjunctival surface of the cartilage. The width of the base is proportioned to the degree of morbid incurvation. Thread or wire sutures attached to two needles are then passed through the upper edge of the cartilage from the inside of the lid, carried between the cartilage and skin, and brought out by the needles at the two extremities of the incision, near the margin of the lid. The border of the tarsus beyond the grooved line is then drawn outward, and toward the apex of the cartilage, by tying these sutures.

The authors of all these operations admit that there is a liability to relapse within three or four years, when the same or other measures must be repeated. Another point in which these entropion operations are often unsatisfactory is that the resulting cicatrices are irregular, and the eyeball is sometimes nearly or quite as much fretted by these as by the condition it was sought to remedy. These uncertain results render it often desirable to employ palliative measures when these can be properly followed up, and where they promise a reasonable degree of relief, rather than operative means.

Dr. Green, of St. Louis, "makes an incision through the conjunctiva and tarsus, about two mm. from the row of openings of the Meibomian glands, from near the inner to the outer canthus; separating the lid margin from the body of the tarsus, and thus permitting it to be easily everted. A strip of skin not more than two mm. in width, its lower boundary being at one millimetre and a half above the line of the eyelashes, tapering to a point at each end, is then excised, leaving the orbicularis fascia and muscle intact, so that the nutrition of the loosened lid margin is maintained through the muscular layer." Dr. Green places sutures as follows: "The curved needle is first introduced a little to the conjunctival side of the row of eyelashes, and brought out just within the wound made by the excision of the strip of skin; it is then drawn through and inserted again in the wound near its upper margin, and passed deeply backward and upward, so as to graze the front of the tarsus and emerge through the skin of the eyelid a centimetre or more above its point of entrance. On tying together the two ends of the thread the skin-wound is closed, and the loosened lid margin is at the same time everted, and brought into a correct position. There is very little tension upon the stitches, and there is never any injurious strangulation of the included tissues. Three sutures generally suffice for the accurate adjustment of the lid margin."

FIG. 38.



ECTROPION.

Eversion of the lids may be acute and temporary, or the consequence of chronic alterations or traumatic injuries of contiguous parts, or a result of defect of innervation of the facial nerve supplying the orbicularis muscle. In old persons eversion is not uncommon, from a want of due action of the lachrymal puncta. The secretions remaining in the eye irritate the conjunctiva at the inner angle, and cause thickening and eversion, aggravating the already existing evil, until at length the entire lower margin of the lid is pushed away from the globe, forming the condition termed blear-eyed. The everted and perhaps closed punctum no longer conveying off the tears, they overflow upon the cheek, excoriating the skin and making matters still worse. Division of the punctum and of the canaliculus for the distance of a line allows the tears to be again taken up, and with the aid of soothing and of very mild astringent applications the thickened conjunctiva improves in condition, and the border of the lid gradually regains its proper place. A similar train of phenomena is induced by chronic marginal blepharitis, especially when the edges of the lids have become rounded and denuded of cilia. This is to be removed by treatment of the primary disease, and by reopening the punctum, if this is occluded. Where the above means are not sufficient to bring a flabby eyelid up to its proper position, the lids may be shortened, at the outer canthus, by freshening their edges for a little distance and uniting them by sutures, — *tarsoraphy.*

Cicatrices of the skin from burns, or after necrosis of bone near the orbital margin, are frequent causes of ectropion; and by hindering the proper function of the lids in conducting off the ocular secretions, they tend to slowly increase the thickening of the conjunctiva and the malposition of the lid. The traction of such cicatrices is to be relieved only by blepharoplastic measures.

Where there is no external traction from cicatrices, but merely an elongation of the lid border, too great to be overcome by the patient topical use of astringents, excision of a V-shaped piece, comprising the whole thickness of the lid, is the best procedure. The apex of the V is at the part farthest from the lid margin. Both the conjunctival and the cuticular edges of the wound must be carefully held together by fine sutures; otherwise the border of the lid will have a slight notch, which is not only unsightly, but may be a source of annoyance by serving as a channel for the flow of tears upon the cheek. Diffenbach proposed making the excision in the lid, not including its border; when, by bringing the integument together laterally, the edge of the lid is crowded up to its place.

Acute and complete eversion of the lids often occurs in ophthalmia neonatorum, and other severe forms of conjunctivitis. The lid should be at once replaced, and retained in position by gentle pressure with the fingers, or with a pledget of prepared cotton, until any spasmodic action of the orbicularis has subsided. This tendency to turn out generally disappears with the acute inflammation; but even if, as in cases I have seen, the conjunctiva of both lids has been thickened

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No. 1.

The voyager who sails from the dark waters of the restless Atlantic into the deep blue Mediterranean, notices at sunset a rich purple haze, which rises apparently from the surface of that fair inland sea, and drapes the hills and vales along the beautiful shore with a glory that fills the heart of the beholder with unutterable gladness. The distant snow-covered peaks of old Granada, clad in the same bright robe, seem by their regal presence to impose silence on those whom their majestic beauty has blessed with a momentary poetic inspiration which defies all power of tongue or pen. It touches nothing which it does not adorn, and the commonest objects are transmuted by its magic into fairy shapes which abide ever after in the memory. Under its softening influence, the dingy sail of a fisherman's boat becomes almost as beauti-

No. 2.

ful an object to the sight as the ruins of the temple which crowns the height of Cape Colonna. But when he approaches nearer to that which had seemed so charming in its twilight robes, his poetic sense is somewhat interfered with, and the shore, though it may still be very beautiful, lacks the supernal glory imparted to it by distance. It is very much after this fashion with manhood, when we compare its reality with our childish expectations. We find that we have been deceived by a mere atmospheric phenomenon. But the destruction of the charm which age had for our eyes as children, is compensated for by the creation of a new glory which lights up our young days, as we look back upon them with the regret of manhood, and realize that their joys

No. 3.

can never be lived over again. Few men would be willing to live again their years of manhood, however prosperous and comparatively free from trouble they may have been; but fewer still are those in whose memory the records of boyhood are not written as with a sunbeam. There is no pleasure so satisfactory as that which an old man feels in recalling the happiness of his youthful days. All the woes and anxieties and heart-burnings that disturbed him then have passed away, and left only sunshine in his memory. He who retains the happy spirit of boyhood cannot have outlived all of its

No. 4.

generosity and simplicity. "Once a man, and twice a child," says the old proverb; and if at the last we could only recall something of the sincerity and innocence and unselfishness of our early life, second childhood would indeed be a blessed thing.

Many will grow enthusiastic with the recollection of their schoolboy days,—their snowballings, their manly sports, their mighty contests with the boys of the town,—and, though they may not claim the genius of the former head-

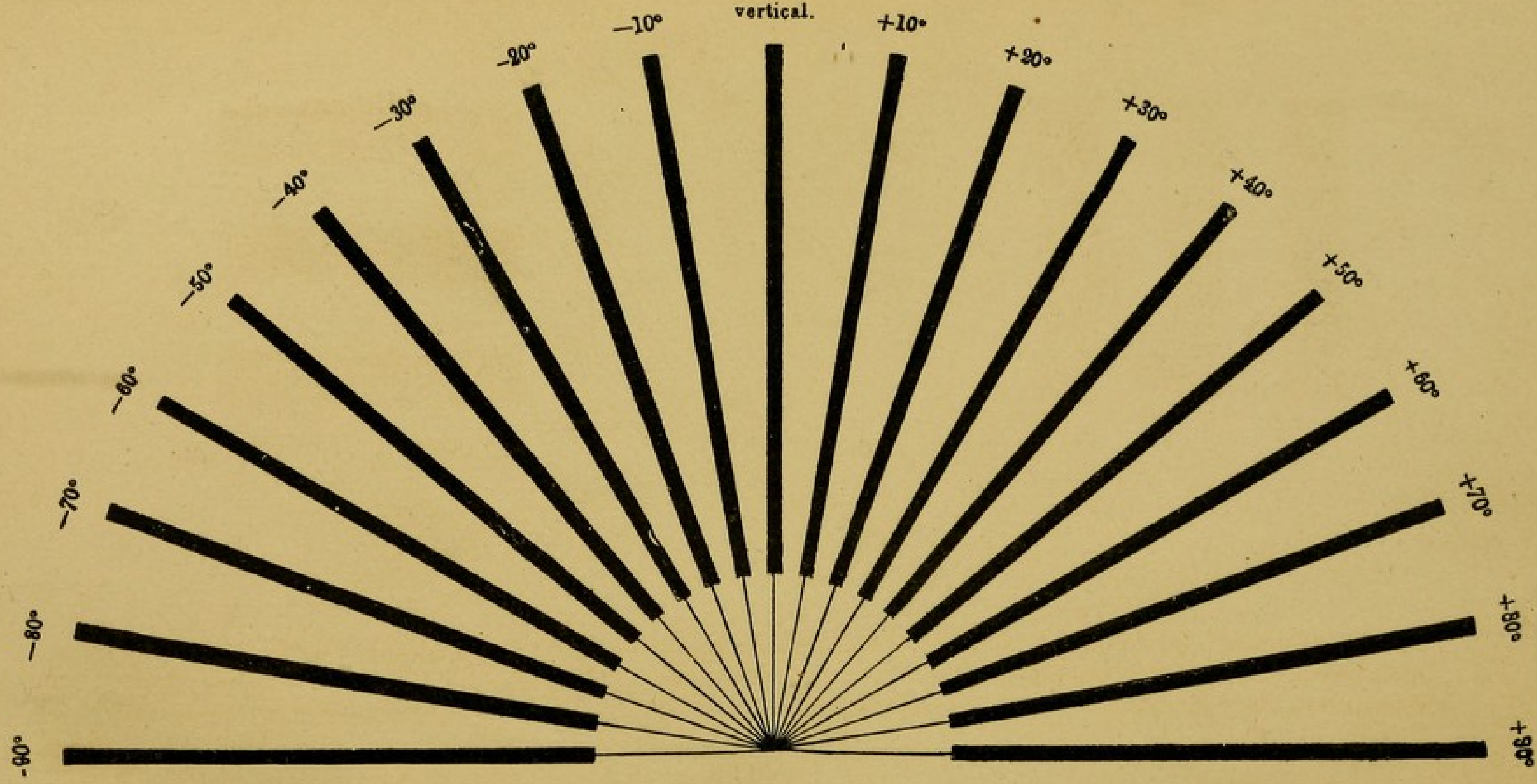
No. 5.

master of Rugby for the guardian of their youthful sports and studies, will cherish an affectionate remembrance of a wise, judicious, and lovable teacher.

The generosity, and all the priceless charms of boyhood, rarely outlive its careless years of happiness. They are generally severely shaken, if not wholly destroyed, when the youth begins to take his

No. 6.

share in the conceit and ambition and selfishness of full-grown humanity. It is sad to think that a human boy, like the morning star, full of life and joy, may be stricken down by death, and all his hilarity stifled in the grave; but it is even more melancholy to think that he may live to grow up, and be hard and worldly and ungenerous. For this latter fate is accompanied by no consola-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