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DISEASES OF THE EYE

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A HANDBOOK

OF THE

DISEASES OF THE EYE

AND THEIR

TREATMENT

BY

SIR HENRY R. SWANZY, A.M., M.D., D.Sc.

PAST-PRESIDENT OF THE ROYAL COLLEGE OF SURGEONS IN IRELAND, PAST-PRESIDENT AND BOWMAN LECTURER OF THE OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM, SURGEON TO THE ROYAL VICTORIA EYE AND EAR HOSPITAL, AND OPHTHALMIC SURGEON TO THE ADELAIDE HOSPITAL, DUBLIN.

AND

LOUIS WERNER, M.B., F.R.C.S.I., Sen. Mod. Univ. Dub.

OPHTHALMIC SURGEON TO THE MATER HOSPITAL, ASSISTANT SURGEON TO THE ROYAL VICTORIA EYE AND EAR HOSPITAL, PROFESSOR OF OPHTHALMOLOGY, UNIVERSITY COLLEGE, DUBLIN.

TENTH EDITION

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THIS BOOK IS DEDICATED

TO

THEODOR LEBER

EMERITUS PROFESSOR OF THE UNIVERSITY OF HEIDELBERG

AS A MARK OF

ADMIRATION FOR HIS EMINENT SERVICES

TO OPHTHALMOLOGY

PREFACE

In the present edition, as in the previous ones, the endeavour has been to keep the book abreast of modern ophthalmology, in so far as this is possible in a work of its size, mainly intended for students. The amount of text is about the same as before, although, in consequence of an alteration in the shape of the book, the number of pages is less. The chapters are differently arranged, with the result that the earlier ones now treat of the normal eye and its functions, and the methods for examining them. The book has been thoroughly revised throughout, obsolete matter having been discarded, while new developments have been introduced. The book now, for the first time, contains coloured figures, to the number of twenty-one, from original paintings by one of us (L. W.), and it is believed that these will prove helpful to the student.

Our thanks are due to Dr. Kathleen Lynn for the great pains she has taken in the preparation of the index.

We desire also to express our thanks to Mr. H. K. Lewis for the care he has given to the production of the book and for his readiness to carry out all our suggestions.

H. R. S.
L. W.

Dublin.

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TO THE STUDENT.

The student may at first omit the portions printed in small type, and those marked with an asterisk, including the whole of chapter xiii. With these exceptions he should carefully read chapters i., ii., xiv., and xv., immediately on joining the ophthalmic hospital or department.

DISEASES OF THE EYE

CHAPTER I.

Preliminary Note on the Clinical Examination of Eye Patients.

In general medicine and surgery, the importance of systematic clinical methods is well recognised. System is even more necessary in the clinical study of diseases of the eye, where the changes from the normal are often so minute that they may readily escape observation, and the symptoms depending on derangement of the functions of the organ are sometimes such, that the patient may himself be unaware of them.

Before examining the eye, a general observation of the patient should be made, whereby suggestive hints are often obtained for diagnosis. For example: the manner in which a patient enters a room may help to distinguish between an affection of the nervous apparatus of the eye and cataract, or his gait may suggest an affection associated with disease of the spinal cord. Again, a strumous appearance, enlarged glands, eczema, syphilitic eruptions, or the aspect due to hereditary syphilis afford information not to be disregarded.

There are many obvious local conditions, which are liable to escape the attention of a beginner who is, as so many are inclined to be, too hasty in beginning a close inspection of the eyeball itself; for example, the presence of slight strabismus, photophobia, or slight ptosis, or the sleepy appearance due to the heavy thickened lid in granular ophthalmia. We mention these merely to indicate the advantages which may be gained by quietly taking a general view of the patient, and of his eyes, at a little distance, before proceeding to examine the latter more closely.

The examination of the eye may be divided into three parts,

which are usually taken in the following order: 1. Objective examination in daylight. 2. Subjective, or functional, examination. 3. Objective examination in the dark room. All these will be described in their appropriate places in the following pages, and it is only necessary here to mention some of their subdivisions. Under the first will come inspection (and palpation when possible) of the orbit, eyelids, lacrimal passages, conjunctiva, cornea, anterior chamber, iris (its colour and structure, and the mobility, shape, and size of the pupil), anterior layers of the lens in the pupillary area, and testing the intra-ocular tension. The second will include tests for acuteness of vision, field of vision, accommodation, orbital muscles, colour-vision, and light-sense. Finally, in the dark room the anterior parts of the eye, including the lens, and sometimes the anterior portion of the vitreous humour, are first examined by reflected light, with oblique illumination, and then with a strong + lens in the ophthalmoscope. The details of the fundus are then observed with the ophthalmoscope, and the refraction is estimated if necessary. One should never omit to compare the affected eye with its fellow, if only one eye be diseased.

It is not intended that all these methods of examination should be put into use, or considered even necessary, in every case; but they should be borne in mind, if nothing is to escape attention.

OPTICAL STRUCTURE AND FUNCTIONAL EXAMINATION OF THE EYE.

Optical Structure of the Eye.—The eye is a dark chamber lined by the uveal pigment, which prevents the rays of light from entering it, except through the transparent media and pupil. It possesses three refracting or dioptric[1] media, limited by three convex surfaces. The dioptric media are the aqueous humour, the substance of the crystalline lens, and the vitreous humour. The convex surfaces are the anterior surface of the cornea,[2] and the anterior and posterior surfaces of the crystalline lens.

By aid of this apparatus, which is called the *Dioptric System* of

[1] The phenomena of refraction are sometimes referred to as Dioptrics, and those of reflection as Catoptrics.

[2] The posterior surface of the cornea may be neglected, since it is parallel to the anterior surface and the index of refraction of the cornea is the same as that of the aqueous humour.

the eye, distinct inverted images of external objects are formed on the retina, in the same way images are formed by a convex lens (see § 22, chap. xiv.).

The refracting surfaces, which are practically spherical, are centred on the *Optic Axis* (*O P*, Fig. 1), an imaginary line which, passing through the optical centre (*N*) of the eye, meets the retina at a point (*P*), the posterior principal focus (§ 15, chap. xiv.), slightly to the inner side of the macula lutea (*M*).

The optic axis of the eye is similar to the principal axis of a convex lens (see § 14, chap. xiv.). The optical centre *N*, which is called the *Nodal Point*, is situated just in front of the posterior surface of the lens, and rays passing through it are not deviated in their path, being in fact secondary axes (§ 14, chap. xiv.). *V M* is the *Visual Line*, which unites the object looked at (called the point of fixation) with the macula lutea (*M*) and passes through the nodal point.

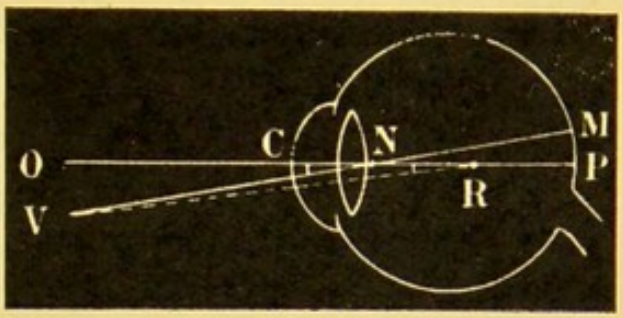


FIG. 1.—*O P*, Optic axis; *V M*, Visual line; *O R V*, angle γ; *R*, centre of rotation; *N*, nodal point; *C*, centre of cornea.

The *Line of Fixation* (*R V*) joins the centre of rotation (*R*) of the eye with the point of fixation. The angle *O R V* formed at the centre of rotation, by the optic axis and the line of fixation, is called the angle γ.[1]

The line of fixation and the visual line so nearly coincide that in practice we regard them as identical; and hence the angle γ is practically the same as *O N V*.

The angle κ is the angle between the fixation line and a perpendicular line through the cornea, opposite the centre of the pupil. In practice it is the angle κ which is measured. It is not

[1] Some writers call this angle α (alpha). But the angle α originally meant the angle between the visual line and the major axis of the corneal ellipse, and was founded on the view that the cornea was an ellipsoid—a view which has been shown to be erroneous by Tscherning and others. Indeed, the "working area," or optical portion of the cornea, which includes 13° to 16°, is approximately spherical.

equal to the angle γ, because the centre of the pupil is a little to the inner side of the centre of the cornea.

In order to measure the angle κ, the eye is placed at the perimeter (p. 18) as for an examination of its field of vision, that is to say, looking at the zero point. A candle flame is then moved along the arc of the perimeter, until the corneal image of the light appears to the observer (whose eye is in a line with candle and image) to be in the centre of the pupil. The position of the flame at the perimeter then gives the angle κ. The average size of the angle κ is 5°.

Refraction.

By the Refraction of the Eye is meant, in a general sense, the faculty it has *when at rest* (*i.e.*, without an effort of accommoda-

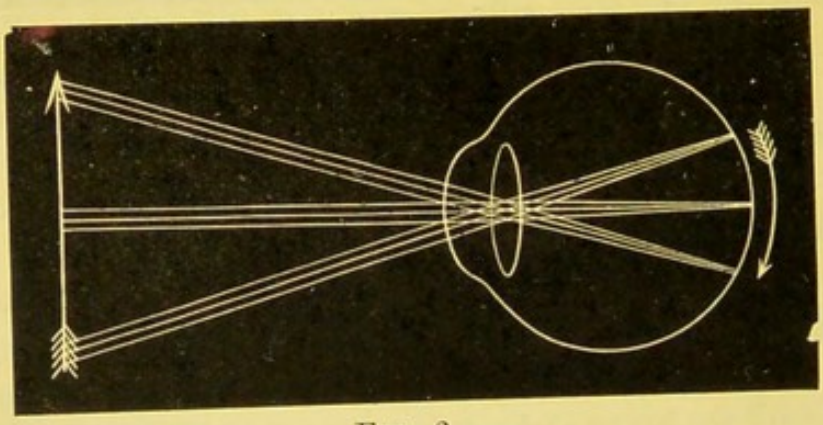


Fig. 2.

tion) of altering the direction of rays of light which pass into it, making parallel rays convergent, and divergent rays less divergent. But, as usually understood, it means the relation which the position of the retina bears to the principal focus of the dioptric system.

In Normal Refraction, or Emmetropia (ἔμμετρον, *the standard*; ὤψ, *the eye*), as it is termed, the retina lies at the posterior principal focus (Fig. 2), and therefore parallel rays are brought to a focus on the layer of rods and cones of the retina, and form on it a distinct inverted image of the point or object from which they come. The emmetropic eye, in a state of rest, is thus adapted for seeing distant objects, and its far point (punctum remotum) is at infinity. Conversely, if the retina be illuminated, the rays proceeding from any point on it will emerge from the eye parallel. In the normal eye the posterior focal length of the dioptric system is 23 mm.,

and the average length of the eyeball including the sclerotic is 24 mm.

Accommodation.

The eye can see near objects distinctly as well as distant objects, although the rays from any given point (*a*, Fig. 3) of a near object reach the eye with a divergence so considerable, that they could not be brought to a focus on the retina by the unaided refraction, but would converge towards a point (their conjugate focus *a'*) behind the retina, and would not form a distinct image on the latter, but merely a blurred image or circle of diffusion (at *b c*). It is obvious, therefore, that an increase of refracting power in the eye is necessary, in order that near objects may be

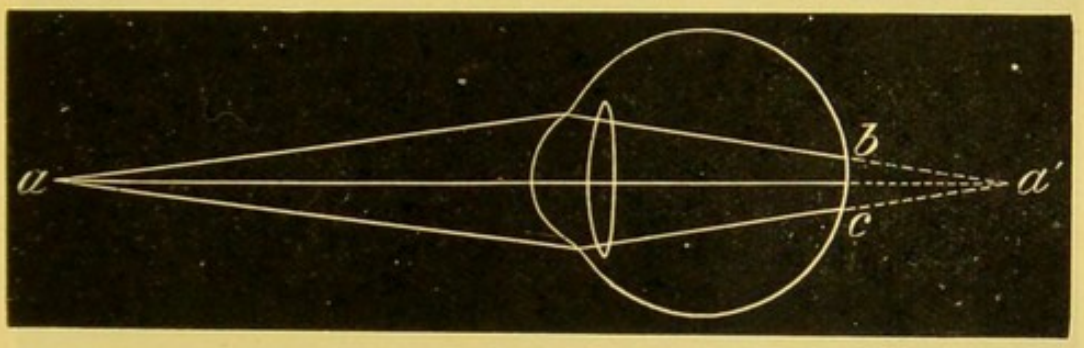


Fig. 3.

distinctly seen. It is this increase in the refracting power for the purpose of near vision which is called Accommodation.

The Mechanism of Accommodation is as follows :—The ciliary muscle (*m*, Fig. 4) contracts, thus drawing forward the chorioid and the ciliary processes, and relaxing the zonula of Zinn (*z*), which is attached to the latter. The lens (*l*), which was flattened by the tension of the zonula, is now free to assume a more spherical shape, in response to its own elasticity. The posterior surface of the lens scarcely alters in shape, being fixed in the patellary fossa ; but the anterior surface becomes more convex, thus increasing its refracting power. Associated with the act of accommodation is a contraction of the pupil. The accompanying figure (Fig. 4) represents the changes which take place in accommodation, the dotted lines indicating the latter state.

Tscherning has shown that the increased curvature of the anterior surface of the lens occurs mainly in the centre of that

surface—in other words, that in accommodation the anterior surface becomes somewhat conical, and not merely more spherical. He holds that this is due to a tightening, and not to a relaxation, of the zonula. This theory has been vigorously combated by other observers, and its true value remains to be determined.

During accommodation the lens alters its position so as to become slightly lowered.

Accommodation is always associated with contraction of the pupil and convergence of the optic axes.

The Far Point and the Near Point.—It is possible for the eye,

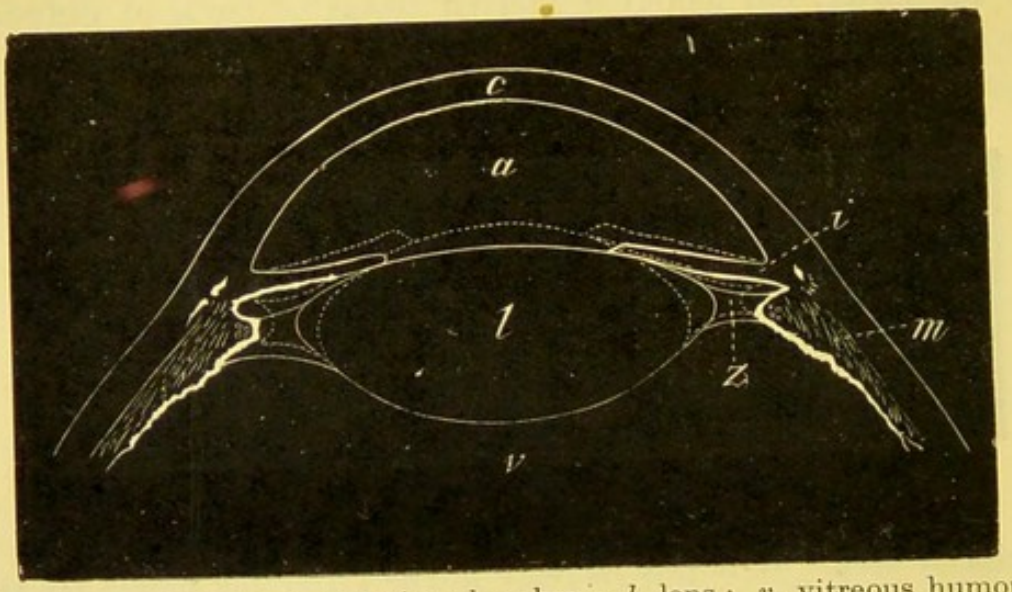


FIG. 4.—*c*, cornea; *a*, anterior chamber; *l*, lens; *v*, vitreous humour; *i*, iris; *z*, zonula of Zinn; *m*, ciliary muscle.

by changing the accommodation, to see objects accurately at every distance from its Far Point—*i.e.*, its most distant point of distinct vision (Punctum Remotum,—R.), up to a point only a few centimetres from the eye, called the Near Point (Punctum Proximum,—P.). We can find the latter by directing the patient to look at a page printed in small type, and by bringing it slowly closer and closer to his eye, until a point is reached where he cannot distinguish the words and letters, which become blurred. A point very slightly more removed from the eye than this, where he can read distinctly, is the near point. Between the near point and the eye vision is indistinct, because no effort of the ciliary muscle can produce the amount of convexity of the lens required for so short a distance.

* **The Amplitude and Range of Accommodation.**—This is the amount of accommodative effort of which the eye is capable —*i.e.*, the effort it makes in order to adapt itself from its Far Point (R.) up to its Near Point (P.). The amplitude of accommodation (a), therefore, is equal to the difference between the refracting power of the eye when its accommodation is exerted to the utmost (p), and when at rest (r), as expressed by the formula $a = p - r$. It may be represented by that convex lens placed close in front of the eye, which would take the place of the increased convexity of the lens, or, in other words, which would give to rays coming from the nearest point of distinct vision a direction as if they came from the far point. The number of this lens expresses the amplitude of accommodation in a given eye.

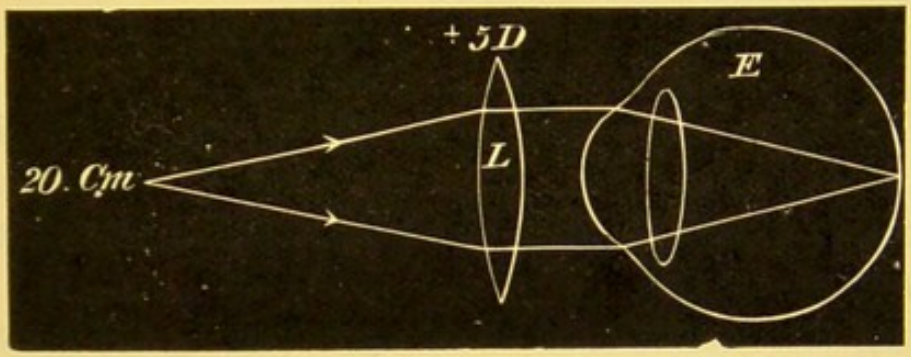


FIG. 5.

For example: if, in an emmetropic eye (E, Fig. 5) the near point be situated at 20 cm., then a convex lens (L) of 20 cm. focal length placed close to the eye (between that point and the eye) would give to rays coming from the near point a direction as though they came from a distant object (*i.e.*, would make them parallel), and this normally refracting eye would then be enabled, by aid of its refraction alone, to bring these rays to a focus on the retina. Making use of the above equation, we find in this case—since a focal length of 20 cm. represents a lens of 5 D—that $a = 5 - r$, but R being situated at infinity (designated by the sign ∞), $r = \frac{1}{R} = \frac{1}{\infty} = 0$; therefore $a = 5 - 0 = 5$ D.[1]

The amplitude of accommodation (*i.e.*, the number of the lens

[1] It must be observed that R represents the *distance* of the Far Point from the eye, while r represents the *refractive power* which is added to

which would represent it) is the same in every kind of refraction, according to the age of the individual, but in emmetropia alone is $a = p$ as above, because in it alone is $r = 0$.

It is evident that, as the refractive power of the eye is increased during accommodation, the eye is rendered temporarily myopic as regards parallel rays (Fig. 6).

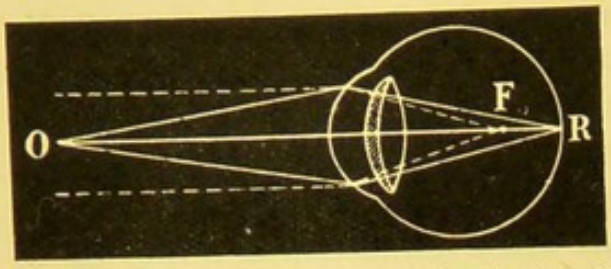


FIG. 6.—Eye accommodated for *O* which forms a distinct image on the retina, *R*. Parallel rays now unite in front of the retina at a shorter distance, *F*.

Under the head of "Anomalies of Accommodation," chap. xv., will be found Donders' diagram representing the amplitude of accommodation at different ages.

The Range of Accommodation is the distance between the far point, R, and the near point, P. As will be seen later on, it is not always the same for a given amplitude.

Connection between Accommodation and Convergence (Relative Accommodation).—By convergence we mean the inward rotation of the eyes which is necessary in looking at a near object, in order to obtain single vision with both eyes. With each degree of convergence of the visual lines a certain effort of accommodation is associated. Thus, if the object be situated 2 metres from the eye, the visual lines converge to that point, and a certain effort of accommodation (0·5 D) is made. But this connection between accommodation and convergence is somewhat elastic, for the accommodative effort may be increased or decreased, while the object is kept distinctly in view, and the same convergence maintained. That it may be increased is shown by the experiment of placing a weak concave glass before the eye, when it will

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the eye by accommodation, or by a lens, in order to adapt it for the distance R. Hence it is evident that $r = \frac{1}{R}$, because the strength, or refractive power, of a lens is inversely as its focal length—*e.g.*, a lens of the strength of 4 D will have a focal length of $\frac{1}{4}$ that of a lens of 1 D—*i.e.*, $\frac{1 \text{ m.}}{4} = \frac{100 \text{ cm.}}{4} = 25$ cm. (see § 28, ch. xiv.). Similarly, $p = \frac{1}{P}$ and $a = \frac{1}{A}$, P representing the *distance* of the Near Point, and A the focal length of the lens *a* which represents the Amplitude of Accommodation.

be found that the object is still distinctly seen; or if a weak convex glass be held before the eye the object will also be clearly seen, showing that the accommodative effort may be lessened without affecting vision or convergence. This amplitude of accommodation for a given point of convergence of the visual lines, found by the strongest concave and strongest convex glasses with which the object can still be distinctly seen, is called the Relative Amplitude of Accommodation. That part of it which is already in use, and is represented by the convex lens, is termed the negative part; while the positive part is represented by the concave lens, and has not been brought into play. For sustained accommodation at any distance, it is necessary that the positive part of the relative amplitude of accommodation be considerable in amount.

Moreover, the convergence may be altered, while the same effort of accommodation is maintained, as is shown by the experiment of placing a weak prism with its base inwards before one eye. In order that the object may then be seen singly, it will be necessary for the eye before which the prism is placed to rotate somewhat outwards; and it will be found that the individual can do this, while at the same time he sees the object with the same distinctness, showing that the same effort of accommodation has been maintained, although the angle of convergence of the visual axis is less than before.

CONVERGENCE.

* **Range and Amplitude of Convergence.**—The nearest point for which the eye can converge and still see single is the Near Point of convergence. The Far Point of Convergence is the point at which the visual lines meet when the eyes are at rest; as the position of rest is one of slight divergence, this imaginary point usually lies behind the head, and the deviation from parallelism to this degree of divergence is known as negative convergence. The Amplitude of Convergence is the sum of the positive and negative convergence. The Range of Convergence is the distance between the far and near points of convergence.

The near point of convergence is found by bringing an object, such as a fine line, up to the eyes in the middle line, until it begins to be seen double. The far point of convergence, or

rather the negative convergence, can be measured by prisms placed base inwards while the patient looks at a distant object. In some cases the eyes are parallel or slightly convergent when at rest, and then convergence is altogether positive.

The Unit of Convergence. The Metre Angle.

If the visual line (*E* 1, Fig. 7) of an eye (*E*) be brought to bear on a point (1, Fig. 7) 1 metre distant from it in the median line (*M* 1), the angle of convergence (*E* 1 *M*) which the visual line thus makes with the median line is called the Metre Angle. It expresses the degree of convergence necessary for binocular vision at that distance, and is employed as the unit for expressing other degrees of convergence. If, for example, an object be situated $\frac{1}{2}$ a metre ($\frac{1}{2}$, Fig. 7) from the eye, the angle of convergence (*E* $\frac{1}{2}$ *M*) must be practically twice as large as at 1 metre: C. (Convergence) = 2 metre angles. If the object be only $\frac{1}{3}$ of a metre distant, 3 metre angles are required: C. = 3 metre angles. If the object be situated 2 metres from the eye, the angle of convergence will only be one-half as great as that at 1 metre, and here C. = $\frac{1}{2}$ metre angle; while if the eye be directed towards a distant object (*D*) there will be no angle of convergence, and if the visual lines be divergent the metre angle will be negative.

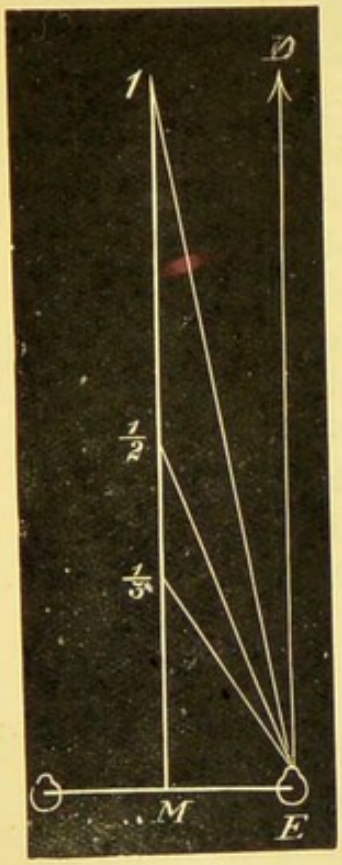


Fig. 7.

Now the emmetropic eye normally requires for each distance of binocular vision as many metre angles of convergence as it requires dioptries of accommodation. For a distance of 1 metre an effort of accommodation of 1 dipotre is required, and also 1 metre angle of convergence; at $\frac{1}{2}$ metre from the eye 2 D of accommodation is required and 2 metre angles; at $\frac{1}{3}$ metre from the eye 3 D of accommodation and 3 metre angles, and so on; while for distant objects neither convergence nor accommodation is required. The positive portion of the average normal convergence is about 10 metre angles and the negative 1 metre angle.

THE SENSE OF SIGHT.

The Sense of Sight consists of three Visual Perceptions or Sub-Senses—namely, the Light-Sense, the Colour-Sense, and the Form-Sense.

* **The Light-Sense** is the power the retina, or the visual centre,

has of perceiving gradations in the intensity of illumination. A convenient clinical method of testing the light-sense is the photometer invented by Messrs. Izard and Chibret. On looking through this instrument towards the sky two equally bright discs are seen. By a simple mechanism one of the discs can be made darker. If the eye does not perceive the difference in illumination between the two discs within 5° its light-sense is abnormal, or we may say its L.D. (Light Difference) is too high. Again, if one disc be made quite dark, and be then gradually lighted, the patient is required to indicate the smallest degree of light, or L.M. (Light Minimum), by which he can observe the disc issuing from the darkness. This should not be more than 1° or 2°.

Another good method is that of Bjerrum, in which the light-sense is tested by grey letters on a white ground, the letters being constructed on the same principle as Snellen's Test Types.

A useful and ready clinical method consists in gradually diminishing the illumination of the test-types and comparing the acuteness of vision of the patient with that of the surgeon, provided the latter have a normal light-sense. The L.D. is most affected in diseases of the optic nerve, and the L.M. in chorioido-retinal affections; but the measurement of the light-sense is not often required in clinical work.

Retinal Adaptation.—It is a common experience, on passing from daylight into a darkened room, to find that at first nothing is visible, but that after a time the various objects in the room begin to appear, until finally almost everything can be seen. This phenomenon is called "Adaptation" and is due to the fact that the retinal purple, which has been bleached by light, is only gradually regenerated. In testing the light-sense, therefore, it is necessary to allow some time for the eye to adapt itself. Complete adaptation is very slow, but for practical purposes 20 minutes may be deemed sufficient. Adaptation is slower at the macula lutea than outside it, probably because of the absence of rods, which alone contain the visual purple.

In some diseases, such as retinitis pigmentosa, in which night-blindness is a prominent symptom, the power of adaptation is extremely slow and defective. Increased power of adaptation, curiously enough, is only met with in total colour-blindness.

* **The Colour-Sense** is the power the eye has of distinguishing light of different wave-lengths. According to the Young-Helmholtz theory, the retina possesses at least three sets of colour-

perceiving elements, those for Red, Green, and Blue or Violet. These are termed primary colours because by their combination white light as well as all other colours can be produced.

According to Hering's theory, the colour-sense and the light-sense depend upon chemical changes in the retina or in the visual substances contained in the retina. He suggests the existence of three different visual substances, the white-black, the red-green, and the blue-yellow, by the using up or Dissimilation, and restoration or Assimilation of which substances the sensations of light and colour are produced. These theories are not satisfactory, for they do not explain cases in which shortening of the spectrum occurs, and many other facts connected with colour-vision, and they are not founded on an anatomical basis. Hering's views are completely disposed of by the discovery that the electrical reactions in the optic nerve, produced by stimulation of the retina by different colours, differ only in degree and not in kind.

Edridge-Green's theory, which is the result of many years' study of the subject, is, that light falling upon the retina, liberates the visual purple from the rods, and a photograph is formed. The decomposition of the visual purple by light chemically stimulates the ends of the cones, and a visual impulse is set up, which is conveyed through the optic nerve-fibres to the brain. He assumes that the visual impulses caused by the different colours differ in character, just as the rays of light differ in wave-length. Then in the impulse itself we have the physiological basis of light, and in the quality of the impulse the physiological basis of colour.

Colour-vision, therefore, consists in the power of distinguishing between rays of different wave-length, and the greater the degree of development of the colour-perceiving centre in the brain, the more acute will be the power of distinguishing differences of wave-length, consequently the smaller will be the interval in the spectrum between the rays which are recognised as different, and therefore the more numerous will be the colours perceived. When the colour-perceiving centre is badly developed, the points of difference will be greater, that is to say, the rays perceived as different will be farther apart in the spectrum, and the number of colours recognised fewer—in other words, there will be blindness for one or more colours.

It may also happen that the visual purple is not acted upon by

the rays at the extreme ends of the spectrum, and then the spectrum will appear shortened.

According to this theory, therefore, the colour-blind are divided into two distinct classes independent of each other, but which may be associated. The first class includes those who see the spectrum shortened at the red or violet ends, or at both; while in the second the number of colours visible in the spectrum is smaller than the normal. A consideration of the way in which the colour-perceiving centre develops, according to Edridge-Green, will help us to understand the various degrees of colour-blindness. At first no difference would be recognised, the whole spectrum would appear of a neutral colour. In the next stage only the extreme ends of the spectrum would be differentiated, namely, the red and violet, with a more or less wide neutral band of grey between them; the grey band would gradually diminish until the two colours met; following on this stage a third colour would appear at the next point of greatest difference, namely, at the centre of the spectrum in the green, and so, in order of succession, yellow, blue, and orange would be added. Thus, if the normal-sighted be designated as hexachromic (seeing six colours),[1] the colour-blind may be divided into the pentachromic (seeing five colours —red, yellow, green, blue, violet), the tetrachromic (seeing four—red, yellow, green, violet), the trichromic (seeing three—red, green, violet), the dichromic (seeing two—yellow, blue),[2] and finally, the monochromic, or totally colour-blind.

Colour Tests.—Testing the colour-sense is by no means a simple matter. It requires a good deal of experience as well as a knowledge of colour-blindness and of the eye itself to apply the tests in a really satisfactory way. It is advisable therefore that they should

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[1] In very rare cases a seventh colour, called indigo, is seen in the spectrum.

[2] When a dichromic sees the whole spectrum occupied by two colours, that half which is towards the red end includes the red, orange, yellow, and some of the green of the normal-sighted. These, of course, appear to the dichromic as one colour, and the same applies to the portion at the violet end. Now the colours seen by the dichromic will be represented by those colours which in the normal-sighted correspond to the centre of each of the two colours seen by the dichromic. These are yellow and blue.

not be entrusted to laymen, or even scientists, but should be carried out by ophthalmologists.

The spectrum affords the most accurate of all tests, but a special spectroscope is required, and, owing to the expense and expert knowledge necessary, it is hardly suitable for clinical use.

Holmgren's test is based upon the Young-Helmholtz theory. The test objects used are coloured wools, of which a large number of skeins of every hue are thrown together.

Test I. (*vide* card on inside of end cover) consists in presenting to the individual, in good diffused daylight, a pale but pure green sample, and requiring him to select out of the bundle of wools of all colours before him all of those samples which seem to him to correspond to the test sample. If this be done correctly it is unnecessary to proceed further: the individual has normal colour-sense. Amongst the skeins, however, there are some which are termed colours of confusion (greys, buffs, straw-colour, etc.); and if he select one, or several, of these he is colour-blind.

If, now, it be desired to ascertain the kind and degree of his defect we proceed to Test II.*a*. A pink (mixture of blue and red) skein is given to be matched. If this be correctly done, the person is termed incompletely colour-blind; but if blue and violet, or one of them, be selected, he is red-blind (sees only the blue in the mixture of blue and red); if he select green or grey, or one of them, he is green-blind.

In order to corroborate the investigation Test II.*b* may be employed. A vivid red skein is given. The red-blind chooses, besides red, green and brown shades darker than the red; while the green-blind chooses green and brown shades lighter than the red. But it is now very generally recognised, that red-blindness and green-blindness invariably go together. In violet (or blue) blindness, purple, red, and orange will be confused on Test II.*a*; but this is an extremely rare variety of colour-blindness. Total colour-blindness will be recognised by a confusion of all shades having the same intensity of light, and is also rare.

The individual tested should not be allowed to name the colours, but merely to match them, as above described. The reason for this is twofold. First, because, although the congenitally colour-blind person is usually unaware of his defect, yet experience may have taught him which of his sensations are called blue, red, etc., by

other people; and hence he can often apply the right names to colours which he really does not see as such. He is assisted in this by whatever of colour-sight is left to him, and by the brightness and saturation of the different colours, but is liable to frequent mistakes. Again, when the colour-blind person does not happen to know of his defect he is often desirous of concealing it, either because he is ashamed of it or from interested motives.

Edridge-Green uses two tests, a classification test and a lantern test. The Classification Test consists of a number of coloured wools, silks, cards, and glasses, with four test-colours—orange, violet, blue-green, and red. The examinee is asked to name the test-colours, and then to pick out from the pile all of similar colour. The Lantern Test, which is very efficient and practical, consists of a lantern with coloured glasses revolving behind a circular opening which can be altered in diameter. The colours can be shown separately or combined, and can be modified by neutral or ribbed glass, so as to represent signals as they are affected by distance, fog, or rain. It forms an ideal test for railway servants and sailors. The examinee is asked to name the colour of the light shown. Edridge-Green is of opinion that the use of colour names is absolutely necessary, or normal-sighted persons will be rejected, through paying attention to shade rather than to colour. It does not matter what name is applied to a colour; but ground for rejection is afforded when the examinee calls two of the main colours of the normal-sighted, as, for instance, red and green, by the same name.

The following should be rejected as being dangerously colour-blind: 1. Those who see only three colours (trichromics), or less than three. 2. Those who have a shortened red end in their spectrum, even though they may be hexachromics. 3. Those affected with central scotoma for red or green.

Edridge-Green considers Holmgren's test unsatisfactory for many reasons; of these may be mentioned the very important ones: that it will not detect persons who have a central colour scotoma, nor those with a spectrum shortened at the red end, and it is just the extreme red rays which are the most penetrating.

A certain proportion of people (3·5 per cent. of men and less than 1 per cent. of women) are congenitally colour-blind in greater or less degree, without any diminution in the other visual functions.

Acquired colour-blindness is found in toxic amblyopia, in atrophy of the optic nerve, and under some other conditions.

The Form-Sense (Acuteness of Vision).—By Acuteness of Vision (V.) is meant the power which the eye, or rather the macula lutea, has of distinguishing form, any anomaly of its refraction, if such exist, having been first corrected. In clinical ophthalmology the testing of this function is an important and ever-recurring duty.

When applied to by a patient on account of imperfect sight it is our first duty, as a rule, to ascertain accurately the condition of refraction and accommodation of his eyes. Should these be abnormal, and it be found that by aid of the correcting glasses perfect vision is obtained, it may in general be concluded that the eye is organically sound, and that the patient's complaints are due to the defect in accommodation or refraction. If glasses do not

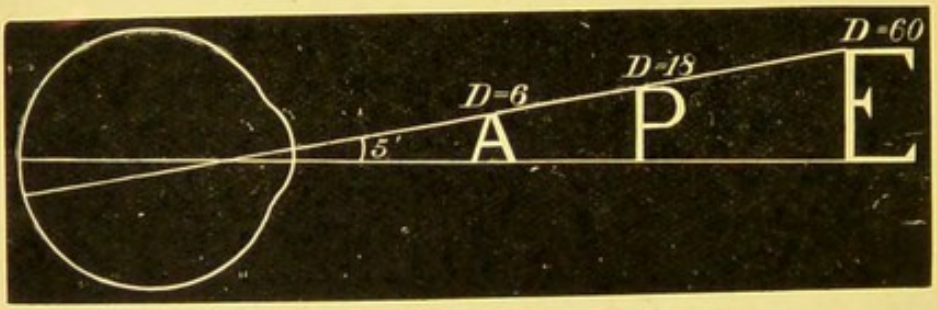


FIG. 8.

restore perfect vision, we must then, by the ophthalmoscope and other methods, decide the nature of the defect.

Now, in order to measure the acuteness of vision we must have a normal standard for comparison—*i.e.*, we must find what is the size of the smallest retinal image whose form can be distinguished. We cannot, of course, measure this image on the retina directly; but, as its size is proportional to the visual angle—the angle which the object subtends at the eye—it is sufficient to determine the smallest visual angle under which the form of an object can be distinguished. It has been found, experimentally, that the average size of this angle is 5 minutes (Fig. 8).[1]

In order practically to ascertain the degree of acuteness of vision

[1] The minimum separabile or smallest angle under which two points can be distinguished is 1 minute, and corresponds approximately with the distance between three retinal cones, the central one not being stimulated.

we place our patient with his back to the light, while facing him at a distance of 6 metres, and in good light, are placed Snellen's Test-Types for distance. These types are so designed that, at the distance at which they should be seen, they each subtend an angle of 5′ at the eye. The largest type should be seen at 60 metres (Fig. 8) by the normal eye, and the types range from this down to a size visible not farther off than 6 metres. If V = Acuteness of Vision, d = the distance from the eye to be tested to the test-types, and D = the distance at which the type should be distinguishable, then $V = \frac{d}{D}$. For example: if d = 6 metres (a distance which most rooms can command), and if the eye see type D = 6, then $V = \frac{6}{6} = 1$, or normal V.; but if at 6 metres the eye see only D = 60, which should be seen at 60 metres, then $V = \frac{6}{60}$, in short V = 6 divided by the number of the type read. A distance of 6 metres is selected because the test-types are also used to test the refraction, and at that distance the rays proceeding from the type may be considered to be parallel.

In practice these fractions must not be taken in a strict mathematical sense. For example, $\frac{6}{12}$ does not mean that a patient with that degree of V. has his visual capacities lessened by one-half.

A series of types resembling the letter E, in various positions, is also used for testing illiterates. Or, better still, an incomplete circle like the letter C in different positions can be used, the patient being required to tell where the break in the circle is placed. This has lately been recommended as a universal test. The types of Jaeger for near vision are sometimes used for testing the acuteness of V.

Should the patient's sight be so defective that he is unable to read any of the letters, it may be tested by finding at what distance he can count the surgeon's fingers; and if he cannot even do that, then his power of perception of light (his P.L.) should be tested. This is done by means of a lamp in a dark room, the eye being alternately covered and uncovered, and the patient being required to say when it is "light" and when "dark." If the flame be gradually lowered the smallest degree of illumination perceptible will be ascertained.

The eyes must be examined separately, that one not under examination being excluded from vision by being shaded with the patient's own hand or other suitable screen; but it must not be

at all pressed on, as any pressure would dim its vision when its turn for examination may come. When a trial frame is put on, the patient should not be allowed to turn his face to one side, or else he may see with the eye which is covered.

With the advance of age the acuteness of vision undergoes a slight but steady reduction, owing to certain senile changes in the eye.

THE FIELD OF VISION.

By the Field of Vision (F.V.) is meant the space within which, when one eye is closed, objects can be seen by its fellow, the gaze of the latter being fixed the while on some one object or point. Thus, if standing on a hill, we fix the gaze of one eye on some object on the plain below, the field of vision includes not only that object, but many others also for miles around it.

The fixation object is seen by central or direct vision, its image being formed on the macula lutea; the other objects in the field of vision correspond with as many different points in the more peripheral parts of the retina, and are seen by eccentric, or indirect, vision. Eccentric vision is of great importance for guiding oneself and for the avoidance of obstacles. It may be realised by the experiment of looking through a long small-bore cylinder (*e.g.*, a roll of music) with one eye, thus cutting off its eccentric field, while the other eye is closed.

The Examination of the Field of Vision (Perimetry) is carried out for clinical purposes by means of an instrument called the perimeter. This is a semicircular arc of metal capable of revolving upon its middle point, so as to describe a hemisphere in space. The arc is divided into degrees from 0° at its middle point, to 90° at either extremity. At the centre of the hemisphere is situated the eye under examination, while the fixation point is placed exactly opposite, in the middle of the semicircle, at 0°. The test object, a small bit of white paper not more than 5 mm. square, is slowly moved along the inner surface of the arc from the periphery towards the centre, until it comes into view, and the observation is repeated in various meridians. The horizontal, vertical, and two intermediate meridians, at the least, should be examined by placing the arc of the perimeter in the corresponding planes. The patient's

eye must be carefully watched, as any movement of it away from the fixation point would vitiate the results.

The boundary of the field is noted on a diagram or chart (Fig. 9), which represents the projection of a sphere on a plane surface. The radii represent different meridians, and are indicated by a dial with pointer on the back of the perimeter, while the concentric circles correspond with the degrees marked on the arc. A pencil

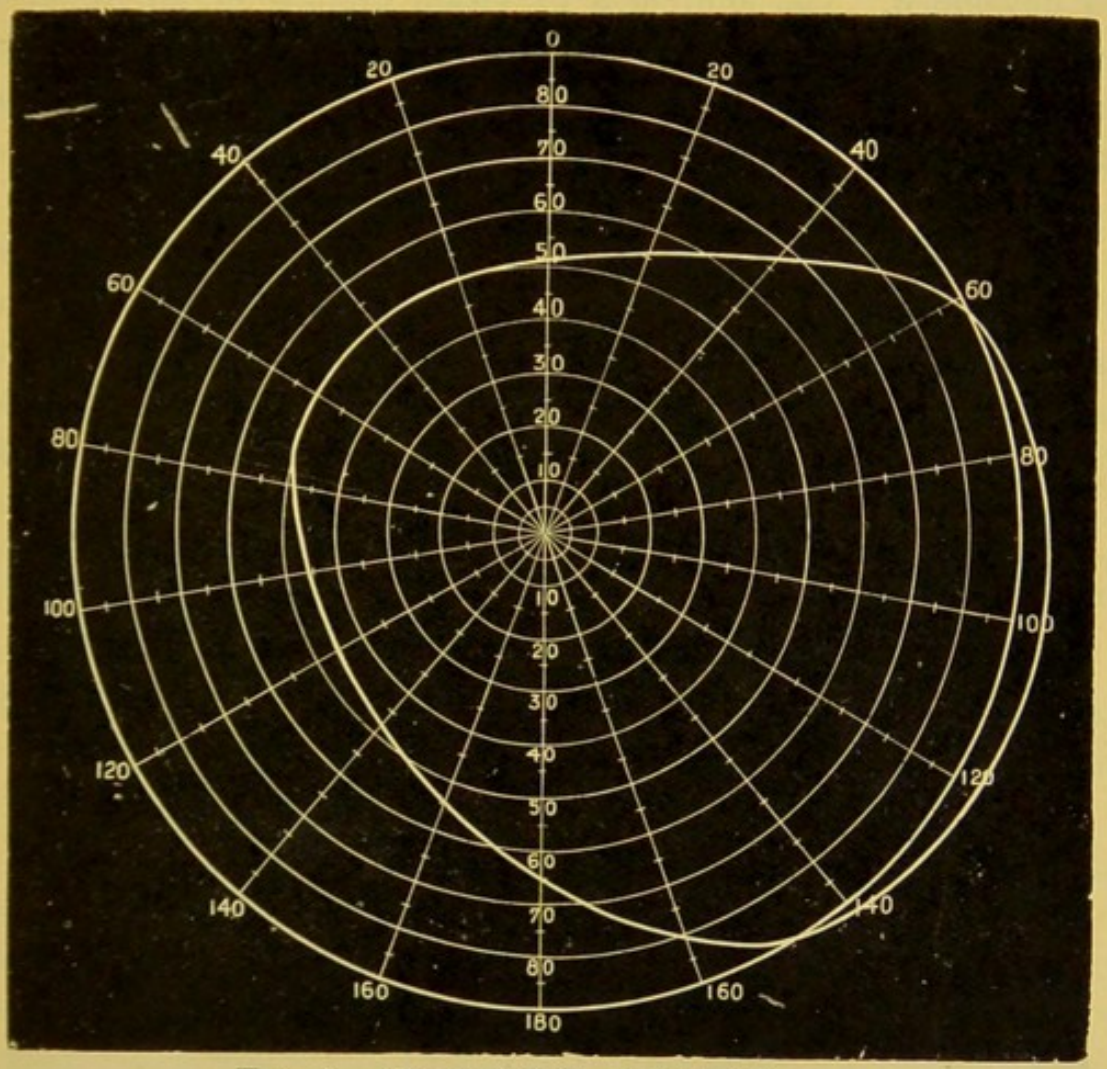


FIG. 9.—Chart of F.V. of Right Eye.

mark is placed on the chart at the spot corresponding with that on the perimeter at which the test object comes into view; and, when the different meridians have been examined, these marks are united by a continuous line, which then represents the outer boundary of the F.V. In some cases (hemianopsia, etc.) it is better to take the field by the circular method, *i.e.*, by placing the test object successively on the different degrees of the arc, and each time rotating the arc through a complete circle, the points or meridians at which the object appears and disappears from view being noted.

The normal F.V. is not circular, but extends outwards about 95°, upwards about 53°, inwards about 47°, and downwards about 65°, as represented by the strong curve in Fig. 9. The limitation upwards and inwards is partly due to the projection of the supra-orbital margin and the bridge of the nose, but also to the fact that the outer and lower parts of the retina are less practised in seeing than are the upper and inner parts, and their functions consequently less developed. The acuteness of vision diminishes progressively towards the periphery of the field, two points of a certain size close together being distinguishable from each other only a short distance from the fixation point, while the farther towards the periphery the larger must be the test objects.

Fig. 10 serves to illustrate the projection of the field of vision of the right eye on the semicircle of the perimeter to its extreme temporal (95°) and its extreme nasal (47°) boundaries, as well as the portion of the retina (*a* to *b*) which corresponds with this extent of field; and it shows that the sensitive portion of the retina, or

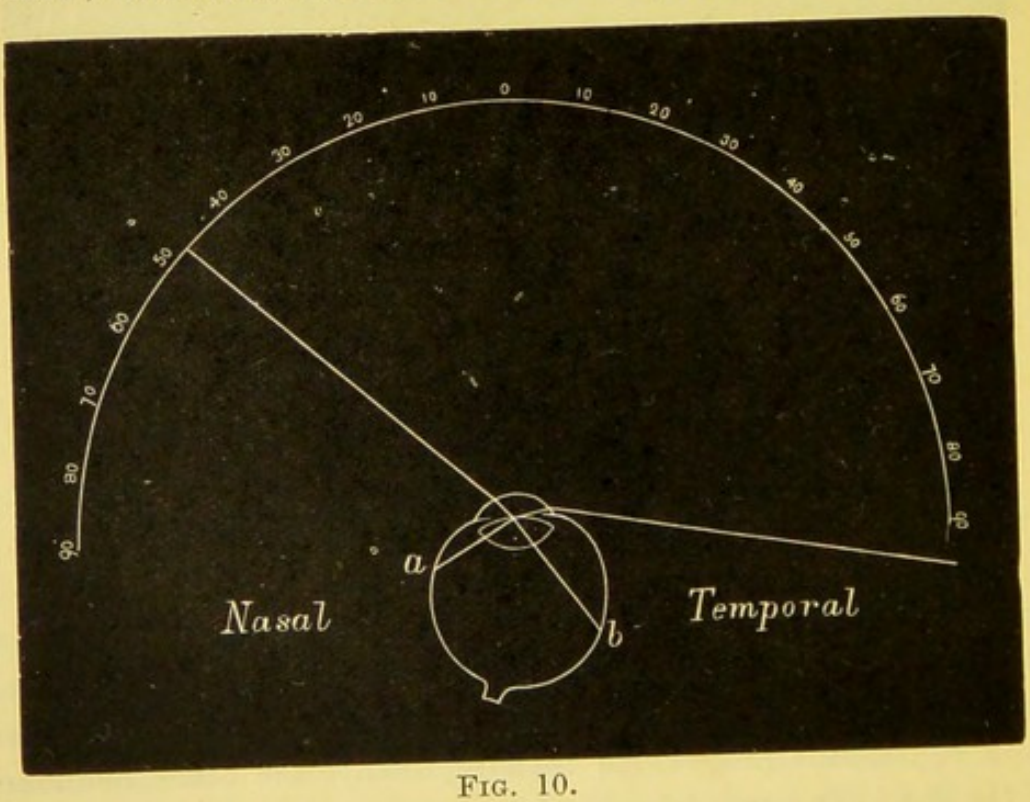


FIG. 10.

rather perhaps the portion of the retina which is most used, extends farther forward on the nasal than on the temporal side. The diagram also explains the remarkable fact that the field extends in the temporal direction more than 90°.

The Blind Spot of Mariotte is a small blind island or scotoma in the F.V., situated about 15° to the outer side of the point of fixation and just below the horizontal meridian. It is shown as a dark spot in Fig. 12. It is due to the optic papilla (optic disc), for at that place the outer layers of the retina are wanting, and hence it possesses no power of perception. The blind spot may become enlarged in cases of opaque nerve-fibres, myopia with posterior staphyloma, and in optic neuritis. There are also, occasionally, minute blind spots in the field, due to large retinal vessels, which interfere with the formation of the image upon the layer of rods and cones.

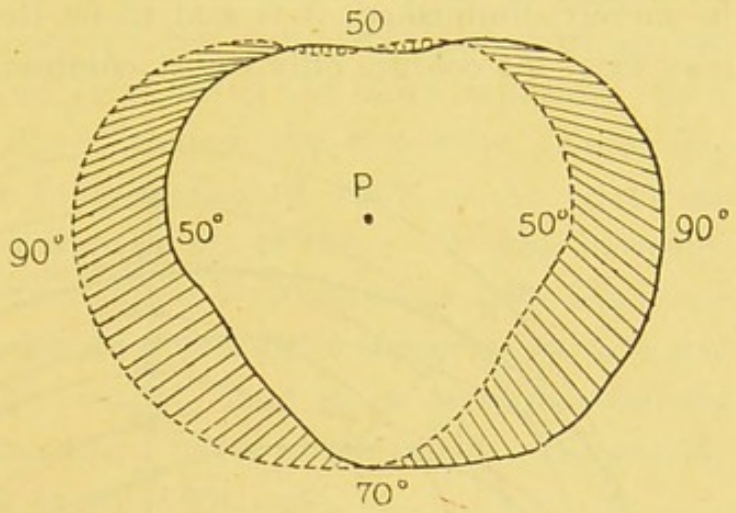


FIG. 11.—Binocular Field of Vision. The white area is common to both eyes, *P* being the fixation point. The shaded portion on the right belongs to the right eye alone, while that on the left belongs to the left eye alone.

The field of vision may also be tested by means of a blackboard; and, although peripheral contractions cannot be discovered in this way it is very useful for detecting central defects (see Toxic Amblyopia).

The presence of a gross alteration in the field may be roughly ascertained if the observer face the patient, who has his back to the light, and use his own hand as a test object. The eye of the observer which is opposite the patient's eye serves as a control, as its field can be tested at the same time as that of the patient's eye.

In the Binocular Field of Vision, since the two visual lines meet at the fixation point, the central portion is common to both eyes (Fig. 11).

Pathological Defects in the Field of Vision.—These may consist in Contractions or in Insular Defects. Contraction of the field takes place either concentrically, that is to say to an equal extent all around the periphery, or irregularly, for instance on the nasal or temporal sides alone. Occasionally sector-like defects occur. Loss of one-half the field is known as Hemianopsia, but it may be limited to a quadrant. A defective island in the field of vision is

called a Scotoma and it may be central—that is, involving the fixation point—para-central, eccentric, or peripheral. Scotomata occasionally assume the shape of a ring, as in Retinitis Pigmentosa. A defect in the field is Positive if it be visible to the patient as a dark area, Negative if it be invisible. If the blindness be complete, the defect is said to be Absolute; but if the acuteness of vision be merely diminished, it is said to be Relative. A relative defect may exist for colours only, most commonly for red and green. In

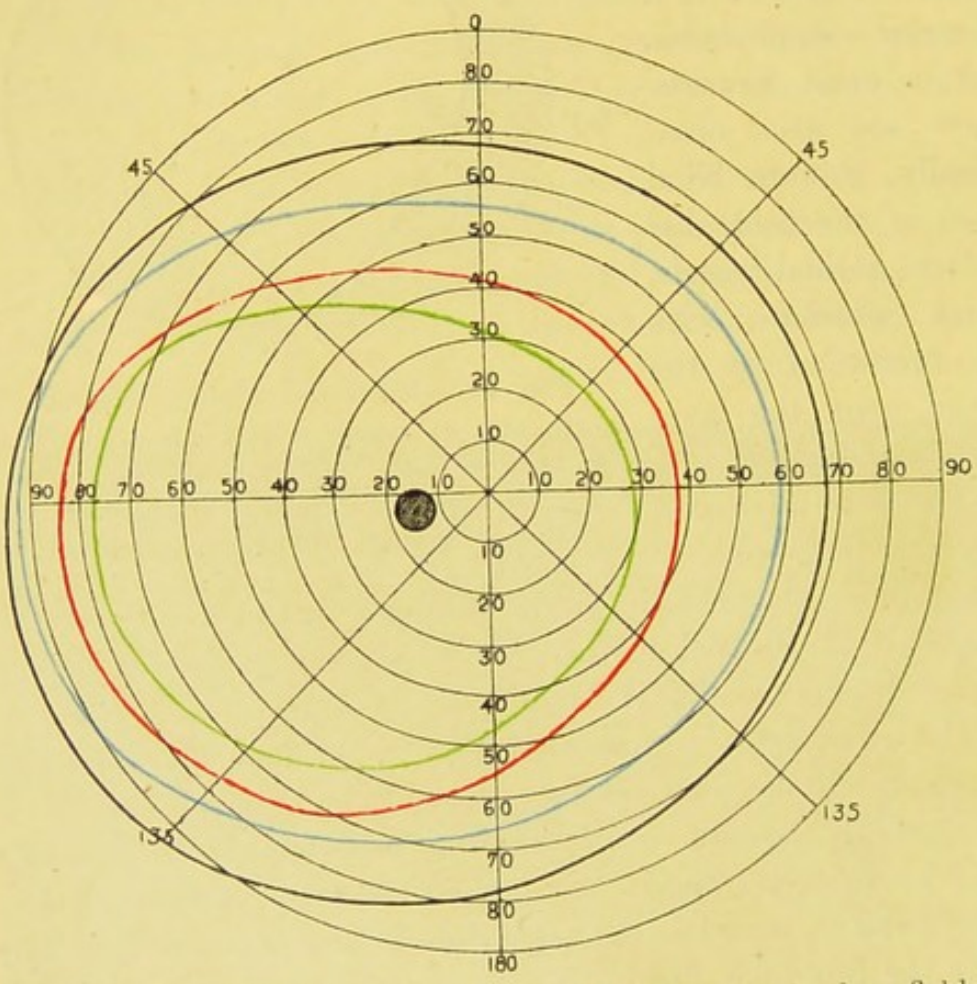


FIG. 12.—Chart of F.V. of Left Eye, showing limits of colour fields.

all eyes the blind spot is a negative and absolute scotoma in the field of vision. When the vision is too defective to permit of the field of vision being tested in the ordinary way, the patient may be asked to indicate the position of a light placed in different parts of the field; this is called testing the Projection of Light.

The Perception of Colours in the Periphery of the Field can be examined with the perimeter, by means of bits of coloured paper not more than 5 mm. square. It has been in this way ascertained

that the boundaries of the power of eccentric perception for the different colours do not seem to correspond with the boundary for white light, nor do the boundaries of the different colours seem to coincide. Examining from the periphery towards the centre by ordinary daylight, blue is the colour which can be distinguished as such most eccentrically, its field extending nearly as far as the general F.V.; then come yellow, orange, red, and, with the most limited field, green. Blue, red, and green being the most important, their fields are noted in Fig. 12. Although the respective colours are distinguishable within the limits indicated, they are by no means so brilliant in hue as when seen by direct vision. It has, however, been demonstrated that every colour is recognisable up to the outer limit of the F.V., if the coloured object be of sufficient surface and be sufficiently illuminated; so that there is, in fact, no absolute colour-blindness in the peripheral parts of the retina, but merely a diminished sensitiveness to coloured light.

The order of the colour-fields may be altered or reversed in certain diseased states, for instance in Hysteria, and possibly also in cases of Cerebral Tumour.

The Perception of Form in the Periphery of the Field is very defective, and its examination is not of much practical importance; but this portion of the field is very sensitive to the movement of objects.

CHAPTER II.

THE OPHTHALMOSCOPE.

BEFORE proceeding to describe the ophthalmoscope, a brief statement of the properties of plane and concave reflecting surfaces (or mirrors) will be of use.

Laws of Reflection.—When a ray of light, O S (Fig. 13), meets a polished surface or mirror, M M, at a given point, S, the angle of incidence, *i*, formed with the perpendicular to the surface, P, is equal to the angle of reflection, *r*, and the incident and reflected rays O S, S R, lie with the perpendicular in one plane.

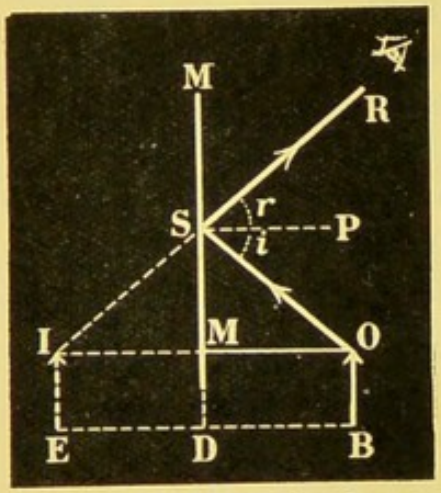


FIG. 13.—Reflection by a plane mirror.

Images formed by a Plane Mirror.—To an observer placed at R the point O would seem to be at I, where the prolongation of R S intersects the line I O perpendicular to the mirror, and O M is equal to M I. Similarly the image of the point B is found on the perpendicular B E, E D being equal to D B. The image I E therefore, formed by a plane mirror, is virtual, erect, and situated behind the mirror at the same distance from it as the object O B.

Images formed by a Concave Mirror.—In Fig. 14, *c* is the centre of curvature of the mirror M M. The rays *a*, *b*, parallel to the axis S *f*, meet the surface of the mirror at M and M′ and are reflected to F the principal focus. The angle of incidence *a* M *c* being equal to the angle of reflection F M *c*, the radius *c* M being perpendicular to the surface of the mirror at M, F lies midway between S and *c*; that is to say, the focal length of a concave mirror is equal to half the radius. Rays from a point *f*, beyond *c*, are made to converge at *f′*, between F and *c*, and the farther away *f* is the nearer will *f′* be to F; *f* and *f′* are conjugate foci. The conjugate focus of a point nearer the mirror than F would be virtual, because the rays then diverge after reflection.

In ophthalmoscopic work the source of light is usually farther away than the centre of curvature of the mirror, and Fig. 15 shows how, in this case, a real inverted and diminished image of the light is formed. The

image of the point O is found at I, the point of intersection of the ray O I, which passes through the centre of curvature C, without deviation, and the ray O S parallel to the axis, which passes through the principal focus F, after reflection; the image of the point B is found in a similar manner. As O B approaches C, I M also approaches it, and increases in size until at C object and image are of equal size and coincide. When the object lies between F and the mirror, a virtual, erect, magnified image is seen. A concave mirror therefore resembles a convex lens in its action (chap. xiv., § 5).

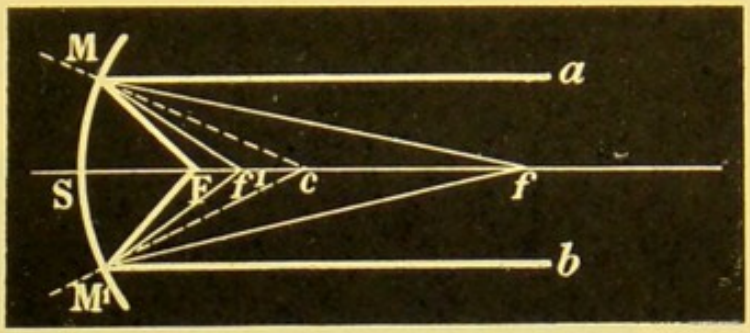


FIG. 14.—Reflection by a concave mirror.

To distinguish a Plane from a Concave Mirror the student should stand with his back to the source of light and, with the ophthalmoscope held in front of him and a little to one side, should throw the light reflected from it into his own eye; he will then see an erect image, if the mirror be plane, or an inverted image, if the mirror be concave. A simpler method consists in facing the source of light, and throwing the reflected light on a screen, say the palm of the hand, and moving the mirror towards or away from it; then, if the mirror be plane, a round image with a dark central spot will be formed at all distances; but, if the mirror be concave, at a certain distance an inverted image of the source of light will be formed.

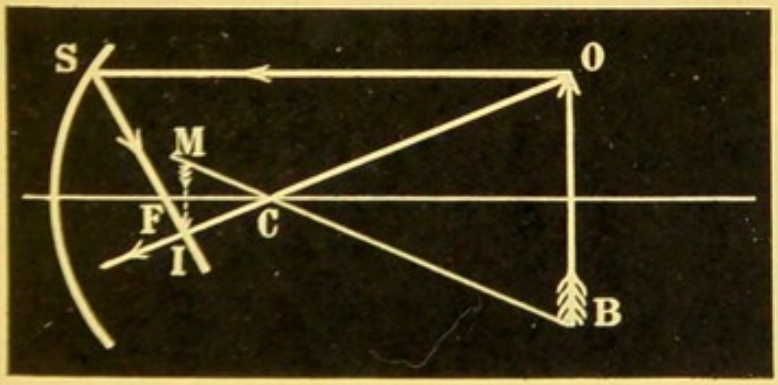


FIG. 15.—Image formed by a concave mirror when the object is beyond the centre of curvature.

The Ophthalmoscope.—Although the dioptric media of an eye may be perfectly clear and normal, yet no detail of its fundus can be discerned by the unaided eye of an observer who looks through the pupil, the latter being for him merely a dark opening. The reason of this is, that

light can only enter the eye through the pupil and the refractive media. In albinos the pupil appears red, because the absence of the uveal pigment allows the light to penetrate the sclerotic and illumine all the interior of the eye in a diffuse manner. To explain :—Suppose the inside of a small box (*vide* Fig. 16) to be

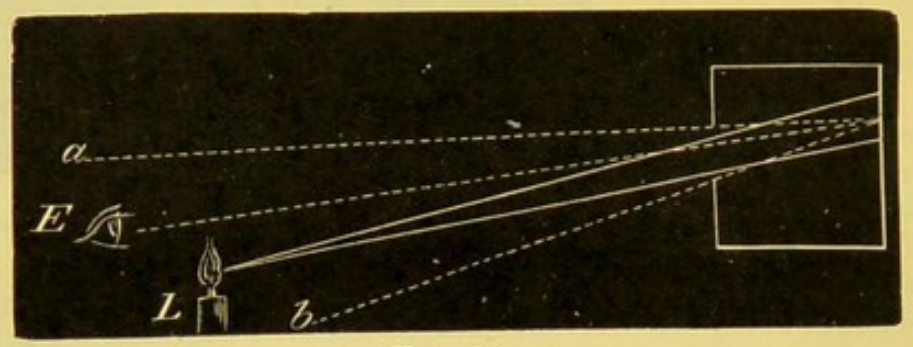


FIG. 16.

blackened, and on its floor some printed letters fastened, and a hole cut in the lid, which is then replaced—it will be found that, by aid of a lighted candle and with a little experimentation, the letters may be read through the aperture. The rays passing from the light (*L*) into the box through the aperture illuminate the opposite surface, and from this surface the rays *a*, *b*, and others pass out again through the opening, and some of them fall into the observer's eye at *E*.

But if, in order to make this box represent an eye, we place a convex lens, *n*, of the proper strength, immediately within the

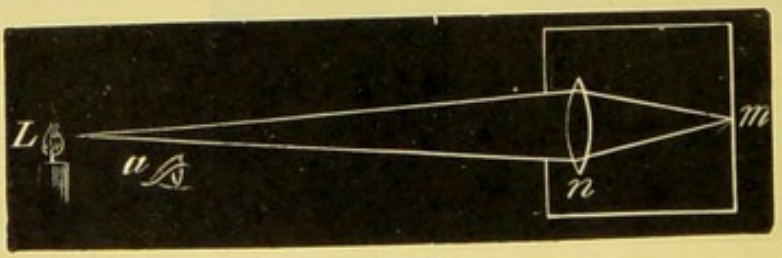


FIG. 17.

aperture, all the rays passing into the box (Fig. 17) from *L* are brought to a focus on its opposite side at *m* by the convex lens *n*, and, according to the law of conjugate foci (§ 17, chap. xiv.), all the rays passing out from the box meet again at the source of light (*L*), and hence none of them can be received by the eye (*a*) of the observer ; nor can this eye be placed in any position where it could receive

any of these rays, for if it be placed anywhere between the aperture and *L*, it would cut off the light passing from *L* into the box.

If the back of the box were further forward, the light would not be focussed on it, and the emergent rays would form parallel or conical divergent beams passing back to and surrounding *L*. In the latter case, if an observer held his eye close beside the light, some of the divergent rays would enter it, and the letters would be visible. This explains the red pupil often seen in hypermetropia and aphakia.

Helmholtz's Ophthalmoscope.—If the eye of the observer could itself be made the source of light, the difficulty would be solved; and, practically, this is what Helmholtz accomplished with his ophthalmoscope in the year 1851. The instrument he invented

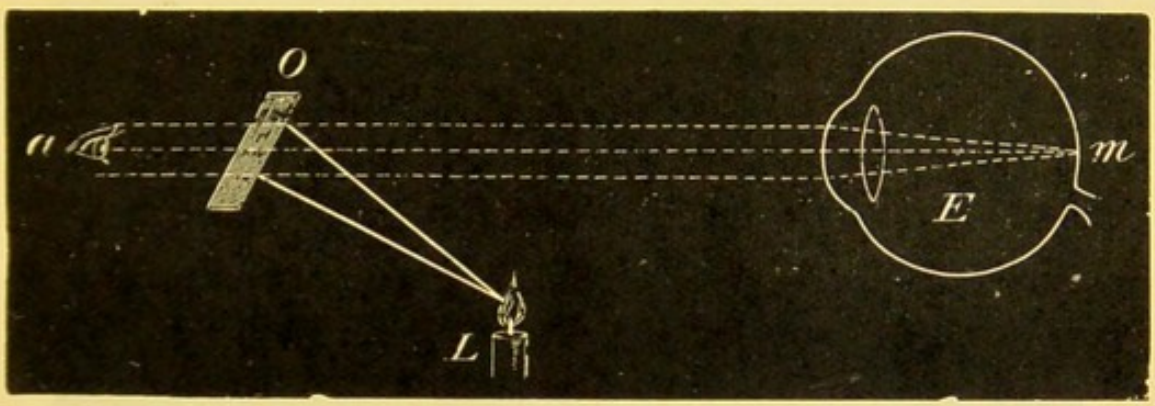


FIG. 18.

was composed of a number of small plates of glass (*O*, Fig. 18), from which light from *L* was reflected into the eye (*E*), and thus the fundus of the latter was illuminated. From *m* rays pass back again by the same path to the ophthalmoscope, some being reflected back to *L*; but some, passing through the ophthalmoscope, and falling into the observer's eye placed close behind the instrument at *a*, form in it an image of *m*.

Modern Ophthalmoscope.—For the original ophthalmoscope of Helmholtz a concave mirror of 20 cm. focal length with a central opening has been substituted. This mirror (*O*, Fig. 19) throws convergent rays into the eye (*E*); and these, being made more convergent by the refracting media, cross in the vitreous humour, and light up part (*a b*) of the fundus. From every point of this illuminated surface rays are reflected back again out of the eye. If the latter be emmetropic, the rays from any one point become parallel

on leaving it; and some of these parallel rays, passing through the aperture (*c*) of the ophthalmoscope, fall into the observer's eye, and, if it be emmetropic, are brought to a focus on its retina; the rays from *m* at *m'*, those from *x* at *x'*, and those from *y* at *y'*—and thus an image of the part *x m y* is formed on the observer's retina.

The foregoing method of examining with the ophthalmoscope is called the **Direct Method,** or the **Examination of the Upright Image.** The light should be placed on the same side as the eye to be examined, it should be on a level with the eye, and sufficiently behind the patient to leave the eye in the shade. The observer uses his left eye for the patient's left eye, and his right for the patient's right eye, and by a slight inclination of his head he can get very close to the patient's eye without coming into contact with his face. By this method the various parts of the fundus are seen in their natural

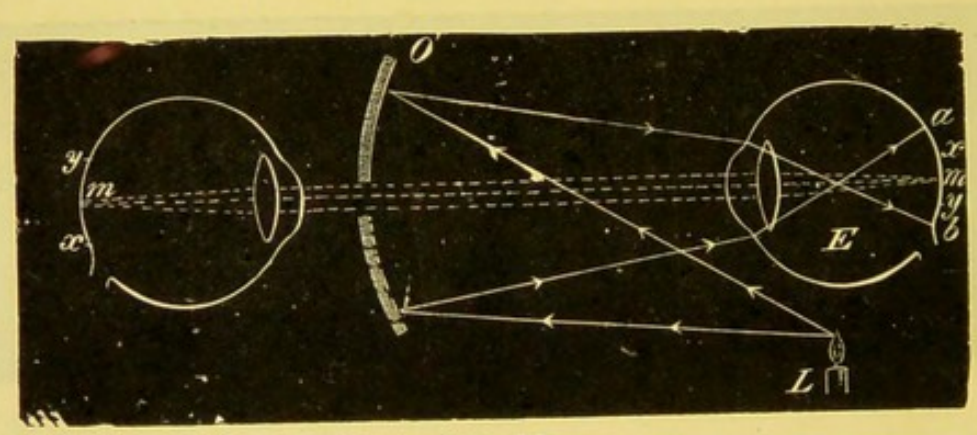


FIG. 19.

positions, but much enlarged. The magnification is about 15 diameters in Em., more in M. and less in H.; and it is consequently very valuable for examining minute details. The area visible at one moment is, however, small, not much larger than the optic disc.

It is necessary that the observer should approach his eye as close as he can to the eye under examination, in order to receive as much of the light coming out of it as possible, and also to obtain the largest possible field. The extent of the area visible at one moment depends also on the refraction, being greatest in H., and least in M.

Moreover, the accommodation both of the observer's and of the patient's eye must be at rest, as otherwise the rays coming from the latter cannot form an image on the retina of the former, at least if both be emmetropic. If the patient exert his accommoda-

tion, the rays will, on leaving his eye, become convergent instead of parallel, and, falling into the observer's eye, will be brought to a focus in front of his retina. The same will happen if the observer exert his accommodation, and still more so if both patient and observer accommodate. The patient's accommodation can be relaxed by making him gaze at the black wall behind the observer's head, or his accommodation may be paralysed with atropine. But atropine should never be used in adults unless absolutely necessary, owing to the inconvenience it causes the patient.

Voluntary relaxation of the accommodation on the part of the observer is often a matter of much difficulty to beginners. With parallel optic axes our accommodation is relaxed; therefore, when we want to relax our accommodation, we produce parallelism of

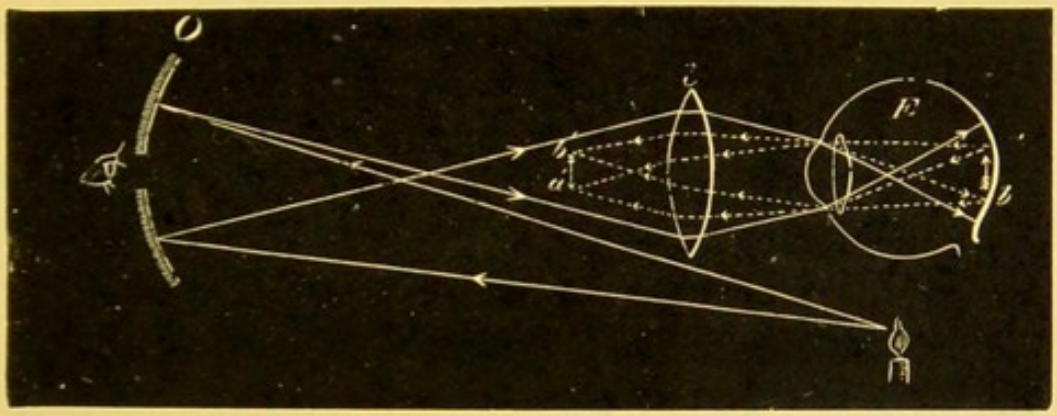


FIG. 20.

our optic axes. This sounds easy enough; yet, when the beginner approaches his eye close up to that of his patient, the knowledge that he is so close to the object he wishes to see renders the accomplishment of this parallelism and relaxation of accommodation very difficult to many. It can only be attained by practice, but it is assisted by the fact that the eye which is not in use gazes at the black wall behind the patient's head. A beginner will find a low concave lens behind the mirror of great assistance.

The **Indirect Method,** or the **Examination of the Inverted Image,** is employed in order to obtain a more general view of the fundus than the direct method admits of.

In addition to the ophthalmoscope, a convex glass—the object lens—(*l*, Fig. 20) of about 14 D is here used. The latter is held at about its focal length from the eye (*E*) under examination, while the observer throws the light from the mirror through it into the

eye. In passing through *l* the rays are made convergent, and this convergence is increased by the refracting media, so that the rays cross in the vitreous humour, and light up a portion of the fundus oculi. From any points (*a* and *b*) of this illuminated place pencils of rays pass out again from the eye, and, becoming parallel, pass through *l* and are united by it at *a' b'*; and thus a real inverted image, magnified about 4 or 5 diameters, is formed of the part *a b*, which image may be seen by the observer whose eye is placed behind *O*. In Em. the image will be formed at the principal focus of the object lens because the emerging rays are parallel, in H. it will be found farther away from the lens, and in M. nearer to the lens than in Em. The stronger the object lens (*l*) the more convergent will the rays from the examined eye be made; and consequently the closer must *a' b'* be to each other, and the smaller and brighter must be the image formed. The weaker the object lens the larger and less brilliant is the image, and the less annoying to the observer are the reflexes from its surfaces.

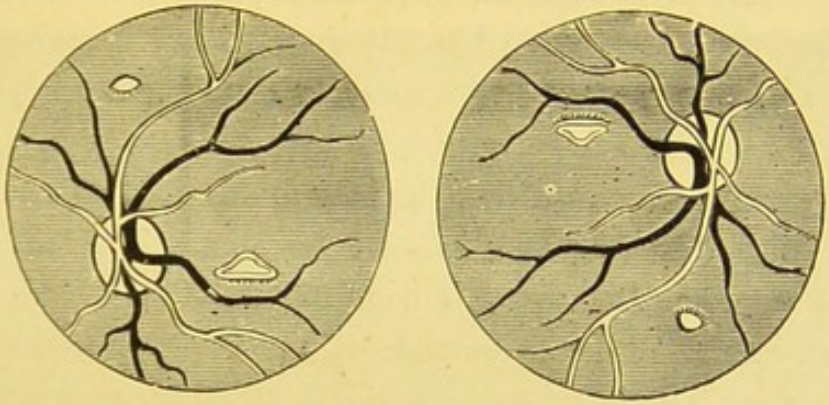
If the lens be held at its focal length from the cornea, and then withdrawn until its principal focus is farther from the eye than the anterior focus of the latter, the image will remain unaltered in size in Em., will increase in size in M., and diminish in H.

In examining by the indirect method, the observer first places the upper edge of the ophthalmoscope to his right supra-orbital margin, and, taking care that he is looking through the central opening of the mirror, he reflects the light of the lamp into the patient's eye at a distance of about 50 cm. A red glare from the fundus, known as the "red reflex," will then be seen in the pupil. Keeping the pupil illuminated, the convex lens of 14 D, held between the forefinger and thumb of the observer's left hand, is brought up in front of the patient's eye, and kept there in the perpendicular position, the observer steadying this hand with the tip of the little finger on the patient's forehead. The object lens is now removed just far enough from the patient's eye to cause the margin of the pupil to disappear out of the observer's field of vision. The observer then ceases to look into the eye, and fixes his gaze on the object lens when the inverted image of the fundus should at once become visible, if the observer accommodates for the proper distance —and will seem to be situated in the object lens, although it really is in the air somewhat this side of the lens. Beginners often fail to

see the fundus clearly, because they do not accommodate sufficiently, and hence a low + lens placed behind the sight hole of the mirror helps to bring the image into focus.

If, as is usually the case, the ophthalmoscope be held in the right hand, it is better to place the light on the patient's left, whichever eye be examined, as the observer's left arm will not then interfere with the light when the lens is held up before the patient's eye.

The diagram (Fig. 21) serves to illustrate the effect of inversion of the image. The left eye is seen in the upright image at *a*, while the same eye is seen in the inverted image at *b*. In the diagram the two images are of the same size for the sake of convenience; although, of course, in reality the upright image is much larger



a *b*

FIG. 21.

than the inverted image. Moreover, it should not be supposed that nearly the whole fundus oculi, as here represented, can be taken in at one view with the ophthalmoscope. The portion visible with the ophthalmoscope at one moment, even in the inverted image, is small; so that it is necessary to examine the different regions in detail, in order to become acquainted with the condition of the whole of the fundus.

The reflex from the surface of the cornea gives a good deal of annoyance to every beginner. It cannot be done away with, but is considerably diminished by holding the object lens farther from the cornea than the focal length of the lens; and, as it moves in the opposite direction to a motion of the object lens, it is possible to see past it. The reflections from the convex object-lens are also extremely annoying, but may be removed to a great extent from

the line of sight by a slight rotation of the lens on its axis. If a very high object-lens (say + 20 D) be used, the reflections from it are more disturbing than from a lower number (say + 14 D).

To examine the *Optic Nerve* (or Optic Disc) the observer sits in front of the patient, and directs him to turn his eye somewhat to the nasal side, and slightly upwards ; because the optic nerves, diverging from the chiasma, enter the back of the eye a little to the inner side of the posterior pole, and the papilla, or disc, comes to be situated about 15° to the inner side of the posterior pole of the eye, and about 3° above it. For instance, if the left eye be examined the patient is to direct his gaze, (without turning his head,) to his right and a little upwards, say towards the observer's left ear. It is well always to seek out the optic papilla in the first instance, not only because it is such an important part of the fundus oculi, but also because, examining from it towards the periphery, we are the better able to determine the locality of any pathological alteration.

Should the patient not direct his gaze in such a way as to enable the observer to see the optic disc or other desired region, it may be brought into view either by a motion of the observer's head in the opposite direction, or by a motion of the object-lens in the same direction, or by a combination of these measures. When the disc is opposite the observer's eye, the pupillary reflex is seen to become paler or even white, and the corneal image of the light will occupy the junction of the middle and outer thirds of the horizontal diameter of the cornea.

The *Macula Lutea* should then be examined. It may be seen by directing the patient to look straight at the hole of the ophthalmoscopic mirror, for it will then correspond with the macula lutea of the observer's eye. It is more readily seen in the inverted than in the upright image ; but its examination is often very difficult, owing to contraction of the pupil produced by the strong light falling on so sensitive a portion of the retina, and by the reflections from the surfaces of the cornea and crystalline lens, which fill the area of this contracted pupil. It is therefore a better plan to direct the patient to look somewhat to the side of the eye under examination —*e.g.*, to the right side of the observer's forehead, if the left eye be under examination, and then by motions of the object-lens to bring the macula lutea into view.

After this the *Periphery of the Fundus* in every direction is to be examined by making the patient look upwards, downwards, to the right, to the left, etc.

The indirect method possesses the following advantages:— It gives a large field in which it is possible rapidly to locate the position of a lesion, it can be used no matter what the error of refraction may be, and it is not necessary to approach close to the patient's face.

Detection of Opacities in the Refractive Media by the Ophthalmoscope.—Opacities in the refractive media can be best detected with the ophthalmoscope by the direct method. All opacities look black in the red pupil, because they intercept the light returning from the illuminated fundus.

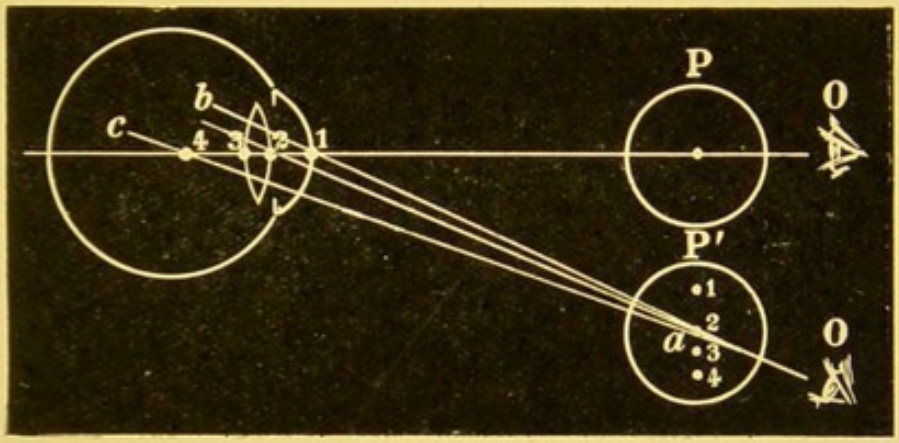


FIG. 22.—Apparent position in the pupil of opacities of the media when the observer alters his point of view.

Two methods of examination are employed. In the first the eye is examined at a distance of about 30 cm.; and the patient is directed to move the eye in different directions, in order to bring any peripheral opacities into view and also to localise them. Movable opacities must lie in the fluid media. They are almost always in the vitreous humour, and can be seen to float to and fro when the eye comes to rest. Fixed opacities move with the eye, and lie in the cornea or lens, or sometimes in the vitreous. Fig. 22 illustrates the apparent displacement of an opacity in the pupil according to its position in the media. When the eye of the observer O is opposite the pupil, the opacities 1 to 4 lying on the axis appear as one point in the centre of the patient's pupil (shown by P). When the eye is rotated upwards, or the observer moves downwards, 2,

which is on the anterior surface of the lens, in the plane of the pupil, will still appear to be in the same position, while 1, seen in the direction *a b*, will seem to be displaced upwards, and 3 and 4 downwards, the relative positions being as indicated in the circle at P′.

The second and more delicate method of detecting opacities consists in examining the eye close up with a convex lens of 20 D, behind the sight hole of the mirror. Very fine opacities can be seen in this way, such as minute punctate deposits on the cornea. Focussing for different levels can be accomplished by approaching closer for deeper opacities, or by using gradually weaker lenses. Too strong an illumination interferes with the perception of faint opacities, hence the plane mirror serves better for this purpose than the concave.

Prominent portions of the interior of the eye, such as a detached retina or an intra-ocular tumour, can also be detected, and examined in detail, by the direct method at a distance, or close up. The estimation of the refraction by the ophthalmoscope will be dealt with in chap. xv.

THE NORMAL FUNDUS OCULI AS SEEN WITH THE OPHTHALMOSCOPE.

The Optic Disc or Optic Papilla.—This is the first object to be sought for by the observer. It presents the appearance of a pale pink disc, somewhat oval in shape, its long axis being vertical. Occasionally the long axis lies horizontally, and sometimes the papilla is circular. The papilla is generally surrounded by a white ring, more or less complete, called the sclerotic ring, and often, outside this again, by a more or less complete black line, the chorioidal ring (Plate I. Fig. 1). The sclerotic ring is due to the chorioidal margin not coming quite up to the margin of the papilla, the foramen in the chorioid for the passage of the optic nerve fibres being somewhat larger than that in the sclerotic, and consequently a narrow edging of the white sclerotic is exposed. The chorioidal ring is the result of a hyper-development of pigment at the margin of the chorioidal foramen.

The complexion of the optic disc results from the pink hue derived from its fine capillary vessels, combined with the whiteness of the lamina cribrosa, and the bluish shade of the nerve fibres.

PLATE I

(To face page 34)

FIG. 1.—The optic disc shows a small central physiological cup, a pale scleral ring, and an outer pigmented or choroidal ring. Close to the latter is a cilio-retinal vessel. The macula lutea, of a deeper red than the rest of the fundus, is surrounded by a delicate oval light-reflex. The bright spot in the centre of the macula is the fovea centralis.

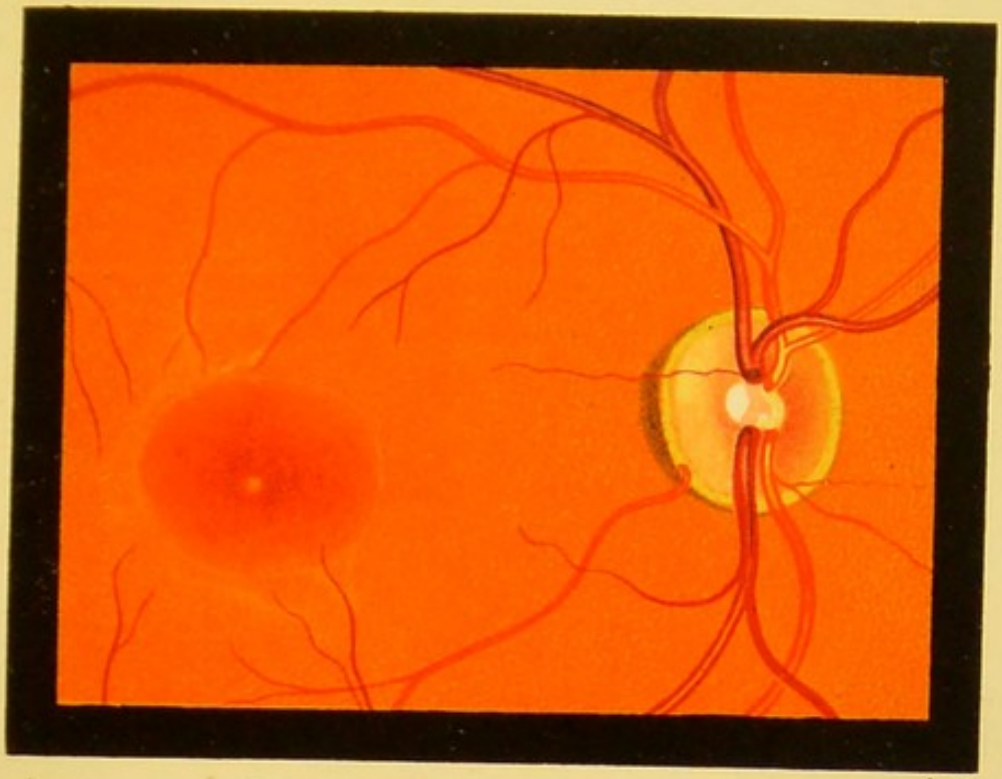
FIG. 2.—The patch of opaque nerve-fibres is of a brilliant white; it is prolonged in the direction of some of the vessels, and presents a characteristic finely striated border. Note the dark colour of the disc, which is chiefly a result of contrast. The vision was the same as in the unaffected eye.

PLATE I

(*To face page* 34)

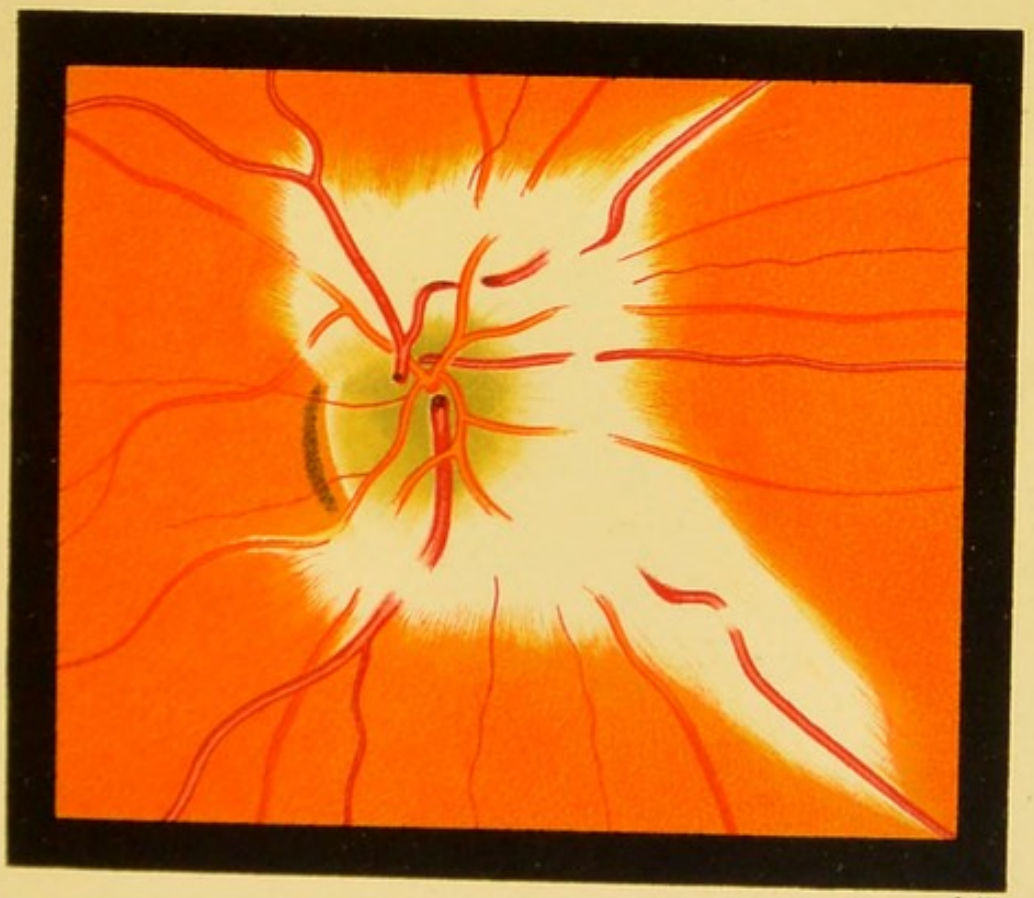
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L. W.

FIG. 1. Normal Disc and Macula.



L. W.

FIG. 2. Opaque Nerve Fibres.

It is frequently not equal all over, but is paler on the outer side, where the margin is more defined, and where the nerve fibres are often fewer than on the inner side. The apparent colour of the papilla depends also upon the complexion of the rest of the fundus. If the latter be highly pigmented, the papilla appears pale in contrast; while, if there be but little pigment in the chorioid, the papilla may appear very pink. The complexion of every normal papilla is not identical, and care must be taken not to make the diagnosis "Hyperæmia of the papilla" where merely a high physiological complexion is present. The upper and lower margins of the papilla are often, especially in young people, a little indistinct, and show a delicate striation by the direct method of examination. This may be greatly exaggerated in hypermetropes, and has in them been sometimes erroneously taken for optic neuritis.

A physiological excavation of the optic papilla is often met with as a white depressed area (Plate I. Fig. 1) either on the temporal side or in the centre of the papilla, and can be recognised by the parallax[1] which may be produced, and by its colour. When the excavation is very deep, one may sometimes observe the lamina cribrosa in the form of grey spots (the nerve fibres) surrounded by white lines (the fibrous tissue of the lamina).

A physiological excavation differs from a pathological excavation, in that it does not reach the margin of the papilla all round. It is caused by the crowding over of the nerve fibres to the inner side of the papilla. Yet sometimes, a healthy optic papilla will be met with, in which the excavation apparently reaches the margin all round. Doubtless, in such cases, the thickness of the translucent nerve-fibre layer alone is interposed between the sclerotic margin and the margin of the cup all round.

The Normal Retina is so translucent that it cannot be seen, the red reflex being due to the chorioidal vessels. At most, a shimmering reflection or shot-silk appearance is obtained from it, particularly about the region of the yellow spot (Plate I. Fig. 1) and along the vessels, but also towards the equator of the eye, and especially in dark eyes, and in young people.

A peculiar, but physiological, appearance known as opaque nerve fibres (Plate I. Fig. 2) is occasionally seen. It is produced by some

[1] For explanation of the parallax see chap. viii.

of the nerve fibres forming the internal layer of the retina regaining the medullary sheath on the distal aspect of the lamina cribrosa, or near the margin of the papilla, which they had lost in the optic nerve just before entering the lamina cribrosa; the rule being that the nerve fibres lose their medullary sheath at the latter place definitely, and enter the retina as axis cylinders only, and hence are quite translucent. But in these cases the nerve fibres reflect the light strongly, giving the effect of an intensely white patch, commencing at the disc, extending more or less into the surrounding retina, and terminating in a brushlike extremity. In such cases the optic papilla appears to be darker than normal, partly from contrast. This appearance is constant in the rabbit's eye.

The Macula Lutea is generally seen as a bright oval ring with its long axis horizontal, this ring being probably a reflex from the surface of the retina (Plate I. Fig. 1). It is remarkable that this halo is not visible with the direct method of examination—a fact due probably to the illumination being much weaker than with the indirect method. The area inside the ring is of a deeper red than the rest of the fundus, and at its very centre there is an intensely bright point, the fovea centralis. The ring is not seen in old people. The macula lutea is situated to the temporal side of the optic disc, about two disc diameters away from it, and slightly above the lower margin of the disc.

The General Fundus Oculi surrounding the optic papilla and macula lutea varies a good deal in appearance, according to the amount of pigment contained in the chorioid and in the pigment-epithelium layer of the retina. 1. If there be an abundant supply of pigment in each of these positions, the chorioidal vessels are greatly hidden from view, and the effect is that of a very dark red fundus. 2. If there be but little pigment in the pigment-epithelium layer, the larger chorioidal vessels may be visible, and the fundus may appear to be divided up into dark islands surrounded by red lines. 3. If the individual be a blonde, there is little pigment either in the pigment-epithelium layer or in the chorioid, and the fundus is seen of a very bright red colour, the chorioidal vessels down to their fine ramifications being discernible. In albinos even the chorioidal capillaries may be seen. The chorioidal vessels are flat, they vary much in size, and anastomose freely (see Plate IV. Fig. 1, and Plate IX. Fig. 2).

The Retinal Vessels.—The arteries are recognised as thin bright red lines running a rather straight course, in the centre of each of which is a light-streak. As to the cause of this light-streak there is considerable divergence of opinion. Some attribute it to reflection from the coats of the vessel, or from the surface of the blood column; while others believe that the light is reflected from the fundus through the vessel, which then acts as a very strong cylindrical lens. This light-streak divides the vessel into two red lines. The

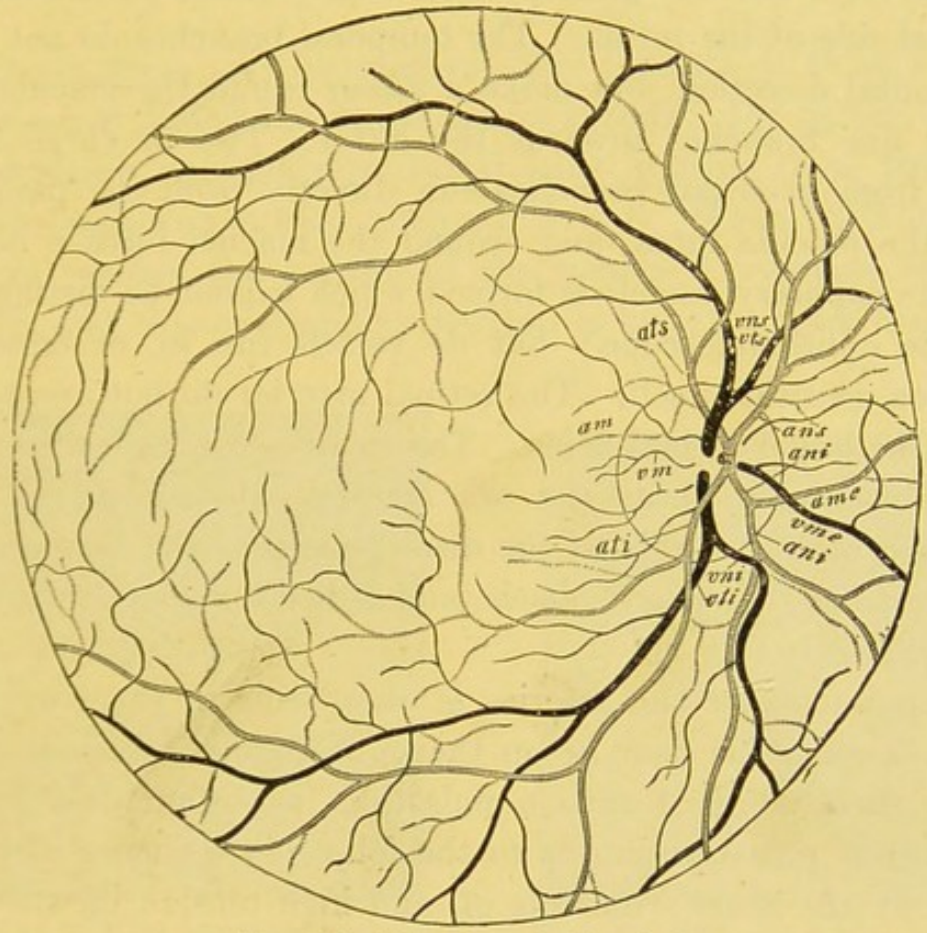


FIG. 23. (*Græfe and Sœmisch.*)

a.n.s., Art. nas. sup.; *a.n.i.*, Art. nas. inf.; *a.t.s.*, *a.t.i.*, A. temp. sup. and inf.; *v.n.s.*, *v.n.i.*, Ven. nas. sup. and inf.; *v.t.s.*, *v.t.i.*, Ven. temp. sup. and inf.; *a.m.e.*, *v.m.e.*, Art. and ven. median; *a.m.*, *v.m.*, Art. and ven. macularis.

veins are darker, wider, and more tortuous in their course than the arteries, and, their coats not being so tense, the light-streak on them is very much fainter.

On reaching the level of the nerve-fibre layer of the retina the central artery and vein divide into a principal upper and lower branch. This first branching often takes place earlier in the vein than in the artery, and the former may even branch before appearing on the papilla, as in Fig. 23. The second branching may take

place in the nerve itself; and when this occurs it will appear as though four arteries and four veins sprang from the optic papilla; but more usually this branching occurs on the papilla, as in Fig. 23. The vessels produced by this second branching pass respectively towards the median and temporal side of the retina, and are termed the Art. and Ven. nasalis and temporalis sup. and inf. (*vide* Fig. 23). The temporal branches run in a radial direction towards the anterior part of the retina. A small horizontal branch, the Art. and Ven. mediana, from the first principal branches is found passing towards the nasal side of the retina. The temporal branches do not run in a horizontal direction, but make a *détour* round the macula lutea, sending fine branches towards the latter. Two or three minute vessels from principal branches run directly from the papilla towards the macula lutea, and around the macula lutea a circle of very fine capillary vessels is formed which cannot be distinguished with the ophthalmoscope; but no vessels run to, or cross over, the fovea centralis itself. The retinal arteries do not anastomose, nor do the larger retinal veins. The small retinal veins have some slight anastomoses near the ora serrata. Occasionally a vessel emerges near the margin of the disc, usually at the temporal side. It arises from the ciliary vessels, and is hence called a cilio-retinal vessel (Plate I. Fig. 1).

No pulsation of the arteries is observable in the normal eye. In the larger veins near or on the optic papilla, or more usually just at their point of exit, a pulsation may sometimes be seen. This venous pulsation is due to the following sequence of events: systole of the heart; diastole of, and high tension in, the retinal arteries; consequent increased pressure in the vitreous humour; communication of this to the outside of the walls of the retinal veins, impeding the flow of blood through them, especially in their larger trunks, which offer little resistance, or at their exit from the eye, where the blood pressure is lowest; and in this way the veins are emptied—the blood gradually coming on from the capillaries overcomes the resistance, and the veins are for a moment refilled. The phenomenon can be most readily observed, if the normal tension of the globe be increased by gentle pressure with the finger during the ophthalmoscopic examination. By increasing the pressure the arteries also can be made to pulsate even in a normal eye, but such a degree of pressure is dangerous.

CHAPTER III.

DISEASES OF THE CONJUNCTIVA.

The Conjunctiva, or Conjunctival Sac, consists of three portions: the *palpebral*, lining the inside of the eyelids; the *bulbar*, covering the sclerotic; and the retro-tarsal folds, uniting these two, which form the *sulcus* or *fornix*, upper and lower. When the bulbar conjunctiva reaches the margin of the cornea it overlaps the latter slightly, and this overlapping portion is known as the *limbus* con-

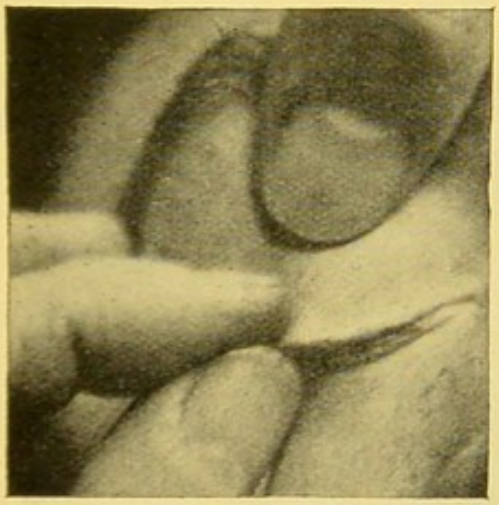


Fig. 24.—First steps in eversion of upper lid.

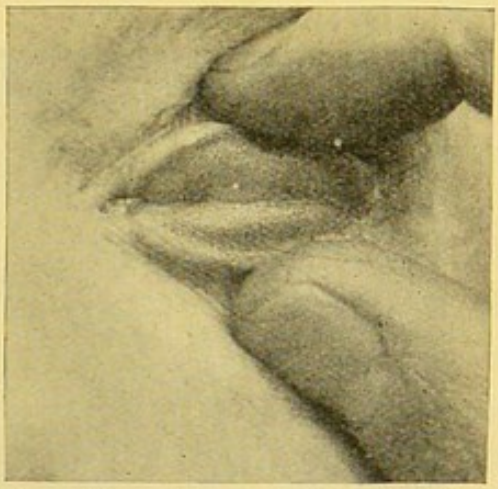


Fig. 25.—Everted lids held in position with one hand.

junctivæ, or corneæ. At the inner angle or canthus there is a vertical crescentic fold, the *plica semilunaris*, on the nasal side of which is a rounded mass of modified skin called the *caruncle*.

On the palpebral surface of the upper lid close to, and running parallel to the margin, is a shallow groove, called the subtarsal sulcus. Some adenoid tissue exists in the fornices of the normal conjunctiva, and follicles are sometimes found, the latter being probably due to the constant irritation to which the conjunctiva is exposed. The conjunctiva is lubricated by the secretion from the glands and conjunctival epithelium. The lacrimal fluid, which has only a very

slight bactericidal action, merely exercises a mechanical effect which consists in the washing away of foreign particles.

The Examination of the Conjunctiva.—Simple inspection in good diffused daylight, the patient facing the window, is better than artificial illumination. The whole of the mucous membrane should be examined, and for this purpose the lids must be everted. The eversion of the lower lid is a simple matter, but a certain amount of practice is required in the case of the upper lid.

Eversion of the upper lid.—The surgeon should face the patient and direct him to look down and to continue looking down, in order to render the upper edge of the tarsus accessible. The point of the thumb of one hand is then placed on the outer surface of the lid, just above the tarsus, and with it the skin is drawn a little upwards and backwards; this causes the margin of the lid to start forwards. The eyelashes (or the margin of the lid) are then taken between the thumb and forefinger of the other hand (Fig. 24) and



FIG. 26.—Method of examining a child's eye.

raised upwards while the thumb above is depressed. The thumb which acts as the depressor should not be taken away too soon, a mistake often made by beginners, and it is better to slide it away sideways. In case of failure a probe or glass rod can be used instead of the thumb. When everted, the lids can be retained in position

by one hand (Fig. 25), while applications are being made to the conjunctiva.

The method of examining the conjunctiva and cornea in infants and children is shown in Fig. 26. The head is firmly held between the surgeon's knees. The conjunctiva is easily inspected, as the lids become everted on merely attempting to open the eye by pulling on the skin near the lid margins. In order to examine the cornea, the lids must not be allowed to become everted, but must be separated with the points of the fingers placed on the ciliary margins as shown in Fig. 27. The cornea at first rotates under the upper lid, but soon comes into view. Care must be taken to avoid injuring the cornea with the finger nails, or using too great pressure on the eye, which might rupture a corneal ulcer. The surgeon too must beware lest retained secretion should spurt up into his own eyes.

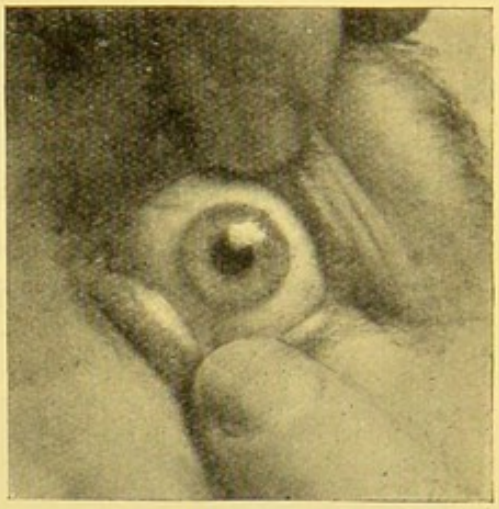


FIG. 27.—Method of exposing a child's eye.

The normal conjunctival surface of the upper lid is smooth, yellowish-pink in colour, and the conjunctiva is adherent to the tarsus. The small branches of the tarsal arches can be seen running in a vertical direction, and the Meibomian glands appear as yellowish or grey lines at right angles to the ciliary margin of the lid. The student should note the appearance and thickness of the edge of the normal tarsus when everted. Figs. 28 and 29 illustrate the method of inspecting the retro-tarsal folds and fornix. The double eversion (Fig. 29) is necessary in cases of suspected foreign bodies in the fornix.

The blood-vessels of the conjunctiva consist of the posterior conjunctival vessels derived from the palpebral vessels, and the anterior conjunctival vessels which pass backwards from the anterior ciliary vessels. In general affections of the conjunctiva the former are chiefly involved. Engorgement of the vessels of the conjunctiva is known as *conjunctival congestion* (Plate II. Fig. 1), in order to distinguish it from ciliary congestion, which accompanies diseases of the cornea and iris. It is bright red in colour, most marked

towards the fornix, and is formed by a network of large, tortuous, superficial vessels, which move with the conjunctiva. *Ciliary congestion* (Plate II. Fig. 2) on the other hand is limited to the circumcorneal area, and diminishes towards the periphery. It is due to engorgement of the episcleral branches of the anterior ciliary vessels. It is pink or violet in colour, and is composed of minute straight radiating vessels, which are frequently indistinguishable to the naked eye as separate vessels. They are situated under the conjunctiva, and cannot be moved with it. In severe inflammations of the eyeball, such as a purulent ulcer of the cornea, these two forms of congestion are frequently present together.

Hyperæmia of the Conjunctiva.—In this condition the blood-



FIG. 28.—Examination of retro-tarsal folds of upper lid.

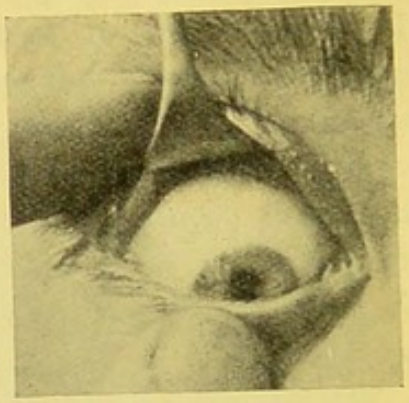


FIG. 29.—Exposure of upper fornix; lid everted and raised with retractor.

vessels of the palpebral conjunctiva are especially engaged. A slight serous exudation sometimes takes place, which may raise the conjunctiva around the cornea, a condition known as *chemosis* (χαίνω, to gape open). Small vesicles may form, and there may be some swelling of the papillæ and development of lymph follicles. Yet there is not any abnormal discharge from the conjunctiva, and herein lies the chief clinical difference between this affection and simple conjunctivitis.

Causes.—Foreign bodies. Dust, foul air, or air loaded with tobacco-smoke. Alcoholic excesses. Accommodative asthenopia. Stenosis lacrimalis, and other forms of lacrimal obstruction. The use of unsuitable spectacles, or the use of the eyes for near work without spectacles, when the condition of the accommodation (*e.g.* hypermetropia, presbyopia) requires them.

PLATE II

(To face page 42)

TYPES OF CONGESTION

FIG. 1.—Conjunctival congestion associated with catarrhal conjunctivitis. The vessels are bright red, tortuous, and easily seen. The congestion is greatest towards the periphery.

FIG. 2.—The delicate pink zone of ciliary congestion immediately surrounds the cornea, and is composed of very minute vessels which are not easily seen separately. A pointed posterior synechia renders the pupil irregular, and on the iris is a reddish yellow tumour (a gumma).

FIG. 3.—These small patches of ciliary congestion precede or follow the development of marginal phlyctens.

FIG. 4.—The ciliary congestion here consists of a fine venous reticulum. Note the few large tortuous veins, and the dilated and greenish pupil.

FIG. 5.—Note the patch of deep violet congestion, with slight diffuse swelling, the discoloration of the sclerotic above and below, and the irregular outline of the cornea due to the encroachment of 'sclerosing opacities.'

FIG. 6.—The appearance of the effusion of blood under the conjunctiva is easily distinguished from a localised congestion.

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FIG. 6.—The appearance of the effusion of blood under the conjunctiva is easily distinguished from a localised congestion.



FIG. 1. Conjunctival Congestion.



FIG. 2. Ciliary Congestion (Iritis).

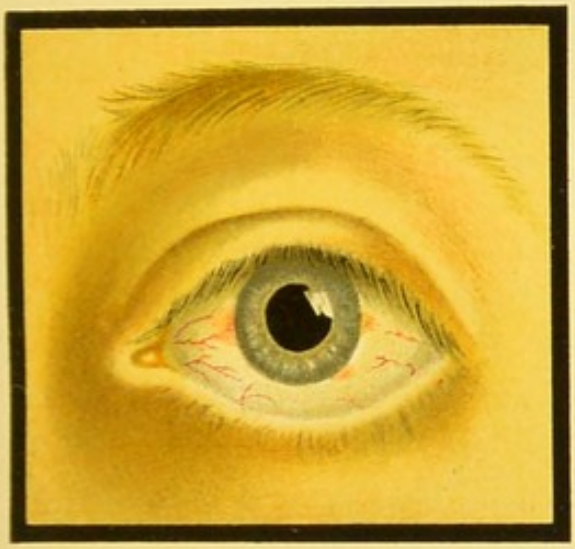


FIG. 3. Ciliary Congestion (Phlyctenular).



FIG. 4. Ciliary Congestion (Glaucoma).



FIG. 5. Congestion in Scleritis.

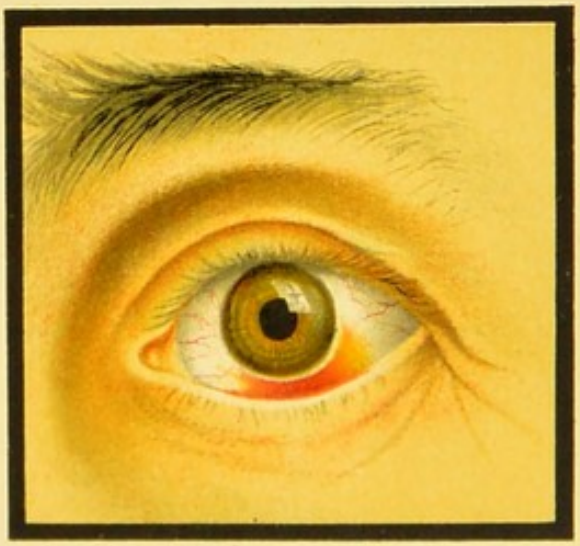


FIG. 6. Ecchymosis of Conjunctiva.

L.W. PINX.

Symptoms.—The eyes are irritable. There is lacrimation and photophobia, with hot, burning sensations, and sensations as of a foreign body in the eye, and the eyelids feel heavy. All these symptoms are aggravated in artificial light.

Treatment.—In addition to the removal of the cause, the instillation of mild astringents or of a drop of tincture of opium and distilled water in equal parts morning and evening will be found beneficial. Adrenaline has no permanent effect on the hyperæmia. The eyes should be protected from the glare of light by dark glasses, and out-of-door exercise is to be recommended.

Conjunctivitis in general.—The term *Ophthalmia* is commonly used as a synonym of Conjunctivitis,[1] which differs from mere hyperæmia in the presence of abnormal secretion. Apart from mechanical or chemical irritation, inflammation of the conjunctiva is almost always caused by micro-organisms gaining access to the conjunctival sac ; or perhaps in some cases, by the sudden development, under favourable conditions, of those which had been already present in a latent condition. They can easily be detected in the discharge, except in the rare cases of metastatic or endogenous origin, and are the cause of its infectious nature. Sporadic cases are very common, but the disease frequently spreads through the members of a household, or occurs as an epidemic. Infection takes place by the direct transference of the secretion from person to person, or indirectly by a common use of the same articles by different people. Inflammations of the conjunctiva are met with in patients of all ages, and at all seasons of the year ; but some forms are more common in the spring and autumn. The palpebral conjunctiva is often affected when the bulbar portion remains normal, and the conjunctiva of the lower lid is more frequently attacked than that of the upper lid.

Differential Diagnosis.—The milder forms of conjunctivitis are apt to be mistaken, by those who are inexperienced, for iritis and *vice versa*, but with care there should be no difficulty in distinguishing between the two affections. Conjunctivitis is accompanied by

[1] Blepharitis is sometimes called Ophthalmia tarsi, and to this there can be little objection, but the name Sympathetic Ophthalmia is liable to mislead, as this disease has nothing to do with the conjunctiva, but is an inflammation of the uveal tract.

conjunctival congestion, the secretion is muco-purulent, and if not in sufficient quantity to be detected in the conjunctival sac, its presence is indicated by the fact that the lids are gummed together in the mornings. The pain is superficial and limited to the eye itself (sensation of foreign body, heat, itching). Vision is not affected, except temporarily by secretion on the surface of the cornea, which is easily removed by rubbing the lids over the eye. Iritis, on the other hand, is recognised by the presence of ciliary congestion, lacrimation instead of a sticky secretion, and by the character of the pain, which is neuralgic and circumorbital. Moreover, the vision becomes impaired at a very early stage of the disease. The ultimate diagnosis rests of course on the appearance of the iris and on the effect of atropine (see chap. vii.).

Varieties of Conjunctivitis.—Although an accurate diagnosis of the different forms of conjunctivitis depends on the discovery of the particular micro-organism in each case, nevertheless the usual classification, which is based on clinical appearances, must for the present be adhered to, partly because these appearances are sufficient in most cases to indicate the line of treatment required, but chiefly because the type of inflammation excited by a given microbe is not sufficiently constant. In the majority of cases no doubt a definite group of symptoms is associated with a particular micro-organism, but occasionally the reaction takes a different form.[1] Again, one and the same clinical picture may be produced by different micro-organisms. In exceptional cases, too, a mixed infection may take place.

From a clinical point of view then, conjunctivitis is divided into different varieties, depending on the nature of the discharge, the pathological changes in the tissues, and the severity of the symptoms. In *Catarrhal Conjunctivitis*, which may be acute or chronic, the discharge is muco-purulent in character, whereas in *Purulent Conjunctivitis* pure pus is secreted. The discharge becomes fibrinous and coagulates to form a membrane, lying on the surface of the conjunctiva, in the so-called *Croupous* variety, or it extends into the substance of the tissues in the *Diphtheritic* form. All

[1] This may be due to altered conditions, such as differences in the resistance of the tissues or blood, or to variations in the degree of virulence of the microbe.

inflammations of the conjunctiva are accompanied by more or less increase of the normal lymphoid tissue, which is of a diffuse character, but in certain cases lymphoid masses are formed which become visible to the naked eye, as in *Follicular* and *Granular Ophthalmia*. In *Phlyctenular Conjunctivitis* small papules, or pseudo-vesicles, are found on the bulbar conjunctiva. Severe cases of conjunctivitis are often attended with slight swelling of the preauricular gland; but in the condition known as *Parinaud's Conjunctivitis* the glandular enlargement is considerable, and reddish vegetations form on the palpebral conjunctiva. *Traumatic Conjunctivitis* may be produced by physical or chemical causes, and inflammation of the lacrimal sac frequently extends to the conjunctiva. In rare cases a *Metastatic Conjunctivitis* due to endogenous infection has been observed. Finally Eczema, Impetigo, and some of the exanthemata (Measles, Scarlatina, Small-Pox) are frequently accompanied by conjunctivitis.

The Bacteriology of Conjunctivitis.—The micro-organisms which are commonly met with as the active causes of conjunctivitis are not very numerous. The following is a list of them, with the clinical type of disease to which each most frequently gives rise :—

Bacilli.

The Koch-Weeks B.—(Acute Contagious Conjunctivitis). The Diplobacillus of Morax—(Subacute Angular C.). The Diphtheria B.—(Membranous C.).

Cocci.

The Gonococcus.—(Purulent C.). The Pneumococcus.—(Catarrhal C.). Streptococcus. Staphylococcus albus et aureus.

The last two most frequently occur as part of a mixed infection, along with the gonococcus and the diphtheria bacillus. They are, however, also found, alone or together, in the conjunctivitis (often membranous) which accompanies impetigo of the face, or which follows scarlatina, but they have never been known to cause an epidemic.

The Xerosis Bacillus (see Xerosis), which is non-pathogenic, is very frequently present in the normal conjunctiva; but it should also be remembered that some of the pathogenic forms, such as the

staphylococcus, pneumococcus, and, it is stated by some, the streptococcus, are also found (especially the first named) in conjunctival sacs devoid of all signs of irritation. In fact the normal conjunctiva is rarely free from micro-organisms. According to Mayou there are fewer micro-organisms in the upper fornix than in the lower.

The epithelium of the conjunctiva offers a certain resistance to the entrance of organisms, and hence many of them will not set up an inflammation unless there be a superficial loss of substance.

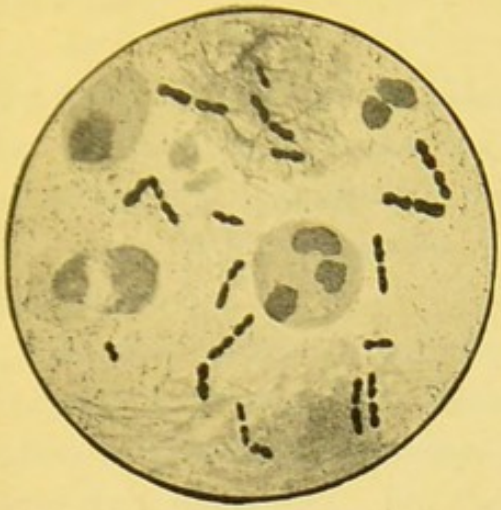
All the above, with the exception of the gonococcus, the Weeks bacillus, and the diplobacillus, stain by Gram's method.[1]

The number of micro-organisms does not always correspond with the amount of discharge, and in some instances none can be found. We have recently had a case of this kind in which, although the discharge was profuse, both cover-glass preparations and attempts to obtain cultures gave negative results on three different occasions. The etiology of such cases is unknown.

In addition to those which have been mentioned, other micro-organisms have occasionally been found in conjunctivitis. In the case of some of them it is very doubtful if they were the exciting cause of the condition of the conjunctiva with which they were associated. The most important varieties will be briefly referred to as we proceed.

Catarrhal, or **Simple Acute,** or **Muco-purulent Conjunctivitis.**—In mild cases the affection is confined to the palpebral conjunctiva, often even to the conjunctiva of the lower lid; but in the severer cases it extends to the bulbar conjunctiva. In the latter event the lids may be slightly hyperæmic and swollen. Both eyes are usually affected, either simultaneously or at a short interval. Lymph follicles and enlarged papillæ are sometimes present. There is a sticky, thin, mucous, or muco-purulent secretion which is often visible in the form of strings in the lower fornix. It dries on the eyelids at night so as to fasten them together when the patient awakes in the morning, and sometimes produces ulceration of the intermarginal portion of the eyelids (intermarginal blepharitis).

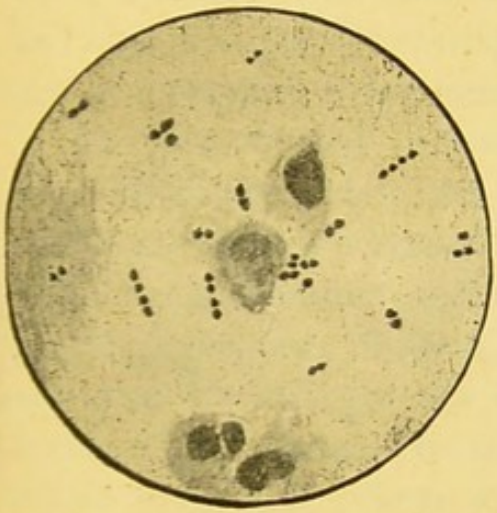
[1] For clinical work, in most cases, cover-glass smears stained by Gram's method, followed by a counter-stain, such as weak Carbol-Fuchsin, will suffice, but in some cases the identity of the particular microbe can only be established by cultures and inoculation experiments.



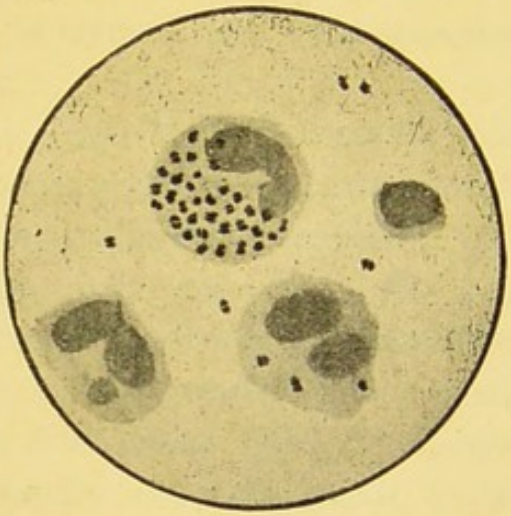
Diplobacillus (*Morax and Axenfeld*). From a case of subacute angular conjunctivitis.



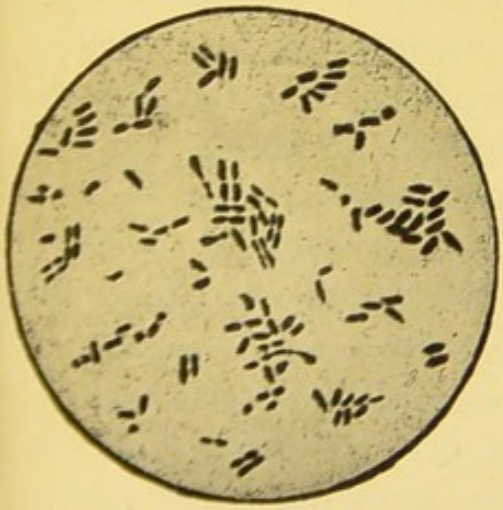
Koch-Weeks bacillus. Secretion from acute conjunctivitis. A few deeply stained *Xerosis b.* are also present.



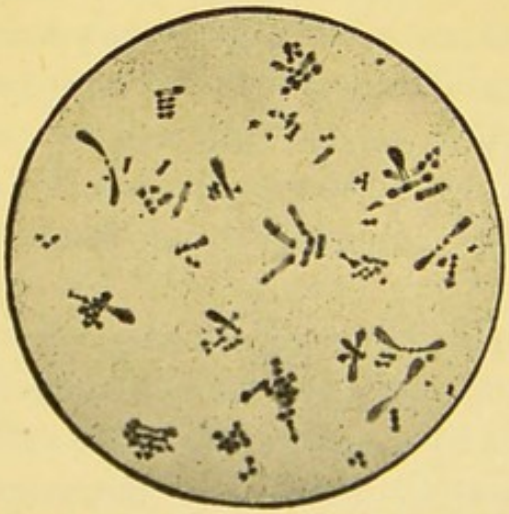
Pneumococcus. From a case of catarrhal conjunctivitis.



Gonococcus. From a case of ophthalmia neonatorum.



Xerosis bacillus. Culture from normal conjunctiva, showing few clubs.



Xerosis bacillus. Culture, diphtheroid form

From preparations and drawings by L. W

In some of the very mildest cases this stickiness, or gumming, on awaking in the morning is a valuable diagnostic sign, for in such cases it is difficult or impossible to recognise by inspection the very slight variation from the healthy appearance of the conjunctiva.

In the severer cases the papillæ are markedly swollen, and may even conceal the Meibomian glands from view. Also, one often sees small ecchymoses in the bulbar conjunctiva, especially in certain epidemics ; but these have no serious import.

Minute grey infiltrations which may break down and form small ulcers sometimes appear at the margin of the cornea, more especially in old people. When there are many of them they may become confluent and form a small grey crescent, which ulcerates, and thus a crescentic marginal ulcer is formed, and very occasionally such an ulcer is followed by iritis.

The catarrh may become chronic, and then the papillæ are more developed, while the blepharitis is liable to extend over to the cutis, causing eversion of the lower punctum lacrimale with resulting lacrimation, and this, in its turn, aggravates the conjunctival affection. Indeed, chronic conjunctivitis is the commonest cause of ectropion of the lower lid in old people. The chronic form of the disease is much less contagious than the acute, which frequently affects a whole family or may result in an epidemic.

The Symptoms are those of a severe case of hyperæmia (sensations of sand in the eye ; hot, burning sensations ; weight of the eyelid), with the addition of the annoyance consequent on the secretion, which, by coming across the cornea, may cause momentary clouding of sight. Photophobia is not generally severe unless there be some corneal complication. The symptoms are worse at night, or by artificial light, and are much less troublesome when the eyes are exposed to the open air.

Causes.—Anything which favours the entrance of micro-organisms into the conjunctival sac, such as direct infection with secretion, also dust, wind, etc. Conditions which lower the resistance of the tissues, either locally by causing hyperæmia, or generally through the system (impure air, exposure to cold, etc.). Perhaps also the microbes are more widespread or more virulent at certain times, as in the spring or autumn. Some of the above-mentioned causes

act no doubt in combination in the conjunctivitis which accompanies impetigo, scarlatina, measles, and smallpox.

The *Koch-Weeks bacillus* produces an acute contagious conjunctivitis, which chiefly attacks young people, and occurs most frequently in an epidemic form.

It is more severe in adults than in children; and is often attended by an erythematous condition of the upper lids, or even by slight œdema. The preauricular glands are sometimes enlarged. The Koch-Weeks bacillus may be easily overlooked, as it is a very fine bacillus and stains feebly.

The *Pneumococcus* is responsible for a mild form of catarrhal ophthalmia, occurring in children or adults, sometimes in small epidemics. A characteristic sign of this variety of conjunctivitis is (according to Morax) an œdema or rose-coloured hyperæmia confined to the margin of the upper lid. It also gives rise to minute ecchymosis of the bulbar conjunctiva. The secretion is at times fibrinous. This variety does not appear to be as common in the United Kingdom as elsewhere. It is of short duration (ten days or so), and can be readily cured.

The conjunctivitis associated with impetigo sometimes assumes a mild catarrhal form. Both *Strepto-* and *Staphylococci* are found to be present. The former can no doubt set up conjunctivitis, but attempts to produce conjunctivitis in man with virulent cultures of staphylococcus aureus have proved ineffectual.

In influenza epidemics conjunctivitis sometimes occurs along with the other symptoms, or it may precede them. It is due to the *Influenza Bacillus*, which is shorter and stouter than the Weeks B., but is difficult to distinguish from the latter. It is much rarer in adults than in children.

Quite recently some cases of conjunctivitis have been observed, which were undoubtedly caused by the hay bacillus (*B. Subtilis*). In all of them particles of earth had found their way into the eye.

The Prognosis of catarrhal conjunctivitis is good, if there be no reason to suspect that the mild form is but the commencement of a more severe inflammation. The infiltrations, and even the ulcers, which sometimes form at the margin of the cornea are not often of serious import, and usually heal, according as the treatment restores the conjunctiva to health.

Treatment.—It will be advisable here to make a few observations

on the treatment of conjunctivitis in general. Patients should always, in the first place, be warned of the danger of infecting other persons. And in order also to avoid re-infecting themselves, droppers should be sterilised, or at least should not be brought into contact with the eye when being used. For bathing the eye sponges should be avoided, and small pieces of lint employed, which must be burnt immediately after use. Bandages should not be worn, nor should the patient be confined to the house, unless in severe or complicated cases.

In catarrhal conjunctivitis cold or iced compresses, with the use of a 1 in 5000 solution of sublimate as a lotion, should be used frequently at the onset, and in mild cases will alone bring about a cure. But the habit, which some patients so readily acquire, of bathing the eyes frequently with cold water should not be permitted, for it is deleterious to the conjunctival affection. When in a day or two the irritation and swelling have somewhat subsided—or from the very commencement, if there be not much irritation—a solution of nitrate of silver, of from 5 to 10 grains to $\bar{3}$j, should be applied by the surgeon to the palpebral conjunctiva with cotton wool twisted on the end of a small piece of stick, such as is used for matches, the lid being well everted. The solution may be neutralised with solution of common salt, which is then finally washed off with water. The neutralisation with salt water is important to check prolonged action of the nitrate of silver, as also to obviate conjunctival staining (called Argyrosis, from ἄργυρος, *silver*) when the treatment is a lengthened one. The application is to be repeated after twenty-four hours, by which time the slight loss of epithelium, the result of the superficial slough, will have been repaired. Immediately after such an application cold sponging or iced compresses are useful, and grateful to the patient. Gentle removal of the loose coagula also gives much relief.

In recent years a number of organic salts of silver have been used instead of the nitrate. The best of these are protargol (in 5 to 20 per cent. sol.) and argyrol (25 per cent.). They do not coagulate albumen, and are therefore supposed to have greater penetrating power, and are practically painless. Personally we still rely on the nitrate in preference to either.

Even weak solutions of nitrate of silver as eye-drops to be used at home by the patient, should be avoided, for staining of the con-

junctiva is very apt to be caused in this way. Protargol and argyrol also cause staining.

Should the surgeon be unable to see the patient daily, astringent and antiseptic eye-drops are very beneficial, and indeed often effect a cure. Sulphate of zinc (gr. ij to the ℥j), with or without Tinct. Opii, ℥j, alum (gr. iv to ℥j), tannic acid (gr. v to viij to ℥j) are those which are most commonly used. They may be combined with boracic acid in saturated solution, corrosive sublimate (1—5000), or oxycyanate of mercury (1—2000). Acetate of lead (1 or gr. ij to ℥j) can also be prescribed, provided the cornea be intact; otherwise deposits of lead are liable to form in it.

A weak boracic acid ointment should be applied along the margins of the lids at bedtime. It prevents the adhesion of the lids in the morning, which is not only unpleasant to the patient, but also prevents free drainage of the secretion during sleep.

Diplobacillary or **Angular Conjunctivitis.**—This form of inflammation requires a description apart, not only because it presents a definite clinical picture, but also because it readily yields to a particular line of treatment. It presents the appearance of a subacute or chronic conjunctivitis, the congestion being limited to the palpebral conjunctiva, more especially of the lower lid, and to the caruncle. The secretion is very scanty, and makes its appearance most commonly round the inner canthus, as a slight greyish-white collection, but still the lids are often stuck together in the mornings. The most characteristic sign, and one which has given rise to the name "Angular," is a peculiar moist hyperæmia, with superficial excoriation, of the skin at the margin of the lids, which usually surrounds the canthi, especially the inner canthus, although the whole margin of the lids may be affected by it. In very mild cases this condition of the skin may be absent. The subjective symptoms consist in sensations of heat, pricking, and itching, and are always much worse in the evening. Corneal affections are not common, but occasionally small superficial marginal ulcers occur; and, less frequently still, severe central ulcers with hypopyon (see chap. v.).

The disease is chiefly met with in adults, but it also occurs in children, in whom it may even cause blepharitis. We have often seen it too as a complication of trachoma in the later stages.

Cause.—The exciting cause is the Diplobacillus of Morax and

Axenfeld, the largest of the micro-organisms found in the conjunctival sac (see p. 47). It grows only on solid media containing serum, in which it produces very characteristic clear depressions. Inoculation easily succeeds in reproducing the disease, but only in human beings. The diplobacilli have also been found in the nose, but it has not been definitely ascertained whether or not they reach the latter through the nasal duct.

Treatment.—This affection shows no tendency to spontaneous cure, and, if neglected, it may last for many months ; but fortunately we have in sulphate of zinc an unfailing remedy. Solutions of from 4 to 10 grains to the ounce will effect a cure in ten days or so, and are much more efficacious than very weak solutions, and are not very painful. Cocaine may be added for patients of nervous temperament. In order to prevent a relapse, the treatment should always be continued for about a week after the subjective symptoms have disappeared. If the lids be tender, an ointment of oxide of zinc (10 per cent.) and icthyol (2 to 5 per cent.) is very useful.

Chronic Simple or **Chronic Catarrhal Conjunctivitis.**—This form of conjunctivitis occurs in adults and old people, and is extremely obstinate, often lasting for years, and sometimes, with or without intermissions, even for a lifetime. The objective signs vary in degree from those of simple hyperæmia without apparent secretion to a moderate catarrh with muco-purulent discharge. But they are never so pronounced as in the acute form of the disease, and the bulbar conjunctiva is seldom much injected.

The subjective symptoms resemble those which have been mentioned in the descriptions of hyperæmia and acute catarrh. They are always worse in the evening, and patients often complain that when they attempt to read, the upper lids feel heavy and inclined to close, so that they feel sleepy. A sensation of dryness of the eyeball is also experienced, when the secretion is scanty or absent. In many cases, however, the sensations complained of are much in excess of the objective appearances.

In the later stages, the conjunctiva, in muco-purulent cases, becomes rough or velvety, from hypertrophy of the papillæ, and ectropion of the lower lid, epiphora, and blepharitis may result. The skin of the lower lid, from the constant irritation caused by the discharge, becomes eczematous and stiff, the inner end of the lid then becomes everted, so that the punctum lacrimale no longer

lies in normal contact with the eyeball, and this, together with narrowing of the punctum and canaliculus by the hypertrophied conjunctiva, leads to epiphora, which again intensifies the irritation of the skin, and still further increases the ectropion. Marginal ulcers of the cornea, too, are liable to occur in old people with chronic conjunctival catarrh.

The *Causes* of this affection are very numerous. It seldom originates in an acute catarrh, but more commonly begins gradually, and owes its origin to local irritation of the conjunctiva or to constitutional causes. Amongst the former are included dust, chemicals, smoke, bad ventilation, exposure to heat or steam, inturned eyelashes, infection from the lacrimal sac, errors of refraction, prolonged reading by artificial light, sleeplessness, and constant exposure to wind or rain. Less well-known causes are: inefficient closure of the eyelids at night, so that a portion of the eyeball remains exposed to the atmosphere; purulent infection of the ducts of the Meibomian glands, or solid infarcts in the Meibomian glands or in small conjunctival cysts. In many cases no definite cause can be assigned.

Treatment is often unsatisfactory, partly owing in many cases to the impossibility of removing the cause when this is due to the nature of the patient's occupation. Indications for treatment are provided by a consideration of the above-mentioned causes. Attention should also be paid to the general health; relief of constipation; avoidance of alcoholic stimulants; correction of errors of refraction and presbyopia; treatment of the lacrimal apparatus (Chap. XVIII.) and of ectropion (Chap. XVII.). In case of defective closure of the lids, a bandage at night may be applied. Suppuration in the Meibomian ducts can be effectually relieved by expression of their contents, daily if necessary, with a glass rod. Any solid white infarcts, if they project above the surface, should be picked out of the palpebral conjunctiva with the point of a needle or knife. With regard to local applications, astringents are the most useful, but they should not be too irritating. Nitrate of silver may be necessary if there be discharge or hypertrophy of the conjunctiva. Protargol, argyrol, or other organic silver salts are less painful, but the possibility of causing argyrosis should not be forgotten. Other useful astringents are alum in solid stick, or in $\frac{1}{2}$ to 1 per cent. solution; copper sulphate; lead subacetate;

tannic acid in solutions containing 1 or 2 grains to ʒj. Boracic acid too may be used in saturated solution, but it is the mildest and least active of all. Adrenaline gives only temporary relief. Frequent use of cocaine is not to be recommended, as it renders the cornea vulnerable to micro-organisms by deranging its epithelium. Very mild cases of diplobacillary conjunctivitis may not be accompanied by the characteristic excoriation of the skin, and may then resemble a simple chronic conjunctivitis; but here a bacteriological examination would at once establish the diagnosis and suggest the appropriate treatment.

Acute Blennorrhœa of the Conjunctiva, or **Purulent Ophthalmia.**—This very dangerous affection, which statistics show to be one of the commonest causes of blindness, is usually seen either as gonorrhœal ophthalmia or as blennorrhœa neonatorum.

Etiology.—In gonorrhœal ophthalmia the etiological moment is the introduction of some of the specific discharge from the urethra or vagina into the conjunctival sac; while in blennorrhœa neonatorum the infection is believed to take place, either during or just after the passage of the head through the vagina, by abnormal secretion from the latter finding its way into the infant's eyes. A few instances have been observed of infants born with the disease. Prolonged labour, due to early rupture of the membranes, or faulty head presentations, and also repeated examinations, would assist infection before delivery. Inoculation may also occur a few days after birth by pus conveyed by the fingers of the mother or nurse, or by towels, etc., used for washing the child's face.

The more severe cases of blennorrhœa neonatorum are caused by a vaginal discharge, which is almost always gonorrhœal, and Neisser's gonococcus, which is the exciting agent, can be found in the discharge from the vagina and in the secretion from the eye. It may be found in the epithelial cells, or in the pus cells, or free. Mild catarrhal conjunctivitis also occurs in newborn infants, and in these cases the ordinary microbes associated with that condition are present, and occasionally the bacterium coli; but in rare cases even the gonococcus may produce a mild reaction, probably owing to attenuation of the virus by dilution or drying. It should also be noted that a typically purulent ophthalmia has, in exceptional cases, been observed in infants (Morax) without the presence of any micro-organisms, but then it usually takes a benign course.

If the infection take place during or immediately after birth, the disease appears most commonly on the third day, but it may appear at any time from the second to the sixth day, according to the virulence of the secretion. If the inflammation come on later than the sixth day, it may be concluded that the infection was produced secondarily by the vaginal discharge being introduced into the eye by the fingers of the mother or nurse, etc.

While purulent ophthalmia in adults is usually gonorrhœal and due to the gonococcus, it may exceptionally be the result of infection by the Koch-Weeks bacillus; the cases due to this bacillus, however, are not so serious as those caused by the gonococcus.

In newborn infants both eyes are commonly affected. The reverse is the case in adults, in whom also the disease is more severe.

Symptoms and Progress.—In mild cases the bulbar conjunctiva may be but little, or not at all, affected, the palpebral conjunctiva alone becoming velvety and discharging a small amount of pus, while there may be no swelling or œdema of the eyelids.

In severe cases of blennorrhœa of the conjunctiva there is, soon after the onset, serous infiltration of the palpebral mucous membrane—which consequently becomes tense and shiny—serous chemosis of the bulbar conjunctiva, serous discharge, dusky redness, and swelling of the eyelids—which makes it difficult to evert them—pain in the eyelids, often of a shooting kind, burning sensations in the eye, and photophobia. This first stage, or period of infiltration, lasts from forty-eight hours to four or five days. The preauricular lymphatic glands may be swollen and tender, and a rise of temperature may occur.

Then begins the second or purulent stage, in which, owing to swelling of the papillæ, the palpebral conjunctiva becomes less shiny and more velvety; while the discharge alters from serous to the characteristic purulent form, the chemosis, however, remaining unaltered, or becoming more firm and fleshy. The swelling of the lids continues, the upper lid often becoming pendulous and hanging down over the under lid; while, at the same time, it becomes less tense and more easily everted. Gradually the chemosis and swelling of the conjunctiva and eyelids subside, and the discharge lessens, the mucous membrane finally being left in a normal state, unless in a small percentage of cases in which chronic blennorrhœa remains. A moderately severe attack of conjunctival blennorrhœa

lasts from four to six weeks. A delicate scarring of the conjunctiva in the fornices may be sometimes left after the attack.

Complications with corneal affections form the greatest source of danger in this affection. They are found chiefly in four different forms. (1) Small epithelial losses of substance on any part of the cornea. If these occur at the height of the inflammation, they are apt to go on to form deep perforating purulent ulcers. (2) The whole cornea becomes opaque (diffusely infiltrated), and towards its centre some greyish spots form, which are interstitial abscesses or purulent infiltrations. (3) An infiltration may form at the margin of the cornea, and extend a considerable distance around its circumference, giving rise to a marginal ring ulcer, and, later on, to sloughing of the whole cornea. (4) A clean-cut ulcer may form at the margin of the cornea without any purulent infiltration of the corneal tissue, and may also extend a long way round the cornea. These ulcers are particularly apt to occur where there is much chemosis, which overlaps the margin of the cornea ; and, being hidden in this way, they are easily overlooked. The chemosis should be pushed aside with a probe, and these peculiar ulcers looked for. They are very liable to perforate.

All the foregoing forms of corneal complication occur both in ophthalmia neonatorum and in gonorrhœal ophthalmia. They may appear at any period of the affection, but the earlier they occur the more likely are they to result seriously.

The danger of these ulcers consists in the perforation of the cornea and in the permanent opacity they are apt to produce, of which more later on.

The severer the case, especially the more the bulbar conjunctiva is involved in the process, the more likely is it that corneal complications will arise. For the corneal process is to be regarded as the result of infection by the conjunctival secretion ; and this infection is all the more apt to occur, where the nutrition of the cornea is impeded by a dense chemotic swelling of the bulbar conjunctiva. Severe chemosis is less common in the blennorrhœa of the newborn than in gonorrhœal ophthalmia, and this may be the reason for the fact that the latter is much the more dangerous affection of the two.

The Prophylaxis of purulent ophthalmia is a matter of the first importance. It should form part of the routine of lying-in practice,

Careful disinfection of the vagina before and during birth, and the most minute care in cleansing the face and eyes of the infant immediately after birth with a non-irritating disinfectant (*e.g.* a solution of corrosive sublimate 1 in 5000), are to be recommended. The method of the late Dr. Credé has found very general acceptance, and is an admirable one. It is as follows :—When, after division of the umbilical cord, the child is in the bath, the eyes are carefully washed with water from a separate vessel, the lids being scrupulously freed, by means of absorbent wool, of all blood, slime, or smeary substance ; and then, before the child is dressed, a few drops of a 2 per cent. solution of nitrate of silver are instilled into the eye.[1] Many obstetricians employ this method now as a matter of routine in their lying-in hospitals for all the infants, whether or not it be suspected that there is danger of infection. The conjunctival irritation which sometimes follows is unimportant as compared with the immense advantages which result from this procedure. By its aid Credé reduced the percentage of his cases of ophthalmia neonatorum from 8 or 9 per cent. to 0·5 per cent.

In all cases of gonorrhœa it is the duty of the surgeon to explain to his patients what the danger is of their carrying any of the urethral discharge to their eyes ; and to charge them to exercise punctilious cleanliness as regards their hands and finger-nails, and care in the use of towels, handkerchiefs, etc.

In respect of *Local Treatment* when the disease has become established :—In the very commencement of the affection the only local applications admissible are antiseptic lotions (Permanganate of Potash Solution, 1 in 10,000 ; Sublimate, 1 in 5000) and iced compresses, or Leiter's tubes. With the former the conjunctival sac should be freely washed out or irrigated. Syringing is dangerous both for patient and for operator, for in syringing out the conjunctival sac a morsel of the corneal epithelium may be removed, and through this the cornea may become infected ; and, as regards the operator, he is in danger of discharge spurting into his eyes. The iced compresses, or Leiter's tubes, should be kept to the eye for an hour at a time, with a pause of an hour, and so on, or even continuously. Cold inhibits the growth of the gonococcus. In this and in

[1] The general opinion now is that a 1 per cent. solution is just as efficient and less irritating.

the next stage the chemosis should be freely, and daily, incised with scissors. If the swelling of the lids be great, the external canthus should be divided with a scalpel from without, leaving the conjunctiva uninjured, in order to reduce the tension of the eyelids on the globe, and, by bleeding from the small vessels, to deplete the conjunctiva. Depletion alone can be obtained by leeching at the external canthus, and in many cases is of great benefit at the very commencement. If in adults the chemosis, palpebral swelling, and rapidity of the onset indicate that the inflammation is severe, it is well to place the patient quickly under the influence of mercury by means of inunctions or small doses of calomel, as by so doing the chemosis is often rapidly brought down, and one source of danger to the cornea is removed.

In the second stage (*i.e.* when the conjunctiva has become velvety and the discharge purulent) caustic applications are the most trustworthy, and in this respect iodoform and other lauded means cannot compete with them. The application employed may be a solution of nitrate of silver of 10 to 20 grains in ℥j of water, which should be applied by the surgeon to the conjunctiva of the everted lids, and then neutralised with a solution of common salt; or the solid mitigated nitrate of silver (one part nitrate of silver, two parts nitrate of potash) may be used, the first application being lightly made in order to test its effect, while careful neutralisation with salt water and subsequent washing with fresh water are most important. Iced compresses may be used to relieve the subsequent pain. An interval of twenty-four hours should elapse before the application is renewed. No remedy is of greater value in purulent ophthalmia than mitigated lapis, when the proper indications for its use are present, and when it is applied with care and intelligence. Between the caustic applications, the pus should be frequently washed away from the eyelids, and from between the eyelids, with a 4 per cent. solution of boric acid, or, better still, the conjunctiva should be douched with a solution of permanganate of potash (1 in 5000) or with a solution of corrosive sublimate of the same strength, and boric acid ointment should be smeared along the palpebral margins, to prevent them from adhering, and thus retaining the pus.

No corneal complication contra-indicates the active treatment of the conjunctiva by the method just described. Iodoform, finely pulverised, has been much praised as a local application in

the second stage of acute blennorrhœa of the conjunctiva. It is to be dusted freely on the conjunctiva once or twice a day. For our part we should trust to it alone in mild cases only. It can, however, be employed with advantage in combination with the above treatment.

When but one eye is affected, it is generally considered necessary to protect its fellow from infection by means of a hermetic dressing. This may be made by applying to the sound eye a piece of lint covered with boracic acid ointment, and over this a pad of borated cotton-wool. Across this, from forehead to cheek and from nose to temporal region, are laid strips of lint soaked in collodion in layers over each other; or a piece of tissue guttapercha may take the place of the lint and collodion, its margins being fastened to the skin by collodion. The shields invented by Maurel and by Buller are serviceable for this purpose. Yet with careful instructions given to the patient, and average intelligence on his part, protection of the sound eye is not necessary. In private cases we do not close the second eye, and have never had ill effects in consequence. Any sign of congestion was met by the application of a 2 per cent. solution of nitrate of silver, and it always proved sufficient to check the development of the disease, as it does in Credé's method of prophylaxis.

Patients should be advised to sleep on the side of the affected eye, in order to prevent the discharge from trickling on to the other side of the face.

Treatment of Corneal Complications.—The involvement of the cornea does not contra-indicate the use of the methods already described, but rather demands their vigorous application. In addition, atropine will relieve pain and diminish the tendency to iritis. Eserine is sometimes employed with the object of reducing the tension, and so improving the nutrition of the cornea by facilitating the lymph circulation, and also on account of its antiseptic properties. But, as its action on the normal tension is practically nil, and its antiseptic properties are very slight, it is better to reserve it for cases of marginal ulcer with prolapse, or danger of prolapse, of the iris, since by the contraction of the sphincter the iris is drawn away from the periphery. Greater care is now required in everting the lids, lest pressure on the globe should cause rupture of the ulcer; and it must be remembered that when a case of acute blennorrhœa

first presents itself, the surgeon, not knowing the condition of the cornea, must use the utmost caution in making his examination, and yet must never fail to get a view of the cornea for the purposes both of prognosis and of treatment. At each visit the cornea must be examined, and it may be found that, as the conjunctival process subsides, any existing corneal affection also progresses towards cure, infiltrations becoming absorbed and ulcers filled up. But even though the conjunctiva be improving, and still more so if it be not, the corneal process may progress, the infiltration becoming an ulcer, and the ulcer becoming gradually deeper, until, finally it perforates.

Should a corneal ulcer become deep, and seem to threaten to perforate, paracentesis of the floor of the ulcer must be resorted to without delay. By thus forestalling nature a short linear opening is substituted for the circular loss of substance, which would have resulted in the ordinary course of events. Through this small linear opening no prolapse of the iris, or else a relatively small one, takes place; and consequently the ultimate state of the eye is usually a better one than it otherwise would have been. The reduction of the intra-ocular tension after the paracentesis promotes healing of the ulcer. It is often desirable to evacuate the aqueous humour, by opening the little incision in the floor of the ulcer with a blunt probe, on each of the two days after the operation.

If an ulcer perforate spontaneously, the aqueous humour is evacuated, and, unless the ulcer be opposite the pupil and at the same time small in size, the iris must come to be applied to the loss of substance. Should the latter be very small, the iris will simply be stretched over it and pass but little into its lumen, and when healing takes place will be caught in the cicatrix, which is but slightly, or not at all, raised over the surface of the cornea, and the resulting condition is called Anterior Synechia.

If the perforation be larger, a true prolapse of a portion of the iris into the lumen of the ulcer takes place. This prolapse may either act as a plug, filling up the loss of substance and keeping back the contents of the globe, but not protruding over the level of the cornea, or it may bulge out over the corneal surface as a black globular swelling, and may then play the part of a distensor of the opening, causing fresh infiltration of its margins. In either case cicatrisation will eventually occur; and if the scar be fairly flat,

it is called an Adherent Leucoma, but if it be bulged out, the term Partial Staphyloma of the Cornea is used.

If the perforation be very large, involving the greater part of the cornea, with prolapse of the whole iris and closure of the pupil by exudation, the result is a Total Staphyloma of the Cornea. The lens may lie in this staphyloma, or it may retain its normal position, but become shrunken.

The question of the treatment of a recent prolapse of the iris in cases of blennorrhœic conjunctivitis is an important one. It has been, and is still largely, the practice to abscise small iris-protrusions down to the level of the cornea, or if large to cut a small bit off their summits, with the object of obtaining flat cicatrices. But in cases of blennorrhœa this proceeding opens a way for purulent infection of the deep parts of the eye, and serious consequences may result. It is better to confine interference with the iris in these eyes to incision of the prolapse, when it seems to be acting as a distensor of the opening, causing fresh infiltration of the cornea; or merely to instil eserine, which has a marked effect in diminishing the size of the protrusion.

It may occur that on the surgeon's visit to a case of blennorrhœa of the conjunctiva, he will find the margins of the eyelids gummed together by sero-purulent secretion, while the eyelids are bulged out by the pent-up fluid behind them. The attempt to open the eye should then be very cautiously made, lest some of the retained pus spurt into the surgeon's eye. The surgeon should also be most careful to wash thoroughly and disinfect his hands and nails at the conclusion of his visit.

In cases of blennorrhœa neonatorum, when the ulcer has been small, on perforation taking place, the lens, or rather its anterior capsule, comes to be applied to the posterior aspect of the cornea. The pupillary area is soon filled with fibrinous secretion. The opening in the cornea ultimately becoming closed, the iris and lens are pushed back into their places by the aqueous humour which has again collected. Adherent to the anterior capsule on the spot which lay against the cornea is a morsel of fibrine, which gradually becomes absorbed by the aqueous humour. In the meantime changes have been produced by this exudation on the corresponding intracapsular cells, which result in a small, permanent, central opacity at that place, where there is also a slight elevation of pyramidal shape over

the level of the capsular surface. This condition is called central capsular cataract, or pyramidal cataract, and rarely results from corneal perforation in adults.

In cases of blennorrhœa neonatorum an inflammatory swelling of the joints, so-called gonorrhœal arthritis, is very occasionally seen. The gonococcus has been found in the fluid removed from the joints in some cases, while in others only the usual pyogenic cocci were present. Even more rarely do peri- and endo-carditis, pleuritis, and meningitis occur.

Metastatic Gonorrhœal Ophthalmia is sometimes met with in adolescents or adults, as an accompaniment of gonorrhœal rheumatism. It is apt to occur with cessation of the urethral discharge. The disease presents the appearance of a moderate catarrhal ophthalmia with scanty secretion, but is occasionally complicated with keratitis, iritis, or scleritis. It shows a great tendency to recur with a relapse of the "rheumatism." It is believed that the gonococci are carried to the eye through the circulation, but gonococci are rarely found in the conjunctival discharge.

* **Membranous Conjunctivitis.**—This disease is characterised by the existence of a fibrinous exudation, either on the surface or in the substance of the conjunctiva, in addition to the other symptoms of inflammation. It was formerly believed, on purely clinical grounds, that the mild form of the disease, known as croupous conjunctivitis, was totally different in nature from the severe or diphtheritic form, and later on this view seemed to be borne out by the discovery of the Klebs-Loeffler bacillus in the diphtheritic cases; but further experience of the bacteriology of membranous conjunctivitis has altered this view. Not only is the diphtheria bacillus found in mild croupous cases, but any of the micro-organisms which commonly cause conjunctivitis, may give rise to fibrinous exudations and the formation of membranes. The same condition in varying degrees of severity can be produced by chemical irritants, such as lime, ammonia, etc., and also by jequirity. Lastly, the diphtheria bacillus may, in rare cases, lead to a simple catarrhal inflammation without the production of a false membrane. The presence of a membrane therefore is only a symptom, and is not necessarily pathognomonic, although it is very suggestive of the Klebs-Loeffler bacillus as the cause.

In severe cases strepto- and staphylo-cocci are generally associ-

ated with the diphtheria bacillus, and indeed the streptococcus, staphylococcus, and pneumococcus acting alone can cause severe membranous inflammation of the conjunctiva.

There is reason to believe that the diphtheria bacillus can only act on the conjunctiva when the epithelium has been injured, say by a slight, even imperceptible trauma, or by a previous inflammation.

Two micro-organisms which are closely related to the true diphtheria bacillus, and which must be distinguished from it, are the non-pathogenic B. xerosis and the avirulent diphtheroid bacillus. But since morphological and cultural differences are of doubtful value in separating the virulent from the non-virulent forms, inoculation experiments are necessary to establish an accurate diagnosis.

Microscopically the false membrane consists of a fibrinous network containing leucocytes, a few epithelial cells, and often micro-organisms. In the so-called croupous cases the underlying epithelium may or may not be adherent to the false membrane, but even in the latter event, although the epithelium separates along with the membrane, the surface left is smooth and becomes covered by regenerated epithelium, so that no trace of scarring occurs.

On the other hand, in the severe or diphtheritic cases the submucous tissue is involved in the exudation, the vessels become compressed by it, and this leads to necrosis. When the dead tissue has been cast off a granulating surface is exposed which heals by cicatrisation. These are true granulations in the surgical sense, and are therefore quite different from the granulations of trachoma.

Etiology.—Membranous conjunctivitis in all degrees of severity is met with for the most part in children, more especially in those under four years of age. It often follows an attack of measles or scarlatina, and is frequently accompanied by eczema or by ulcers of the skin in the neighbourhood of the eyes.

One or both eyes may be attacked. It is an acute disease, which occurs sporadically or in epidemics, but a few chronic cases have been seen to last for many months.

Clinically, the mild or croupous form of the disease can readily be distinguished from the severe or diphtheritic; hence they will be described separately, with the understanding that the real

nature of each case can only be decided by careful bacteriological examination.

Croupous Conjunctivitis.—The symptoms are those of catarrhal conjunctivitis, to which in a few days is added the appearance of a greyish pellicle on the palpebral conjunctiva, sometimes also on the retro-tarsal folds, but rarely on the bulbar conjunctiva. The false membrane can be peeled off, leaving a mucous surface underneath which may or may not bleed. The lids, which may be red and swollen, are always soft and easily everted. After a week or so the second or secreting stage sets in, with the appearance of a discharge, and the false membrane becomes separated, leaving a healthy mucous surface which gradually returns to its normal condition, without any trace of scarring. Observations with reference to corneal complications vary, some observers never having seen them, while others have noted them in 40 per cent. of their cases. Constitutional symptoms are much less frequent than in the severe or diphtheritic variety of this affection.

Treatment.—In the first stage iced compresses or Leiter's tubes applied to the lids, with antiseptic cleansing of the conjunctival sac. No caustic should be used in this stage, as it is apt to produce corneal changes. Sulphate of quinine insufflated, or in 2 per cent. solution, is praised by some surgeons as a useful application at this period. In the secreting stage nitrate of silver applications should be made in the usual way.

When the Klebs-Loeffler bacillus is the active agent antitoxin should be used. Simple instillations into the conjunctival sac, with which we have obtained a good result, may suffice in these mild cases. (See Treatment of Diphtheritic Conjunctivitis.)

Diphtheritic Conjunctivitis.—There is no more serious ocular disease than this, for it may destroy the eye in twenty-four hours; while in severe cases treatment is almost powerless. Fortunately it is exceedingly rare in these countries.

The subjective symptoms of its initial stage are similar, although severer, especially in the matter of pain, to those of blennorrhœic conjunctivitis. The objective symptoms differ from those of blennorrhœa, in that the lids are excessively stiff, owing to plastic infiltration of the sub-epithelial and deeper layers of the conjunctiva, while the surface of the mucous membrane is smooth, and of a greyish or pale buff colour. If an attempt be made to peel off some of

the superficial exudation the surface underneath will be found of the same grey colour, not red and vascular, as in croupous conjunctivitis. Ulcers of the skin covered with a greyish membrane are often present on the eyelids and cheek, or round the nostrils or lips, and the preauricular glands are enlarged. This *stage of infiltration* lasts from six to ten days, and constitutes the period of greatest peril to the eye; for while it lasts the nutrition of the cornea must suffer, and sloughing of that organ is extremely apt to take place. Towards the close of the first stage the fibrinous infiltration is eliminated from the eyelids, and the conjunctiva gradually assumes a red and succulent appearance, and at the same time a purulent discharge is established. This constitutes the second or *blennorrhœic stage*. A third stage is formed by *cicatricial* alterations in the mucous membrane, which often lead to symblepharon, or to xerophthalmos; so that, even if the eye escape corneal dangers in the first and second stages, others almost as serious may await it in the final stage.

Corneal complications are most likely to occur in the first stage, and are then also most likely to prove destructive to the eye. The earlier they appear the more dangerous are they. If the blennorrhœic stage come on before corneal complications appear, or even before an ulcer contracted in the first stage has advanced far, they are more easily controlled.

In the third stage corneal affections, if they occur, are of a chronic nature and are generally accompanied by vascularisation.

This disease is nearly always combined with constitutional symptoms, such as fever, malnutrition, albuminuria, and is sometimes fatal; but, strange to say, it is very rarely followed by paralysis, even of accommodation. It has seldom been observed to follow diphtheria of the throat, although the opposite sequence is not uncommon.

Treatment.—If the disease be due to the Klebs-Loeffler bacillus, antitoxin serum is the sovereign remedy, and as the identification of the diphtheria bacillus takes time, any presumption of its presence should be acted upon without delay. The injections may be given under the skin of the eyelids, and instillations into the conjunctival sac may be made as well. Precautions should of course be taken to avoid the transference of the disease to other persons. In cases caused by the pneumococcus,

Römer's pneumococcus serum [1] may be used. These remarks also apply to croupous conjunctivitis.

Local treatment in the first stage should consist in cold or iced applications and antiseptics; later on warm fomentations, especially if the patient finds them more agreeable, can with advantage be substituted for the cold. In the secreting stage the same lines of treatment should be followed as in catarrhal conjunctivitis, except that greater precaution should be taken in using nitrate of silver; the greater the discharge the more freely it may be applied. Corneal ulcers must be dealt with, whenever they arise, in the same way as though the case were one of blennorrhœic conjunctivitis. When the purulent discharge ceases, solutions of soda, milk, or glycerine may be prescribed as lotions for the conjunctiva, to arrest, if possible, the xerophthalmos.

* **Hay Fever.**—This is not uncommon among the better classes in these countries, although it is rarely seen in our hospital patients. The symptoms, in those liable to it, appear in the early summer each year, and disappear again in the course of six weeks or two months. They consist in catarrh of the nostrils, accompanied by great itching of them and frequent sneezing; while the conjunctiva, especially in the lower fornix, becomes somewhat hyperæmic, and there is lacrimation. There is excessive itching of the eyes, which renders the patient most wretched, and compels him to rub his eyes violently. There is photophobia. The respiratory tract may become involved, with some bronchitis and asthma, and general malaise and elevation of temperature are present. Sometimes the eyes alone are affected. There is no tendency to corneal complications.

Treatment is of no avail in preventing the annual recurrence of the affection, nor is it of much use in alleviating the attack. No strong local application should be employed. Weak collyria, or ointments, of sulphate of zinc, or copper, boric acid, or sublimate, etc., may be tried. Adrenaline, cocaine, or holocaine eye drops (2 per cent.) afford the best relief. Dark glasses should be worn.

Dunbar's hay fever serum, called pollantine, has been used with benefit in some cases.

Trachoma (*τραχύς, rough*), **Granular Conjunctivitis,** or **Granu-**

[1] *Archiv für Augenheilk,* lii. p. 1.

lar Ophthalmia (also called Egyptian Ophthalmia and Military Ophthalmia).—In this disease, in addition to the usual appearances of simple conjunctivitis, there are developed translucent greyish or pinkish-grey bodies about the size of the head of a pin or larger, situated in and close to the fornix conjunctivæ, chiefly of the upper lid. They also occur on the tarsus, in the lower fornix, and sometimes on the plica semilunaris, but are very rarely met with on the bulbar conjunctiva. The tarsal growths are smaller, flatter, and yellower in colour than those seen in the fornix. These bodies are the trachoma bodies or granulations, or "sago grains," they somewhat resemble the follicles of follicular conjunctivitis, except that they are paler, more irregular in size and less apt to occur in rows.

Microscopically they exhibit the structure of *lymphoid follicles*, and consist of an outer zone of small lymphocytes and a central mass of larger endothelioid cells, amongst which some very large cells are found with irregular processes and cell-inclusions. These are the so-called "trachoma cells" or "corpuscle cells"; they are supposed to be phagocytes or enlarged connective tissue cells, and have even erroneously been taken for protozoa, but since they exist in normal lymph follicles in other places, they are not in any sense specific. The cellular elements of the follicle lie in the meshes of a delicate reticulum, the follicle itself being surrounded by a vascular network and a more or less defined capsule.

The unevenness of the conjunctival surface is still further increased by a luxuriant formation of *papillæ* due to the folding of the inflamed and hypertrophied mucous membrane, which also leads to the development of microscopic glands and later on of small cysts. The latter are met with in the furrows between the papillæ, or they may be produced by solid downgrowths of epithelium, which become softened in the centre. The follicles ultimately become absorbed, or soften, and, according to Raehlmann, extrude their contents on the surface. In any case their disappearance is followed by the development of fibrous cicatricial tissue, from the shrinking of which various complications, which will be mentioned later on, ensue. The tarsus may be involved in the inflammation, and in many cases a vascular, richly cellular layer called *pannus* forms in the cornea between the epithelium and Bowman's membrane.

Etiology and Cause.—There can be no doubt but that this disease is contagious, and that it is the result of a specific cause, the nature of which will probably soon be established. Within the last three years, by a method of staining similar to that which is used to demonstrate the presence of the spirochætæ of syphilis, peculiar cell-inclusions have been found in the epithelial cells, in smear preparations. The secretion or scrapings must be taken from recent untreated cases, as the cell-inclusions are not found in old cicatricial cases and rapidly disappear, at least from the surface, under treatment. The appearance which they present varies in different stages. Fig. 30 (from an original drawing, for which we are indebted to the kindness of Professor Greeff, one of the discoverers of these cell-inclusions) illustrates one of the most characteristic stages. Close to the nucleus of the epithelial cell is a cluster of minute rose-coloured granules resembling very minute cocci. In a later stage they may be found lying free outside the cells. The nature of these fine granules has not, however, been ascertained, and their causative relation to granular ophthalmia has not been established. It was at first supposed to have been demonstrated that they were only to be found in trachoma, and not in any other variety of conjunctivitis; and they were observed in the conjunctival follicles produced in anthropoid apes by the inoculation of material obtained from cases of trachoma. As regards the nature of the granules, some of the first observers were inclined to look upon them as protozoa, while the majority held them to be minute micro-organisms. Unfortunately it has not yet been possible to isolate or cultivate them, and hence no pure cultures have been obtained with which to perform experiments. More recently, similar cell inclusions have been found in non-gonococcal forms of ophthalmia neonatorum (and even in the normal conjunctiva), and for this and other reasons the theory has been advanced that these minute bodies are an involution form of the gonococcus. So the matter rests for the present.

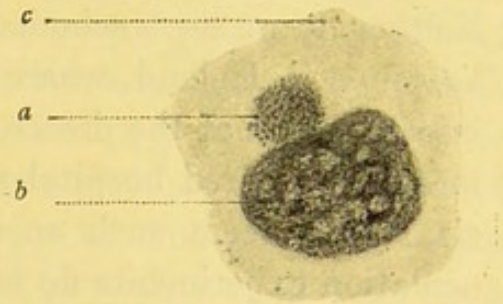


FIG. 30.—Epithelial cell from the conjunctiva of a case of trachoma.

(*a*) cell inclusions, forming a cluster in the protoplasm of the cell, close to the nucleus (*b*), (*c*) isolated granules.

The histological changes are not peculiar to this disease alone —the papillary hypertrophy is well seen in chronic blennorrhœa, for instance—and even lymph follicles occur from other causes; for example, from atropine irritation and in tuberculosis. Infection occurs only by transference of the secretion from one eye to the other by means of fingers, towels, handkerchiefs, etc. Hence the more slovenly in their personal habits, and the more crowded in their dwellings, schools, or barracks nations may be, the more likely is this disease to spread from one individual to another when it once gains a foothold. A great deal, however, remains to be learned as to the manner in which contagion takes place. The infectiousness of chronic cases cannot be very great, for nurses and doctors rarely, if ever, become infected by their patients. Neither do we see trachoma patients infecting other patients in the hospitals in Ireland, where the disease is so prevalent. Were the infectiousness of the disease very great, even the precautions taken in a well-ordered hospital against contagion would hardly be sufficient to prevent such an occurrence occasionally. Moreover, inoculation experiments do not always succeed.

Amongst the better classes, both here and elsewhere, the disease is very uncommon. Even the poor in high, dry, mountainous countries are almost free from it, so that, probably, the atmospheric conditions play some part in the etiology.

Some hold that the affection is dependent on constitutional disease, such as scrofula, tuberculosis, syphilis, etc.; but we cannot endorse this view. No doubt many of these patients are anæmic and out of health, but this is due to the moping habits they contract, and the little open-air exercise they take in consequence of their semi-blindness.

The effect of race as a predisposing cause is doubtful. Jews are said to be peculiarly liable to the disease, but it must be remarked that in them as in others it only occurs amongst the very poor.

Trachoma generally attacks both eyes and is an extremely chronic affection. An acute form is described, which, however, must be very rare, as it is practically non-existent in Ireland, although the chronic variety of the disease is so common here.

Acute Trachoma, or *Acute Granular Ophthalmia*.—The symptoms are those of a more or less acute purulent ophthalmia, associated

with the characteristic appearances of trachoma. But it has been proved in many cases that the acute symptoms are really due to an additional infection by the gonococcus or Koch-Weeks bacillus, and therefore the diagnosis of acute trachoma cannot be depended upon without a careful bacteriological examination.

Treatment.—In the early stage the treatment is the same as for acute blennorrhœa, while at a later period the same methods are adopted as in chronic trachoma.

Chronic Trachoma, or *Chronic Granular Ophthalmia.*—This disease is often unaccompanied by inflammation, and is then unattended by any distressing symptoms, except that the eye may be more easily irritated by exposure to cold winds, foreign bodies, etc., or more easily wearied by reading and other near work. At this period the conjunctiva will be found free from injection or swelling; but greyish-white semi-transparent trachoma bodies, of the size of a rape-seed and less, may be found in the upper fornix, sometimes only by careful examination, or again, they may be seen disseminated over the conjunctival surface of the upper lid, and protruding from it. Gradually these trachoma bodies or granulations give rise to a more or less active vascular reaction, attended with swelling of the papillæ and purulent discharge—in short, slight blennorrhœa. This is the *stage of progression* (Fig. 31). The patients then begin to be

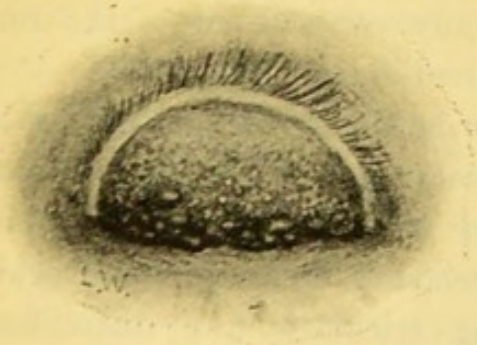


FIG. 31.—Granular ophthalmia; progressive stage.

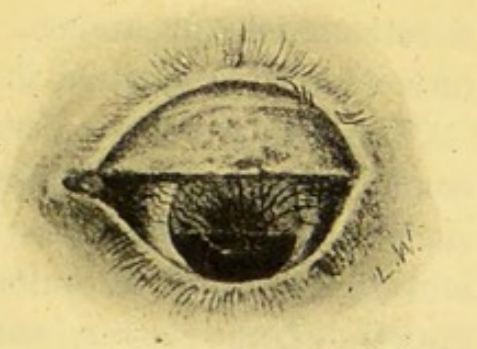


FIG. 32.—Granular ophthalmia; cicatricial stage, with pannus and trichiasis.

more inconvenienced, owing to the discharge which obscures their vision, to sensations of weight in the lids and of foreign bodies in the eye, and to partial ptosis, which is often observable; and this, consequently, is generally the earliest stage at which we see the disease.

The enlarged papillæ often grow to a great size, completely hiding the granulations, constituting what is known as the "papillary form" of the disease. In this stage the granulations may become absorbed, and the disease undergo cure; but more commonly it makes further progress. Fresh granulations appear, while the old ones increase in size and undergo a peculiar gelatinous change. They then often become confluent, leaving only here and there an island of vascular mucous membrane. Sometimes the trachoma bodies are very small, and present the appearances of minute yellowish dots, and in this form they are not always easily found.

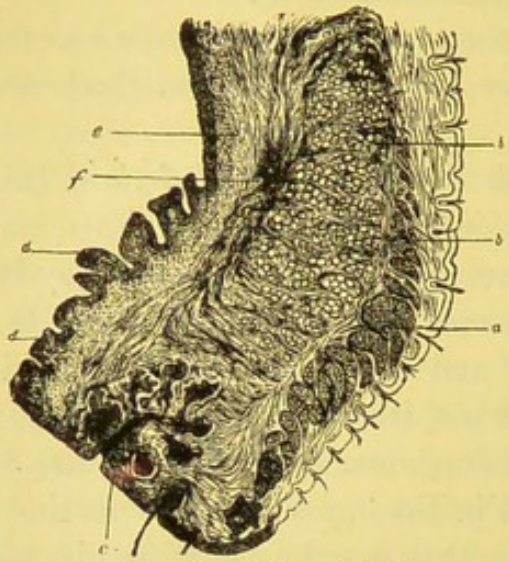


FIG. 33. (*Sœmisch.*)
Section of a trachomatous eyelid.
a, Muscle; *b b*, Tarsus having undergone fatty degeneration; *c*, Atrophied Meibomian Gland; *d d*, Hypertrophied Papilla; *e*, Cicatricial Tissue in the conjunctiva; *f*, Tarsus.

Gradually the follicles become absorbed, or more rarely their contents are expelled, and the connective tissue proliferates so as to cause more or less extensive scarring of the conjunctiva. This constitutes *the cicatricial stage* of the disease. The scarring frequently presents a reticulated appearance, and in many cases assumes the form of a white line situated in the subtarsal sulcus, Fig. 32.

The tarsus may undergo fatty or hyaline degeneration or become hypertrophied, while the diseased conjunctiva on the inner surface of the lid causes curving of the tarsus with entropion and distortion of the bulbs of the eyelashes, followed by irregular growth of the latter, with resulting trichiasis and distichiasis. These changes are represented in Fig. 33. The bulbar conjunctiva may become atrophied, cease to secrete, and become dried, giving rise to xerosis. In consequence also of the shrinking of the conjunctiva, the fornices may become partially or wholly obliterated, thus causing symblepharon (adhesion of the eyelids to the eyeball).

The great danger of granular ophthalmia lies in the complications which may attend it, or which follow in its wake; the former are

pannus, ulcers of the cornea, and severe purulent conjunctivitis, while the latter are the distortions of the lids and eyelashes just referred to.

Pannus (*Lat.* a cloth rag) presents the appearance (Fig. 32) of a superficial vascularisation of the cornea, with more or less diffuse opacity, and often small infiltrations. The new vessels can be seen to grow in from the conjunctiva. It invariably commences in the upper portion of the cornea, extending generally over the upper half, and frequently remains confined to this region. But in many cases, at a later stage, it extends over the whole surface of the cornea; this latter occurrence often takes place almost suddenly, and the vascularisation and opacity sometimes become so intense as to present quite a fleshy appearance, completely hiding the corresponding part of the iris from view. Histologically, pannus consists of a new growth, which is extremely rich in cells, and which closely resembles the conjunctiva when occupied with confluent granulations. It is in fact a vascular granulation tissue, which grows in from the limbus, and is situated between the corneal epithelium and Bowman's layer. After a length of time Bowman's layer becomes destroyed in places, and then the cellular infiltration gains access to the true cornea, and gives rise to permanent changes in its transparency and curvature. In some bad cases of old-standing pannus the latter undergoes a connective-tissue change. It then becomes smooth on the surface, and the vessels almost disappear, so that the cornea is covered with a thin layer of connective tissue, which obstructs the passage of light and is not capable of cure. Small ulcers, and sometimes white deposits, are liable to form at the lower edge of the pannus near the centre of the cornea. These deposits are superficial, and can be easily scraped off.

Another result of pannus, sometimes seen, is a bulging or staphylomatous condition of the cornea, the tissues of which have become so altered and weakened that they give way before the normal intra-ocular tension.

A pannus in which as yet there is no connective tissue alteration, and where there is no staphylomatous bulging, is capable of undergoing cure without leaving any opacity behind, except that which may be due to ulcers that have been present.

Pannus is usually a painless affection, but is sometimes accompanied by photophobia and ciliary neuralgia. It may come on at

any stage of the disease, and causes defective vision, in proportion to the degree and extent of the opacity. Severe pannus is liable to induce iritis.

The connection between pannus and the condition of the conjunctiva is not altogether evident. It was for long held that the corneal affection is due to mechanical irritation, caused by the rough palpebral conjunctiva; but some are opposed to this view, and indeed severe pannus is often seen with a comparatively smooth conjunctiva, while with a truly rough conjunctiva the cornea is frequently perfectly clear. There can now be little doubt that pannus is analogous to the granular disease in the conjunctiva. It is, in fact, the same disease modified by reason of the different tissue in which it is situated, this different tissue being itself a modification of the conjunctiva; and it would seem probable that the cornea becomes diseased by direct inoculation from the conjunctiva of the upper lid. Yet it is remarkable that the bulbar conjunctiva, lying between the upper margin of the cornea and the fornix of the upper lid, never becomes apparently diseased.

Prognosis.—At any period prior to cicatrisation of the conjunctiva an attack of purulent blennorrhœa is liable to come on. If not too severe, this may result in a cure by absorption of the trachoma bodies, and should not be checked. If, however, the attack be very severe, the eye runs dangers similar to those of an ordinary attack of purulent conjunctivitis. These dangers are less the more complete and the more intense the pannus.

On the whole, if the disease come under care at an early period, and if treatment be carried out strictly, vision will be retained in a majority of cases, although a radical cure may be difficult or impossible. Patients require to be under constant treatment for long periods, and the very lengthened time, and steady continuous treatment needed for a cure, are probably the main obstacles to that cure. In most cases of chronic granular ophthalmia, attendance three times a week for a year will be required, to effect anything that can be called a cure. The common experience is that patients attend for some weeks, and then, being very considerably relieved of their distressing symptoms, and finding their sight vastly improved, they cease attendance long before the disease has been eliminated, to return after a brief interval with a condition of things as bad as, if not worse than, before. It is therefore desirable at the

very outset of treatment to explain the tedious and dangerous nature of the ailment to each patient.

Treatment.—The aim of this is to bring about the absorption or disappearance of the trachoma bodies with the greatest possible despatch, in order to prevent the destruction of the mucous membrane, to which they tend.

The methods of treatment on which most reliance is placed, either separately or in combination, are :—the application of caustics, mechanical or operative procedures, and the use of jequirity. In conjunction with these, cases attended by inflammatory symptoms and discharge must be treated according to the general principles indicated on p. 50, and antiseptic lotions or sterilised fluids should be used to keep the conjunctiva free from discharge, and a simple ointment should be applied to the eyelids at night. Complications may require to be dealt with by special methods. Attention should be paid to the general health of the patient, and to the hygienic conditions under which he lives, and finally prophylactic measures should be taken to prevent the spread of the disease to other members of the household or community.

1. *Caustics.*—No caustic application should be made with the object of directly destroying the trachoma bodies, for this can be done only at the expense of the mucous membrane around them. The most useful caustics are nitrate of silver and sulphate of copper. For chronic cases, with but little swelling of the papillæ (blennorrhœa), and with little or no cicatrisation, the best application is the solid sulphate of copper lightly applied to the conjunctiva, especially at its fornix ; but when there is considerable papillary swelling or discharge, a 2 per cent. solution of nitrate of silver, or a light application of mitigated lapis, neutralised with salt solution, is to be preferred. Should there be ulcers on the cornea, or much inflammatory irritation of the eye, sulphate of copper should not be applied to the conjunctiva. An interval of twenty-four hours at least should be allowed to elapse between each application, whether of sulphate of copper or nitrate of silver, and cold sponging for fifteen minutes should be employed immediately after the application. A change of treatment will be occasionally required, even if the remedy first used answer well in the beginning, and one or other of the following can be adopted. Pure liquefied carbolic acid has been used with good result, but we have no experience of

it. It is applied with a camel's-hair pencil, and the excess washed off with plain water. Solution of sublimate, 1 in 1000, or even 1 in 500, applied with lint or cotton-wool to the everted conjunctiva with some pressure and rubbing. Alum, in the solid form, is also used in the same way, and in the same class of cases, as sulphate of copper. Ointments of copper sulphate ($\frac{1}{2}$ to 1 per cent.) or copper citrate (10 per cent.) are sometimes employed, but they are not so active as the crystal.

2. *Mechanical and Operative treatment.*—The best of these procedures are: expression, which aims at evacuating the granulations, and excision of the fornix, by which those situated in that region are removed *en masse*. Expression was formerly practised by the late Sir William Wilde of Dublin, who squeezed out the granulations between the thumb nails. The present day proceeding is carried out aseptically by means of Knapp's roller forceps, or better still

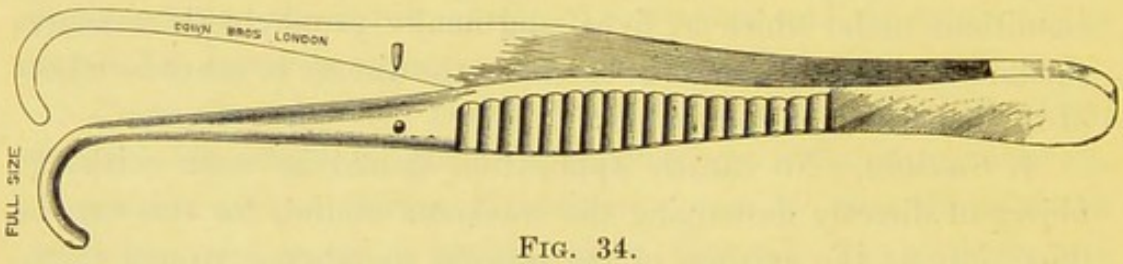


FIG. 34.

with Graddy's forceps (Fig. 34). Similar but smaller instruments are also made for the purpose of reaching the inner and outer angles of the lids, where it is difficult to apply the larger ones. The operation is very painful, and general anæsthesia may be necessary. The retro-tarsal fold of the everted lower or upper lid is grasped as far back as possible between the blades of the instrument, compressed and drawn upon, and in this way the trachomatous tissue is squeezed out with little or no laceration of the conjunctiva. The instrument has to be re-inserted and a neighbouring part of the conjunctiva treated in the same way, and so on, until the whole conjunctiva of each affected eyelid has been operated on. The four eyelids may be manipulated at one sitting, and the evacuation should be as complete as possible. Particular care should be taken to reach the part of the conjunctiva which is hidden under the commissures. Some cases are immediately and permanently cured by this operation; while others, although greatly benefited,

will still require further routine treatment with local remedies. Expression is indicated only where trachomatous substance can be pressed out. Our experience with this method leads us to regard it as a very useful one for the acceleration of the cure of recent cases, some of which we have seen to recover with scarcely any trace of scarring. We often apply silver nitrate immediately after expression.

Excision of the upper fornix of the conjunctiva is largely practised by some surgeons. It is claimed for this method that it shortens the treatment of all forms of the disease; that, after it, existing corneal processes undergo rapid cure; that the granular disease in the palpebral conjunctiva, although not directly included in the operation, disappears quickly; that recurrences of the disease are rarer than by other plans of treatment; and that the resulting linear cicatrix has no serious consequence, and is as nothing when compared with the extensive cicatricial degeneration of the whole mucous membrane which the operation is calculated to prevent. In order to avoid cicatricial contraction care should be taken during the operation, that sufficient mucous membrane be left to completely cover the globe when the patient looks down. Supplemental treatment with the customary local applications is employed until the cure is obtained. We find this an exceedingly useful procedure in some cases. When the tarsus is much thickened Kuhnt advises a partial or complete excision of it, including the conjunctiva over it, if the latter be diseased.

Other mechanical methods are: scarification, scraping with a sharp spoon, brushing the conjunctiva with a metallic or stiff tooth brush, followed by a rubbing with (1 in 500) solution of corrosive sublimate, electro-cautery, and electrolysis.

3. Infusion of Jequirity (*Abrus precatorius*, Paternoster Bean), long used in the Brazils, was introduced to the notice of European surgeons by de Wecker. The infusion is made by macerating 154 grains of the decorticised jequirity seeds in 16 oz. of cold water (a 3 per cent. infusion) for twenty-four hours. Twice a day for three days the lids are everted, and the infusion thoroughly rubbed into the conjunctiva with a bit of lint. The result is a severe conjunctivitis with a somewhat croupous tendency (even the cornea being often hidden by the false membrane), accompanied by great swelling of the eyelids, much pain, and considerable constitutional

disturbance, rapid pulse, and temperature of 100°, or more. At first the pannus becomes more visible, but as the inflammation subsides, it diminishes or even disappears, while complete cure of the granular ophthalmia itself is rarer. Iced compresses to the eyelids may be used during the inflammation. A fresh infusion (not more than seven days old) must be employed in order to secure the best reaction. The majority of surgeons, amongst them the authors, find the remedy harmless, if not always successful; but a good many cases are on record where violent diphtheritic conjunctivitis, followed by blennorrhœa of the conjunctiva, and by more or less extensive ulceration of the cornea, and even complete loss of the eye, were produced. We have, occasionally, seen small superficial ulcers form on the cornea without further injury. The presence of a purulent discharge from the conjunctiva is a contra-indication for this treatment, which is then liable to increase the intensity of the blennorrhœa in a dangerous degree. Cases where there is little or no papillary swelling, but nearly dry trachoma with pannus, are the most suitable for its use, and we cannot recommend it too highly in these cases. It is marvellous to see the rapid and effective cures of the severest pannus by this remedy in properly selected cases. But the presence of well-marked pannus of the cornea without ulceration is the only thing that can render the employment of jequirity justifiable, and in addition to this, as stated, the conjunctiva should be free from blennorrhœa.

The occurrence of acute dacryocystitis is said to form an unpleasant complication of the jequirity treatment, even in cases in which the sac was previously quite normal; but we have never seen it to occur.

In our opinion the danger of jequirity ophthalmia can be minimised considerably by taking care, when beginning the treatment, to allow twenty-four hours to elapse before making a second application. One can then gauge the degree of reaction, which is liable to vary with different infusions or with the idiosyncrasy of the patient.

Of late jequiritol,[1] which is a sterilised preparation of Abrin,

[1] P. Römer *Von Græfe's Archiv f. Ophth.* lii. The jequiritol and serum can be obtained from E. Merck, Darmstadt. For hospital use it has the disadvantage of being very much more expensive than jequirity.

the active principle of jequirity, dissolved in glycerine and standardised experimentally, has been used. As it is supplied in four different strengths its action can, to a certain extent, be controlled, and if the reaction be too great, Jequiritol-serum can be used to check it, either by simple instillation into the conjunctival sac, or by subcutaneous injection. Although it is safer than jequirity, nevertheless ulcers of the cornea and dacryocystitis have also been observed after its use. We, as well as others, find that strengths number I. and II. produce little or no effect ; but their employment at first may render the stronger solutions less dangerous.

After the subsidence of the jequirity inflammation some of the local remedies, above referred to, should be regularly applied for the purpose of completing the cure of the conjunctival condition.

4. *Treatment of complications.*—Where pannus is present, an occasional drop of atropine should be instilled, in order to control the tendency to iritis ; but pannus in itself requires no special treatment unless it persists after the conjunctival disease has entered the cicatricial stage, when, as stated above, jequirity is of service.

The operation of peritomy may also be performed for pannus. It consists in the excision of a portion of the conjunctiva, about 5 mm. broad, around the corneal margin. Destruction of the vessels with the actual cautery is sometimes useful in the treatment of pannus.

Ulcers of the cornea, if small, require no additional treatment beyond atropine ; but if severe must be dealt with accordingly. (See chap. v.) Sometimes small white spots resembling lead deposits form in the centre of the cornea ; they are quite superficial, and can be easily removed with the point of a knife.

Diplobacillary conjunctivitis is not a very uncommon complication of trachoma, but when it occurs the patients do not always present the well-known appearances of angular conjunctivitis. In such cases sulphate of zinc relieves the acute symptoms considerably.

If the upper lid be tightly pressed on the globe, as it sometimes is, the physiological lid-pressure varying in different individuals, an impediment is offered to the cure by any method, and pannus is promoted. It is then necessary to relieve the pressure by a canthoplastic operation. (See chap. xvii.)

The treatment of xerophthalmia, entropion, and such-like sequelæ are described under their respective headings.

Opinions differ as to the value of the treatment of trachoma by X-rays, radium, and high frequency currents. Carbon dioxide snow is also being used at present.

In addition to the local treatment it is of great importance that the hygienic surroundings of patients suffering from granular ophthalmia be seen to, and that they be obliged to spend a considerable time daily in the open air.

As regards *Prophylaxis*, patients should be warned of the danger of infecting others. They should sleep by themselves in well-ventilated rooms, observe habits of cleanliness, and have separate towels, etc. Schools and public institutions should be inspected, and if there be any cases of granular ophthalmia present, an examination should be made of all the inmates, and all persons affected with the disease as well as suspicious cases should be isolated.

Follicular Conjunctivitis.—This variety of conjunctivitis is characterised by a catarrhal inflammation of a mild type, to which is added the presence in the conjunctiva of small round greyish or yellowish-pink bodies the size of a pin's head, which disappear completely as the process passes off, leaving the mucous membrane as healthy as they found it. These little bodies are situated chiefly in the lower fornix of the conjunctiva, and may be discovered by eversion of the lower lid, when they will be seen arranged in rows parallel to the margin of the lid. Whether they are easily discovered or not depends on their size and number, and on the amount of co-existing hyperæmia or chemosis of the conjunctiva. The structure of these bodies shows them to be lymph follicles.

Follicular conjunctivitis usually attacks both eyes, and is a tedious affection, lasting often for months. It is met with chiefly in children, and most frequently in schools. Systematic examinations of the conjunctiva in schools have shown that a very large number of the children have follicles in the lower fornix, and occasionally they may be seen in the upper lids towards the angles. In some cases post-nasal adenoids are associated with them. The conjunctiva is otherwise normal and in these cases the follicles produce no irritation or distress of any kind. To this condition the name "Folliculosis" is sometimes given, and it is believed that it renders the eye more liable to catarrhal infection. When this occurs, follicular conjunctivitis is the result.

The existence of lymph follicles in the normal conjunctiva is disputed, and it is of course possible that, in cases in which they are found, their presence may be explained by the repeated but transient irritation, to which the conjunctiva, from its exposed position, is constantly liable.

Considerable difference of opinion prevails as to the relation of this disease to trachoma, some believing that it is merely a mild or aborted form of the latter. The question cannot be definitely settled until the real nature and cause of these two affections are known. Clinically they seem to be distinct, and from our observation in this country, where both are common, there are no practical reasons for regarding them as different forms merely of the same disease. The chief points of difference between them are :—Follicular conjunctivitis affects children, even in the upper-class schools ; trachoma occurs at all ages, but mostly in adults, and is confined to the lower classes. In follicular conjunctivitis the follicles are, with rare exceptions, confined to the lower lid ; they are more uniform in size and more regular in their arrangement than in trachoma ; furthermore they never produce cicatrices, pannus, or any of the ill effects which follow trachoma.

The Symptoms are much the same as those of catarrhal conjunctivitis. Frequently there is little or no injection of the bulbar conjunctiva, and the chief symptom is asthenopia—an inability to continue near work for any length of time—and much distress in artificial light.

Causes.—These are much the same as in simple catarrhal conjunctivitis. The long-continued use either of atropine or of eserine is liable to bring on the disease.

Treatment.—The most useful remedy in this troublesome affection is an ointment of sulphate or citrate of copper of from gr. ss. to gr. ij in ʒj of vaseline. The weaker ointments should be used at first, and later on the stronger ones if it be found that they cause no excessive irritation. The size of half a pea of the ointment is inserted into the conjunctival sac with a glass rod once a day. Eye-drops of equal parts of tincture of opium and distilled water are of use in some cases. Abundance of fresh air, with change from a damp climate or neighbourhood to a dry one, is of importance. If the use of a solution of atropine have induced the disease, it should be discontinued ; and if a mydriatic be still required, a

solution of extract of belladonna (gr. viij ad ℥j) may be employed in its stead.

In cases of folliculosis no local treatment is required. It may be well to add that no alarm need be created in a school on account of the occurrence of follicular conjunctivitis. The utmost that may be necessary is the separation of those cases in which there is much discharge, which might spread the catarrhal inflammation.

*** Parinaud's Conjunctivitis.**—This is a well-defined form of subacute conjunctivitis which may occur at any age. With very rare exceptions it attacks only one eye. It was first described by Parinaud in 1889. The chief features of the disease are :—The appearance of granulations or vegetations on the tarsal conjunctiva or fornices, with painful and considerable enlargement of the pre-auricular and neighbouring glands, on the same side as the affected eye ; the disease is ushered in with chills and malaise ; there is slight mucous, or fibrinous, secretion but no suppuration ; a complete cure results in the course of some months, without any corneal complication or subsequent scarring of the conjunctiva.

The upper lids become swollen and perhaps nodular to the touch, and there is sometimes chemosis ; but the subjective eye-symptoms are slight. The granulations are red or yellowish, and at first semi-transparent, and they vary in size, being at times only as large as the head of a pin, while again they may even form polypoid growths. Small yellow granules and superficial erosions are also often present, generally in the furrows between the large granulations. The glandular inflammation sets in along with, or immediately after, the eye-symptoms, and may end in suppuration. The sub-maxillary and sometimes even the cervical glands are affected. The last symptoms to disappear are ptosis and some amount of glandular enlargement.

Cause.—Up to the present the cause is unknown, and no case of the transmission of the disease to others has been observed. Inoculation experiments have proved unsuccessful. The theory of an animal origin, which was originally advanced, has not been proved. The histological changes according to Verhoeff and Derby, consist in areas of necrosis in the subconjunctival tissue and extensive infiltration with lymphocytes and phagocytes, but no suppuration. The deeper layers are in a state of chronic inflammatory reaction. Hoor, on the other hand, found that the nodules ex-

hibited a tubercular structure, but failed to obtain any evidence of their tubercular nature. The only affections with which this disease is liable to be confounded are trachoma and tuberculosis, from which it can be distinguished by its symptoms and course, as well as by bacteriological methods.

Treatment.—The disease tends to get well without treatment in the course of a few months. Various remedies have been tried, but simple antiseptic treatment is almost sufficient. The duration of the disease may be shortened by excision of any large granulations, or the application of the galvanocautery. If the glands suppurate, they should be opened.

* **Tubercular Disease of the Conjunctiva.**—This disease affects only one eye as a rule, and usually commences in the palpebral conjunctiva of the upper lid or in the upper fornix, and very rarely on the bulbar conjunctiva, in the form of a caseating ulcer, or as an inflammatory new formation of the granuloma type. The granular form occurs in the shape of small yellow or grey subconjunctival nodules, resembling miliary tubercles, or may result in the development of flattened outgrowths, cockscomb-like excrescences, or even pedunculated tumours. The margins of the ulcers are well defined, and their floors either of a yellowish lardaceous appearance, or covered with greyish-red granulations. The surrounding conjunctiva is swollen, and if the palpebral conjunctiva be much involved the lid becomes enlarged in every dimension, and the ulcerative process may soon destroy part of the lid. It is liable also to extend to the bulbar conjunctiva, and the cornea may become covered with pannus. The preauricular and submaxillary glands are usually enlarged. The discovery of the tubercle bacillus would make the diagnosis positive, but as it not infrequently happens that the bacilli elude detection owing to their scarcity, while excised portions of the growths do not always show a typical tubercular structure, one of the various tuberculine tests, or inoculation experiments, may be necessary in order to remove all doubt. The application of one or more of these methods of diagnosis will serve also to distinguish this disease from secondary syphilitic ulceration of the conjunctiva, between which and the tubercular ulceration there is sometimes a resemblance. Moreover, in the syphilitic ulcer the detection of the spirochæta pallida, or the application of Wassermann's test, would decide the diagnosis. The granular form

of tuberculosis may sometimes be suggestive of trachoma, or even of a malignant growth. Tubercular conjunctival disease is usually unattended by pain, or there is only a slight burning sensation; but, again, when the ulceration is extensive, severe pain may set in.

The disease is very chronic, its progress sometimes extending over many years. It is rarely met with except in youth. Some of those whose eyes are attacked are already the subjects of tuberculosis in other organs, but very many of them are perfectly healthy in that respect. In fact, there is reason to believe that tuberculosis of the conjunctiva is much more often a primary disease, the result of an ectogenic infection, even in cases where already tuberculosis exists elsewhere, than of infection occurring through the blood. Tubercle bacilli introduced into the normal conjunctival sac have, it is true, been found to be harmless, for the intact epithelium offers an insuperable obstacle to their entrance into the tissue. But a superficial loss of substance of the conjunctiva is sufficient to allow of its inoculation with the bacilli, and then the disease becomes established. The frequent lodgment of foreign bodies under the upper lid explains why this is the situation in which the disease most commonly begins. But although conjunctival tubercular disease is not often secondary to tubercular disease in other parts of the system, yet it is itself liable to be the starting-point of general tuberculosis.

Treatment.—The fact last mentioned makes it most important, in cases of primary tubercular disease of the conjunctiva, to thoroughly eradicate the diseased focus so as to avert infection of other organs, and this can often be effected. If the ulcers be not already too extensive they must be curetted, and the actual cautery freely applied. They may then be dusted with iodoform or lactic acid may be applied pure or in 50 per cent. solutions. Injections of tuberculin are also useful (see chap. vii.).

* **Ophthalmia Nodosa.**—This disease is caused by the irritation (chemical or mechanical) of the hairs of certain kinds of caterpillars. The hairs give rise to 'foreign body' granulomata, which appear as small nodules chiefly on the lower part of the bulbar conjunctiva. Both clinically and microscopically the condition bears a resemblance to tuberculosis, hence it has also been called pseudo-tubercular conjunctivitis. The presence of the hairs makes the diagnosis positive. In nearly all the recorded cases there was a history of

caterpillars having accidentally come into forcible contact with the eye. The nodules are small, semi-translucent, and reddish or yellowish grey in colour. The disease is chronic, as the elimination or absorption of the hairs takes some time, but it terminates in complete recovery, unless the hairs have made their way into the iris, in which case a severe iridocyclitis may be set up.

* **Lupus** of the conjunctiva usually occurs as an extension of the disease from the surrounding skin, or rarely from the lacrimal sac. It is seen as a patch or patches of ulceration, covered with small dark-red protuberances or granulations, chiefly on the palpebral conjunctiva, which bleed easily on being touched.

Like lupus of the skin, these ulcerations undergo spontaneous healing and cicatrisation in one place (unlike tubercular ulceration in that respect), while they are still creeping over the surface in another direction. But it is now known that lupus, wherever it may occur, is a tubercular disease, and that the two forms differ only in their clinical aspect.

Treatment.—Scraping with a sharp spoon, and the application of the actual cautery. Iodoform. Tuberculin. X-rays.

* **Syphilitic Disease of the Conjunctiva** occurs both as primary and as secondary disease. It will be treated of in chap. xvii., on Diseases of the Eyelids.

Ulcers of the Conjunctiva.—In addition to tubercular and syphilitic ulcers, the following conditions may lead to ulceration of the conjunctiva :—Injuries, foreign bodies, the separation of sloughs or membranes, pemphigus, epithelioma, smallpox ; phlyctens also appear as small superficial ulcers on the bulbar conjunctiva at one stage of their existence.

* **Spring Catarrh,** or **Vernal Conjunctivitis.**—In this extremely chronic but rather rare disease, the tarsal conjunctiva of the upper lid is invaded by hard flattened bodies of a pale pinkish colour arranged close together, and known as tesselated or pavement granulations (Fig. 35). They are often slightly pedunculated. The conjunctiva assumes a milky-white opalescence. The bulbar conjunctiva becomes injected, slightly œdematous, and at the limbus somewhat elevated with hard, gelatinous-looking and nodular greyish swellings (Fig. 36). The lower palpebral conjunctiva is often milky-looking, but never shows granulations. All these appearances may be present in the same case, or any one (the bulbar

appearances, or the pavement granulations, or the milky-white opacity) or two of them may be absent. The margin of the cornea itself is apt to be invaded (Fig. 36) with a more or less circular infiltration resembling arcus senilis. Very occasionally the cornea becomes seriously implicated owing to the growth on the limbus extending over a great portion, or even over the entire cornea. There is a scanty mucous or muco-purulent secretion, and the patient may complain of the eyelids being stuck together in the morning, of difficulty of using the eyes for near work, of itching and burning sensations, and all these symptoms are increased by exposure to heat. The eyelids droop slightly, giving the patient a sleepy look.

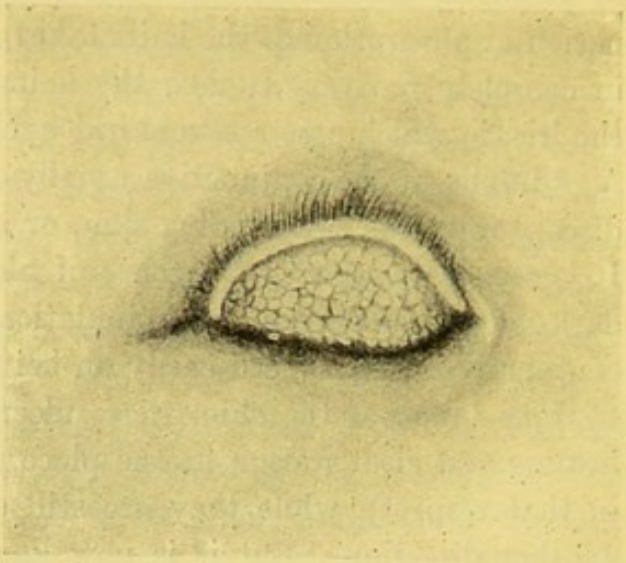


FIG. 35.—Spring catarrh. Upper lid everted. From sketch by L. W.

Strictly speaking the disease is not a catarrh. The condition of the upper lid might at first suggest granular ophthalmia. The pathological changes consist in hypertrophy and hyaline degeneration of the subconjunctival tissue, and proliferation of the epithelium, which sends solid or cystic processes into the stroma. It is still uncertain which of these is the primary change. The conjunctival secretion is very rich in eosinophil cells, a point which would assist the diagnosis in doubtful cases.

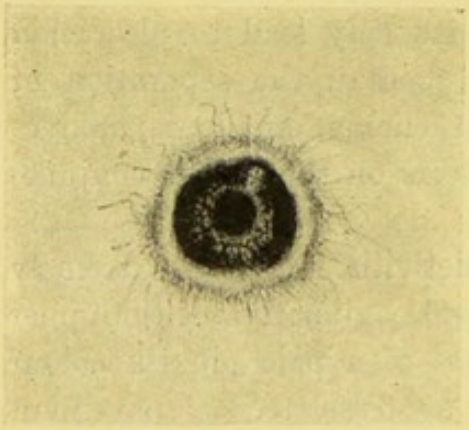


FIG. 36.—Circumcorneal growth in spring catarrh. Sketched by L. W.

The affection is chiefly met with in boys between six years of age and puberty, and is in most cases bilateral. The patients sometimes look anæmic, and have in many cases enlarged lymphatic glands. Blood changes are

often present, and consist not so much in an absolute increase of the white corpuscles, as in a relative increase of lymphocytes.

The disease makes its appearance with the advent of warm weather in the late spring or early summer, and generally disappears, or is much modified, in the cool seasons, to return again with the next warm season, and this is liable to go on for many years. In the intervals between the attacks the congestion and subjective symptoms disappear, but the other appearances persist until recovery sets in.

This disease has been attributed to the action of strong light, or to ultra-violet rays, and protection from light certainly improves some cases ; yet exposure to snow in high altitudes where the light is particularly strong is also beneficial owing to the cool atmosphere. The cause of the disease is really unknown.

The Treatment of the majority of these cases yields unsatisfactory results. Protection glasses should be worn. So far as possible all exposure to heat of sun or artificial light should be avoided. If possible the patients should reside in a cool place in the summer. Weak astringent collyria, or ointments, may be used ; or iodoform ointment (1 in 15), a little put into the eye once a day ; or massage twice daily in conjunction with yellow oxide ointment. Dilute acetic acid 1 or 2 minims to the ℥j is also recommended. De Schweinitz recommends boroglyceride locally, and arsenic internally. Antipyrin and quinine internally have proved of use in some cases. For the tarsal granulations Theobald has found marked benefit from use of the roller forceps. Strong salicylic acid ointment (20 grs.—℥j) has been recommended, but we have tried it without much effect. Adrenalin drops have proved very beneficial in some cases, and some good results have been obtained with radium.

* **Hyaline, Colloid, and Amyloid Degeneration.**—This very rare disease is a primary affection of the conjunctiva, and is not associated with amyloid disease in any other part of the system. It has been found combined with granular ophthalmia, but this was most likely due to a fortuitous coincidence of the two diseases. It is most frequently met with in patients between twenty and twenty-five years of age, generally in one eye only, and it is extremely chronic, lasting for years. The retro-tarsal folds and palpebral conjunctiva are chiefly attacked, but it may also involve the bulbar portion. It causes great tumefaction of the affected lid, without

any inflammatory symptoms. The eyelid can be but partially elevated, and is often so stiff and hard that it can only be everted with difficulty. The conjunctiva is yellowish, wax-like, non-vascular, and friable. The disease ultimately extends to the tarsus.

Microscopically, homogeneous masses are found in the conjunctiva, with variable staining properties, according to which they are called Amyloid, Hyaline, or Colloid. Calcification occurs in the later stages. Ræhlmann believes that the amyloid changes are always preceded by lymphoid infiltration. Figs. 37 and 38 are from a case in the Mater hospital which presented the clinical appearance of amyloid disease with the histological structure of a purely lymphoid thickening.

Treatment.—A partial removal of the diseased parts by the knife

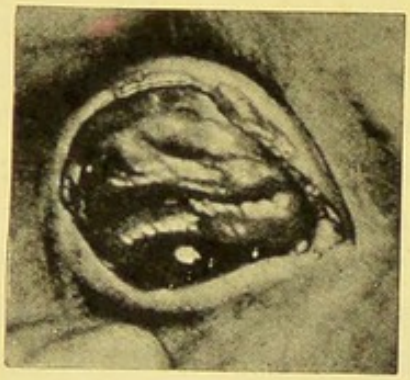


FIG. 37.—Lymphoma of conjunctiva.

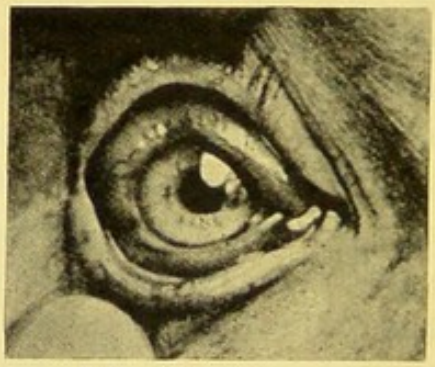


FIG. 38.—Same case as Fig. 37.

or scraping is all that is necessary, as the remainder disappears spontaneously, and further excessive scarring is thus avoided. A very good result was obtained in the above case by this method.

* **Xerosis** (ξηρός, *dry*), or **Xerophthalmos,** is a dry, lustreless condition of the conjunctiva, associated in the severer forms with shrinking of the membrane. There are two forms of the affection —the parenchymatous, which is a local affection, and the epithelial, which is associated with general malnutrition.

In *Parenchymatous Xerophthalmos* there is a more or less extensive cicatricial degeneration of the conjunctiva, dependent upon changes in its deeper layers, while its surface and that of the cornea become dry, and the latter becomes opaque, and the eye consequently sightless. The conjunctiva shrinks so completely, in many of these cases, that both lids are found adherent in their

whole extent to the eyeball, which is exposed merely at the palpebral fissure, where the opaque and lustreless cornea is to be seen. From what remains of the conjunctiva, scales, composed of dry, horny epithelium, fat, etc., peel away, and the lacrimal secretion, which is much diminished in quantity, rolls off the oily surface of the keratinised epithelium. The motions of the eyeball are restricted in proportion to the extent of the conjunctival degeneration. There is no cure for this condition.

Fig. 39 represents a case of xerophthalmos, the result of pemphigus, which occurred in a patient at the Royal Victoria Eye and Ear Hospital. Here the eyelids were not wholly adherent to the eyeball, and the cornea remained clear.

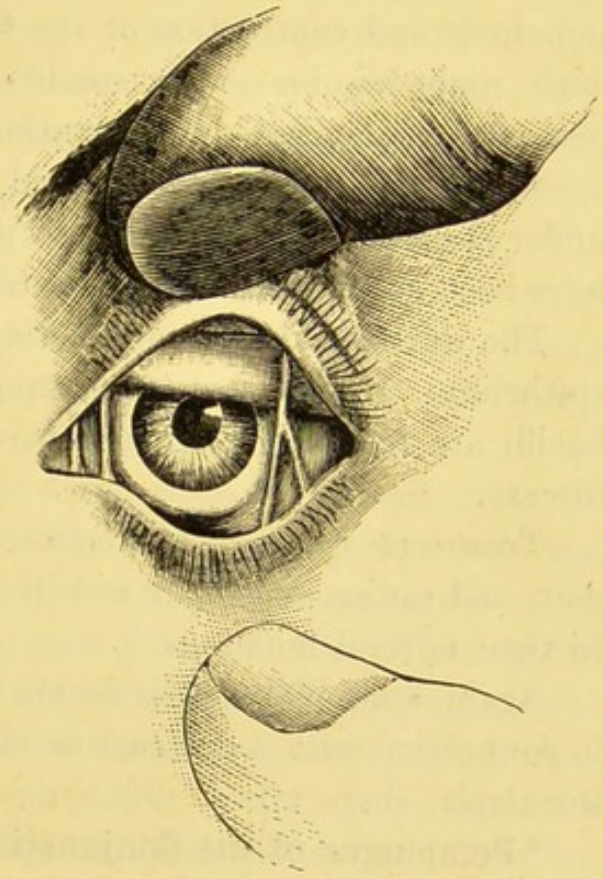


FIG. 39.

The Causes of parenchymatous xerosis of the conjunctiva are granular ophthalmia, diphtheritic ophthalmia, pemphigus, burns, exposure of the eye from exophthalmos, and the condition is said to be very occasionally seen as a primary disease, described as essential shrinking of the conjunctiva. Many observers altogether deny the existence of this primary disease, and maintain that the cases described as being of that nature are merely the result of pemphigus, and we are inclined to agree with this view.

Treatment.—As cure is impossible in this form of xerophthalmos, the only indication is to afford relief, so far as it can be done, from the distressing sensations of dryness of the eyes which are complained of. The best applications are milk, glycerine, olive oil, and weak alkaline solutions, and the eyes should be protected from all irritating influences by protection goggles. Transplantation of mucous membrane, or temporary union of the lids, produces as a rule only a transient improvement.

Epithelial Xerosis of the conjunctiva is confined to the epithelium of that part of the conjunctiva which covers the exposed portion of the sclerotic in the palpebral opening. It there becomes dry and dull and covered with a white foam due to altered Meibomian secretion. The xerotic patches, which are triangular in shape, with the base at the corneal margin, are known as Bitot's Spots. The whole bulbar conjunctiva is loose, and easily thrown into folds by motions of the eyeball, and there may be a good deal of secretion. This form of xerophthalmos often occurs in epidemics, but also sporadically, accompanied by night-blindness (the light-sense unimpaired) and contraction of the field of vision. When combined with night-blindness the condition has been noticed chiefly in persons of debilitated constitution, who have been exposed to strong glares of light, and is said to have appeared in epidemics, under these conditions, in foreign prisons and barracks. Epidemics have been chiefly seen in Russia, especially during the Lenten fasts.

The dryness of the conjunctiva is due to cornification of the epithelium, which the tears cannot properly moisten. Xerosis bacilli are found in large numbers, but are not the cause of the disease.

Treatment by rest, protection from glare of light, nutritious diet, and tonics, especially cod-liver oil, invariably restore the eyes to their normal functions.

Again, epithelial xerosis occurs in very young cachectic children, in connection with a destructive ulceration of the cornea (see Keratomalacia, chap. v.).

* **Pemphigus of the Conjunctiva.**—This is another rare disease. It has been seen in connection with pemphigus vulgaris of other parts of the body, but it also occurs as an independent disease. It is attended by attacks of much pain, photophobia, and lacrimation; and the conjunctiva, at each place where subconjunctival exudation of serum has been situated, undergoes degeneration and cicatricial contraction. Such attacks succeed each other at shorter or longer intervals, for weeks, months, or years, until finally, the entire conjunctiva of each eye may have become destroyed and the eyelids are adherent to the eyeball. The cornea gradually becomes completely opaque, or, having ulcerated, is rendered staphylomatous. In the course of the disease the eyelashes are apt to become turned in on the eyeball, or even entropion may follow.

The lacrimal puncta and canaliculi may become obliterated; and these conditions aggravate the suffering of the patient.

The foregoing is a description of a severe case. In less severe cases the conjunctiva may not be completely destroyed, and the cornea may not be affected.

Bullæ are seldom seen, for the conjunctival epithelium is so delicate that the serous exudation beneath it breaks it down at once. Consequently, the conjunctival surface is found in these cases to be covered by what looks like a membranous deposit, upon removal of which a raw surface is exposed; and these appearances have led to the mistaken diagnoses of croupous and of diphtheritic conjunctivitis. Rarely deep-seated bluish cysts are present. They existed in the case illustrated by Fig. 39.

Treatment is helpless in respect of arresting the progress of the disease, or of restoring sight when lost in consequence of it. The most that can be done is to relieve the distressing symptoms by emollients to the conjunctiva, and by the use of closely fitting goggles, to afford protection from wind, dust, and sun. Internally, arsenic is indicated.

Pinguecula (pinguis, *fat*) is the name given to a small yellowish elevation on the exposed part of the bulbar conjunctiva near the margin of the cornea, usually at its inner side, more rarely at its temporal margin, but sometimes in each place. It is most commonly seen in old people as a triangular patch or rounded tumour. Notwithstanding its name, it contains no fat, but is composed of connective tissue, hyaline deposits, and elastic fibres. It is supposed to be due to the irritation caused by small foreign bodies. It rarely grows to a large size, and requires no treatment unless it become very disfiguring, when it may be removed with forceps and scissors. When an eye becomes congested or ecchymosed, the pinguecula, if present, stands out as a white or yellow patch and may lead in some cases to mistakes in diagnosis.

Pterygium (*πτέρυξ, a wing*).—This is a vascularised thickening of the conjunctiva, triangular in shape, situated most usually to the inside of the cornea, sometimes to its outer side, but never above or below it. The upper and lower margins of the triangle are limited by a shallow depression or fold. The blunt apex of the triangle, or head of the pterygium, lies on the cornea; its base is at the semilunar fold or outer canthus as the case may be, while the neck is

situated at the limbus. The growth frequently, but not always, exhibits a tendency to advance into the cornea, the centre of which it seldom reaches, and yet more rarely does it extend quite across the cornea.

In its early growth the pterygium is somewhat thick and succulent looking, and very vascular; but finally it ceases to grow, and then becomes thin and pale, and this is its retrogressive stage; yet it never entirely disappears. Sight is not affected unless the pterygium extend over the pupillary region of the cornea. A limitation of the motion of the eye to the other side, and consequent diplopia, is sometimes caused by a pterygium; but, for the most part, it is the disfigurement alone which brings these cases to the surgeon.

Cause.—It was formerly believed that the starting-point of a pterygium was an ulcer at the margin of the cornea, which in healing caught a fold of the limbus conjunctivæ and drew it towards the cicatrix, throwing the mucous membrane into a triangular fold. But ulcers are never found at the apex of a true pterygium, and the condition brought about in this manner is known as pseudo-pterygium and differs in many ways from true pterygium. The false pterygium may occur at any part of the circumference of the cornea. It is very variable in shape, is non-progressive, and in most cases a fine probe can be passed under the neck of the growth where it bridges over the limbus. Again, in a false pterygium a nebula or leucoma is frequently found at the apex.

Fuchs believes that pterygium develops from a pinguecula, and that the latter causes nutritive changes in the cornea, loosening the superficial lamellæ, and allowing the connective tissue of the limbus to grow in on the cornea.

Pterygium is not a common affection in this country; it is most frequently met with in sandy or dry countries.

Treatment.—Unless the pterygium be very thick, and have invaded the cornea to some extent, or be progressing over the cornea, it is well to let it alone; the more so as by removing it a not quite normal appearance is given to the eye, for a mark is necessarily left both on cornea and conjunctiva. If it be progressive or very disfiguring, it should be removed, other proposed modes of dealing with it being futile. This may be effected either by ligature or excision.

In the method by ligature a strong silk suture is passed through

two needles. The pterygium being raised with a forceps close to the cornea, one needle is passed under it here and the other needle in the same way close to its base, the ligature being drawn half-way through. The thread is cut close behind each needle, thus forming three ligatures, which are respectively tied tight. In four or five days the pterygium comes away.

For excision the apex is seized with a forceps and dissected off either with a scissors or fine scalpel, care being taken not to injure the true cornea ; or a good plan is to pass a strabismus hook under the pterygium when raised up from the sclerotic, and to forcibly separate the corneal portion by drawing the hook under it. The dissection is continued towards the base of the pterygium, where it is finished with two convergent incisions meeting at the base. The mucous membrane in the neighbourhood of the base is separated up somewhat from the sclerotic, and the margins of the conjunctival wound are then brought together with sutures.

Pterygia sometimes recur even after repeated operations, and in rare instances a fleshy mass may be formed which renders the condition of the eye worse than it had been originally. In such an event the growth must be dissected up with a surrounding portion of conjunctiva and reflected towards the canthus, and on the large area of exposed sclera, carefully cleaned, a Thiersch skin graft or a flap of mucous membrane from the lip should be applied ; the flap margins may be inserted under the edges of the conjunctival incision. It is recommended that the graft should be pressed firmly down on the raw surface while the lids are held open for three to five minutes before the bandage is applied. McReynold's operation, which is said to be least likely to be followed by a recurrence, consists in incising the conjunctiva along the lower edge of the pterygium, loosening up the conjunctiva below, and drawing the pterygium when separated from the cornea into the conjunctival pocket so formed by sutures.

* **Lithiasis** consists in the calcification of the secretion of the Meibomian glands, which are seen as small white or yellowish spots not larger than a pin's head in the conjunctiva. There may be one only, or very many. Concretions similar to these but more superficial also occur in the lower fornix ; they are found in the interior of newly formed glands which have become cystic. These concretions often give rise to much conjunctival irritation, and if they

protrude over the surface of the conjunctiva may injure the cornea. Each one—the eye having been cocainised—must be separately removed by a needle, an incision having first been made with it in the conjunctiva over the concretion.

Uric acid deposits have been observed in the palpebral conjunctiva in gouty patients.

* **Conjunctivitis Petrificans.**—Under this title Leber has described a rare and remarkable disease of the conjunctiva. In the course of a brief period, and accompanied by some slight inflammatory reaction, a stony hard, white, chalky substance is deposited, in more or less extensive patches, in the previously healthy conjunctiva, the deposit being scarcely raised over the conjunctival surface. The disease attacks a part of the bulbar or palpebral conjunctiva, and may extend to the intermarginal portion of the eyelid. One or both eyes may be attacked. After a time, which varies from a week to several months, the deposit is thrown off or absorbed, and the affected part suffers either no detriment or there may be slight thickening and shrinking. There is no great tendency to corneal complications, but slight marginal ulcerations, which heal readily, occasionally occur. In one case severe diffuse opacity of the cornea seriously affected the sight. Frequent relapses are liable to take place in the same or in different parts of the conjunctiva, and the whole course of the affection may extend over several years, and then end in complete cure.

No cause has as yet been assigned for this disease, although Leber suspects it to be an ectogenic microbic infection. Warm fomentations, and the careful operative removal from time to time of the chalky scales as they become loosened from the main mass, have been the chief features of the treatment. Local instillations of diphtheria antitoxin were found to give relief to the symptoms in the acute stage, in a case recently recorded; and in another, painting with benzoate of lithium solution (1 in 40) proved very efficacious.

Subconjunctival Ecchymosis (Plate II. Fig. 6).—The rupture of a small subconjunctival vessel in the bulbar conjunctiva, without conjunctivitis, is of frequent occurrence. It suddenly gives a more or less extensive purple hue to the 'white of the eye,' causing the patient much concern. It is common enough as a spontaneous affection in old people, and may be associated with arterio-sclerosis,

but it also occurs in the young, and even in children, from severe straining, as in whooping-cough and vomiting. It is occasionally significant of diabetes. It also occurs sometimes during epileptic fits, and profuse subconjunctival hæmorrhage is occasionally found in cases of fracture of the base of the skull, the blood having made its way along the floor of the orbit. It is of no importance so far as the integrity of the eye is concerned.

Treatment.—The extravasated blood becomes absorbed without treatment, but massage through the lids or dionine may accelerate the process.

Subconjunctival Serous Effusion. Chemosis.—This has been previously alluded to in connection with some forms of conjunctivitis, but it may appear in inflammatory affections of the neighbouring parts (orbit, lacrimal sac, eyelids). A stye for instance is sometimes accompanied by well-marked chemosis. Dionine also produces a serous exudation, which is preceded, however, by an initial stage of congestion. In Bright's disease a slight degree of chemosis often occurs. Tumours of the orbit may also produce chemosis; it is then non-inflammatory and the result of venous stasis. A fistula of the anterior chamber at the limbus can also give rise to a limited chemosis.

Treatment.—As a rule no special treatment is required beyond that of the disease of which it forms a symptom; but if it be excessive the conjunctiva may be snipped with scissors, with very good effect.

Emphysema of the Conjunctiva, when it occurs, is usually associated with emphysema of the lids (see chap. xvii.).

Injuries of the Conjunctiva.—Foreign bodies frequently make their way into the conjunctival sac, and cause much pain, especially if they get under the upper lid, by reason, chiefly, of their coming in contact with the corneal surface during motions of the lid and of the eye. If the foreign body be under the lower lid it will be easily found on drawing down the latter, and, provided it be not actually embedded in the mucous membrane, which is a rare occurrence in the lower lid, it is easily removed with a camel's-hair pencil or with the corner of a soft pocket-handkerchief; but if the foreign body be under the upper lid it is necessary to evert the latter before it is reached. Should the foreign body, which usually lodges in the subtarsal sulcus, be embedded in the conjunctiva it

must be pricked out with the point of a needle or other suitable instrument. For the effect of minute foreign particles, *e.g.* dust, etc., see chronic conjunctivitis (p. 53).

Large foreign bodies, such as a grain of wheat, may lie hidden in the upper fornix for several weeks. We have seen ulceration of the cornea caused in this way, and also cockscomb-like granulations in the fornix.

The conjunctiva is frequently injured in severe wounds of the eyelids or eyeball. The interest and treatment are centred here chiefly on the other important parts, which have been injured. A tear or wound of the conjunctiva (usually of the bulbar portion), when it occasionally occurs without injury to other parts, is in general of very slight moment. If the wound be extensive its edges should be drawn together with a few points of suture; but otherwise healing will take place with the aid simply of a bandage to keep the eye closed for a few days.

A common form of injury, which may involve the conjunctiva alone, is a burn by acid or lime. In the case of a strong acid getting into the eye, if the patient be seen immediately after the occurrence, the whole conjunctival sac should be well washed out with an alkaline solution (1 per cent. soda solution). In the case of lime, after all the larger particles have been most carefully removed from the eye with forceps, a weak solution of a mineral acid may be used for washing out the conjunctival sac; or, as is recommended by some, a solution of sugar as thick as syrup may be poured into the eye. Later, olive or castor oil, or even butter, may be applied, the subsequent treatment being continued with weak sublimate ointment. Cocaine may be employed to relieve the pain. But even in the case of unslaked lime the conjunctiva may be washed with plain water, provided plenty be used and that the operation be done quickly. The heat generated by the slaking of the lime is developed slowly, and further it is the chemical action rather than the heat which is injurious.

In the case of a severe burn of the conjunctiva, the resulting cicatrix is liable to produce a more or less extensive union of the eyelid to the eyeball (Symblepharon), which often interferes with the motion of the latter, or even with vision, if the cornea be obscured. No measures taken during the healing process can prevent symblepharon if the degree of the burn be such as to bring it about.

The relief of symblepharon by operation will be dealt with in chap. xvii., on Diseases of the Eyelids.

Cysts.

* **Simple Cysts** of the conjunctiva are very rare. They appear as clear spherical protuberances of about the size of a pea, seated usually on the bulbar conjunctiva. The walls of the cysts contain but few vessels, are thin, and almost transparent; while for contents they have a clear limpid fluid. These cysts cannot as a rule be moved from their position, because they are adherent to the conjunctiva, which indeed takes part in the formation of their walls. The majority are dilated *lymphatic* vessels, as shown by their endothelial lining. Small beadlike strings of dilated lymphatics are very frequently seen on the bulbar conjunctiva. *Retention cysts* are also developed in Henle's and Krause's glands, as well as in the so-called glands resulting from chronic inflammatory conditions. *Implantation cysts*, due to proliferation of included surface epithelium, occur as the result of injury, and *congenital cysts* are also met with.

Treatment.—The cyst may be dissected out, or it may suffice to abscise its anterior wall, and to scrape or cauterise the interior.

* **Subconjunctival Cysticercus** is a little more common than simple cyst of the conjunctiva. It is distinguished from the latter by its free mobility under the conjunctiva, to which it is not attached; by its thicker and more vascular walls; and, above all, by the presence of a round, white, opaque spot on the anterior surface, first pointed out by Sichel, and looked on by him as pathognomonic of a cysticercus. This spot indicates the position of the receptaculum; and occasionally, when this comes to be placed on the posterior surface of the cyst, it may be difficult, or impossible, to make the diagnosis with certainty, but in doubtful cases the character of the hooklets and the tuberculated cyst-wall will solve the question after the excision.

Treatment.—The cyst may be pushed to one side under the conjunctiva, an incision made in the latter, the cyst then pushed back again, and dissected out through the opening.

* Tumours.

Solid tumours of the conjunctiva may be divided into congenital (Dermoid, Lipoma, Nævus) and acquired. The latter are benign (Papilloma, Angioma, Lymphoma, etc.) or malignant (Epithelioma, Sarcoma).

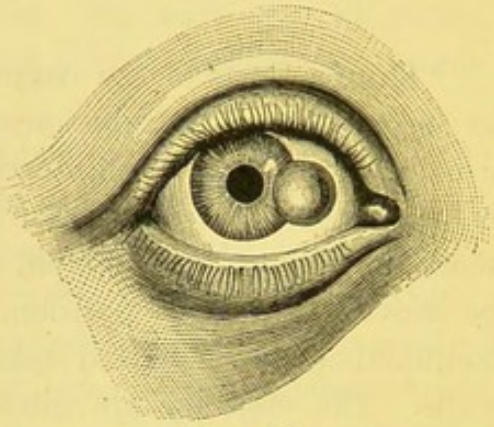


Fig. 40.

*** Dermoid Tumours.**—These are of a pale yellow or white colour, and in size are from that of a split pea to that of a cherry. They are smooth on the surface, dry looking, and sometimes have fine hairs, and sit usually at the outer and lower margin of the cornea; but, in the case illustrated by Fig. 40, the tumour was situated on the inner side of the cornea, extending over somewhat on the latter, and not at the most usual seat. In structure they resemble that of the skin.

They often increase in size at puberty, and the hairs then grow. They are congenital tumours, supposed to be due to an arrest in development, but they often have a tendency to extend over the cornea. If this tendency be present, the tumour must be removed by dissecting it off the cornea, care being taken not to go into the deep layers of the latter.

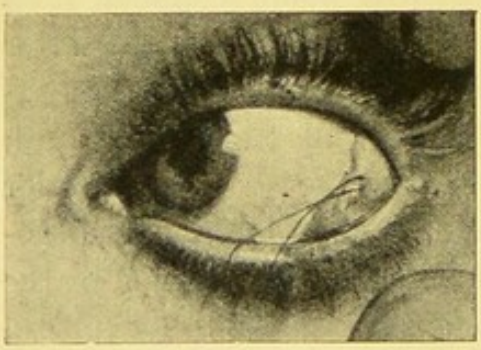


Fig. 41.—Dermo-lipoma with hairs.

Dermo-Lipoma occurs as a fibro-fatty congenital tumour, usually situated between the superior and external recti muscles. They are not encapsuled, and the fatty portion of these tumours is continuous with the orbital fat. Pure lipoma is exceedingly rare. Fig. 41 represents a dermo-lipoma in an unusual situation. The patient sought relief on account of the irritation caused by the long hairs which were only noticed about puberty.

Osteoma is a very rare congenital tumour, which occurs in the same situation as the dermo-lipoma.

Nævus (or Mole).—This congenital and usually pigmented growth appears most commonly at the limbus, as a brown spot, or as a flat gelatinous looking swelling, of a brown or reddish colour. It may be stationary, or may become progressive at puberty. The pigmented variety occasionally forms the starting point of a pigmented sarcoma. Microscopically a conjunctival nævus consists of epithelial downgrowths combined with groups or alveoli of smaller so-called nævus cells, the origin of which is doubtful. Cases which have been described as benign epithelioma and dermo-epithelioma were most probably unpigmented nævi.

Treatment.—If the nævus be disfiguring or progressive it can easily be excised.

Hæmangioma (Vascular Nævus).—This is generally met with in young people and is often congenital, but is sometimes the result of injury. It may be capillary or cavernous and is liable to increase in size. It occurs along with the same condition of the lids, but also separately, especially on the plica or caruncle.

Treatment.—Electrolysis or ligature. Good results have been obtained with ethylate of sodium carefully painted on and with carbon dioxide snow.

Polypus and Granuloma.—True mucous polypi never occur on the conjunctiva. The growths, to which the name of polypus is given, are tumours of different kinds which become pedunculated owing to the movements of the lids and eyes; they are fibromata or papillomata. Granulomata, or granulation tissue, occurring after operations (squint, enucleation, chalazion) or produced by foreign bodies, or even by tuberculosis, may also assume a polypoid form. The soft fibromata are sometimes the cause of bloody tears.

Lymphoma.—Diffuse lymphoma of the conjunctiva occurs in leukæmia or pseudo-leukæmia, but also as a primary affection, which is probably an early stage of amyloid disease (see Figs. 37 and 38). Small lymphomatous or lympho-sarcomatous tumours are met with rarely, chiefly at the inner canthus. Some of the cases described as lymphoma were examples of Parinaud's disease.

Papilloma, or **Papillary Fibroma.**—This is a non-malignant growth, which may spring from any part of the conjunctival sac. It may occur at any age, and several tumours may be present. It is much more common in men than in women. It appears in the beginning as a small round red knob. The papillomata growing

from the tarsal conjunctiva and from the semi-lunar fold frequently take on a cauliflower appearance; while on the bulbar conjunctiva and in the fornix the growths are liable to be pedunculated, with a papillary surface. The limbus of the conjunctiva is a favourite seat for a papilloma (Fig. 42), and in the early stage it may be impossible to distinguish it from an epithelioma. But at a later stage, when the growth has overlapped the cornea, the papilloma merely overlies it and can be lifted freely off it with a probe, while the epithelioma, as a rule, infiltrates the corneal tissue. Moreover, enlargement of the preauricular gland only occurs in the latter. But it must be remembered that papillomata in elderly people sometimes become malignant.

Treatment.—Thorough removal with knife or scissors, followed by the actual cautery, as otherwise the growth is liable to recur.

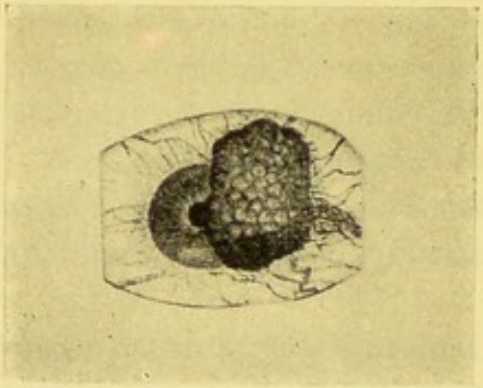


FIG. 42.—Papilloma growing at the limbus.
Sketched by L. W.

Malignant Tumours (Epithelioma, Sarcoma).—These rare growths generally take their origin in the limbus, most frequently at the temporal side. They are often extremely slow in their growth, lasting perhaps several years before attaining any considerable size. They are epibulbar tumours, that is to say, they spread on the surface of the eyeball and very rarely penetrate it. They may be pigmented or not. The pigmentation is explained by the fact that the limbus contains pigment, although generally so slight in amount as not to be visible to the naked eye. There is no cachexia, and the liability to metastases is less than in the case of intra-ocular growths, but the tendency to local recurrences is very great. The disease is rarely met with under forty years of age. On account of the alveolar structure so often present in these tumours, differences of opinion not infrequently arise in the effort to distinguish between sarcoma and epithelioma. The tumour soon becomes surrounded by a localised congestion, and, as it grows, it interferes with sight and prevents closure of the lids, but does not cause much pain until the late stages, when ulceration and hæmorrhage are apt to occur.

Epitheliomata are usually non-pigmented, and at first may be mistaken for phlyctens—of which, however, the margins are not so steep—or for papillomata (*vide supra*). The surface is wart-like or papillary, or it may be nodular, but the nodules are not so smooth nor so large as in a sarcoma. The cornea becomes infiltrated by the growth and the lymphatic glands may be enlarged.

Sarcomata on the other hand are generally pigmented, the tumour is smooth or nodular, and rarely polypoid, and when it extends over the cornea, is not adherent to it, or at least does not involve it except in a very late period.

But conjunctival sarcoma also starts from other parts of the conjunctiva, and in a case at the Royal Victoria Eye and Ear Hospital sarcomatous tumours were four times removed from different parts of the fornix, an interval of some months elapsing between the appearance of each small tumour, and finally enucleation became necessary. Malignant growths on the eyelids often involve the conjunctiva secondarily, and this is a common occurrence in rodent ulcer.

Treatment.—Both epithelioma and sarcoma of the conjunctiva demand prompt operative removal, in order to prevent an extension of the growth to the rest of the eye, as well as to avert metastases to other organs. The knife and actual cautery may save the eye and the patient's life in the early stages. When a recurrence takes place it is safer to remove the eye, more especially if the patient cannot be kept under constant supervision.

CHAPTER IV.

PHLYCTENULAR CONJUNCTIVITIS, AND KERATITIS.[1]

Both from a clinical and nosological point of view it would be incorrect to divide this affection into two, under the heads of Diseases of the Conjunctiva and Diseases of the Cornea; and therefore it is treated of here as one disease, and, being an important disease, a special chapter is given to it. It is important, because it is excessively common, and because it is capable of causing considerable damage to sight. Moreover, even when it occurs on the cornea, it might, strictly speaking, be regarded as a conjunctival disease, for that corneal layer, which it primarily attacks, is the epithelium, and this—and probably also Bowman's membrane and the anterior layers of the true cornea—as we know from the fœtal development of the membrane, is a continuation of the conjunctiva in a modified form over the cornea.[2]

The disease is characterised by the eruption of phlyctenulæ or phlyctens (*φλύκταινα*, *a vesicle*, or *pustule*) on the conjunctiva bulbi, on the conjunctival limbus, or on the cornea. It is chiefly a disease of children up to the eighth or tenth year of age, except that it may be said not to occur in the first year of life. It is seen occasionally in adults, especially in women. The appearance of the phlycten is preceded by a localised patch of ciliary congestion, which remains for some time after the phlycten has healed (Plate II., Fig. 3).

Notwithstanding the derivation of the word, a phlyctenula, or phlycten, is originally neither a vesicle nor a pustule. It is a formation *sui generis*, and, when on the conjunctiva, is a solid

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[1] *κέρας, a horn.*

[2] The posterior epithelium—or, according to some, this along with the membrane of Descemet and the posterior layers of the true cornea—is to be reckoned to the uveal tract; while the true cornea is a modification of the sclerotic.

elevation consisting of leucocytes, and some lymphocytes, also giant cells and epithelioid cells, and is of a greyish colour. In a late stage the phlycten, especially on the cornea, may become a pustule by infection. On the conjunctiva two types of the disease can be recognised :—

1. **The Solitary,** or **Simple, Phlycten.**—Of this there may be one or several, varying in size from 1 mm. to 4 mm. in diameter. The vascular injection is immediately around the phlycten, and is not diffused over the conjunctiva, yet it is true that occasionally any form of phlyctenular disease may be associated with simple conjunctivitis, which is to be regarded as secondary to the phlyctenular affection. At first there may be shooting pains and lacrimation, but these soon pass away. If the phlyctens be not seated close to the cornea the affection is not serious ; and the length of time required for its cure depends on the size of the phlyctens, varying from seven to fourteen days, as a rule.

2. **Multiple,** or **Miliary, Phlyctens.**—These are very minute, like grains of fine sand, and are always situated on the limbus of the conjunctiva, which is swollen. The general injection and swelling of the conjunctiva are considerable, and there may be a good deal of conjunctival discharge; and, occurring as it does almost exclusively in young children, the affection may be called Eczematous Conjunctival Catarrh of Children (Horner). The irritation, and so-called photophobia, and lacrimation are often considerable. This form is very apt to appear after measles and scarlatina.

Both forms are liable to extend to the cornea, and then only does the disease become serious. This event may come about in the following different ways :—

The Solitary Phlycten may be seated partly on the limbus conjunctivæ and partly on the margin of the cornea, and may undergo resolution.

Or, it may give rise to a deep ulcer, which either heals, leaving a scar, or perforates, causing prolapse of the iris, etc.

Or, it may form the starting-point of a fascicular keratitis, the pustule becoming an ulcer, at the margin of which the corneal epithelium is raised and infiltrated in crescentic shape. This now steadily advances for many weeks towards the centre of the cornea, followed by a leash of vessels which has its termination in the concavity of the crescent. The process is accompanied by much

irritation of the terminal branches of the fifth nerve in the cornea, and the consequent reflex blepharospasm. A permanent mark indicates the track of the ulcer.

The Multiple Miliary Phlyctens on the limbus conjunctivæ may cause some slight superficial infiltration and vascularisation of the cornea in their immediate neighbourhood, which pass off when the phlyctens disappear.

Or, they may be accompanied by deeper marginal infiltrations of the cornea, which become confluent and result in an ulcer that extends along the margin of the cornea for some distance, forming a ring ulcer. It is a serious form of ulcer; for, if it extend far around the cornea, it may destroy the latter in a few days by cutting off its nutrition.

The only condition which may give rise to an error in diagnosis is a patch of scleritis (chap. vi.). In scleritis the vascular injection is deeper than the conjunctival vessels, and of a more purple colour (Plate II., Fig. 5); the affected part is usually tender on pressure, and there is no vesicular or pustular formation on it.

Primary Phlyctenular Keratitis occurs principally in three different forms:—(1) Very small grey sub-epithelial infiltrations, which are apt to result in small ulcers, and then heal, leaving a slight opacity. This opacity may ultimately quite disappear, especially in the case of children, and when situated peripherally. (2) Somewhat larger and deeper infiltrations, resulting in ulcers of corresponding size, which heal by aid of vascularisation from the margin of the cornea. The opacity left after these ulcers is rather intense, and clears up but little, especially if the situation be central. (3) Large and deep-seated pustules, due to secondary infection, often at the centre of the cornea, giving rise to large and deep ulcers, which may be accompanied by hypopyon and even by iritis, and which frequently go on to perforation.

Photophobia is usually a prominent symptom in phlyctenular keratitis, and the blepharospasm often causes eczematous fissures at the outer canthus. The term photophobia, however, is not altogether correct, for it is the fifth nerve (from the cornea) which is mainly the afferent nerve here, rather than the optic nerve. This is evident from the fact that in the dark the patient does not get complete relief. The explanation of this reflex

blepharospasm has been given by Iwanoff, who showed that the cells which form the phlyctenula, in making their way from the margin of the cornea to their position under the epithelium, follow the course of the nerve filaments, which they must irritate in their progress. The accompanying Figs. 43 and 44 are from his original paper.

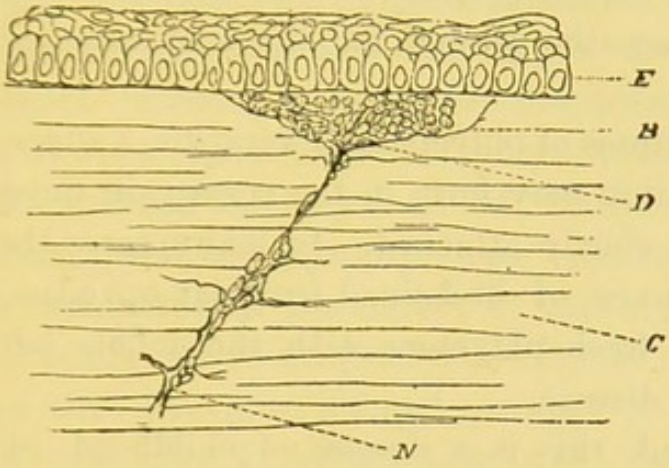


FIG. 43.—*E*, Epithelium; *B*, Ant, elastic Lamina; *C*, True Cornea; *N*, Nerve Filament, with Lymph Cells on its course; *D*, Phlyctenula.

Enlarged cervical glands, eczema of the eyelids, face, and external ear, and catarrh of the Schneiderian mucous membrane, frequently accompany phlyctenular conjunctivitis and keratitis.

In these cases, in children of three or four years of age, temporary amaurosis has sometimes been observed after a severe and long-continued blepharospasm has passed away. The patient is found to be unable to see even large objects, or to find his way, although the pupil-reflex is active, and a strong light may still be distressing. There are no ophthalmoscopic appearances. This blindness passes away completely, usually in from two to four weeks, although the interval before recovery of sight may be several months. A certain mental dullness, which also ultimately disappears, is noticed in some cases. This temporary loss of sight has been held by some to be due to disturbance of the intra-ocular circulation, and of the nutrition of the retina from pressure of the eyelids on the eyeball. It has been regarded by others as having a cerebral origin of a functional nature; for it is likely at this tender age, when the psycho-physical processes are not as yet firmly established, that the desire not to

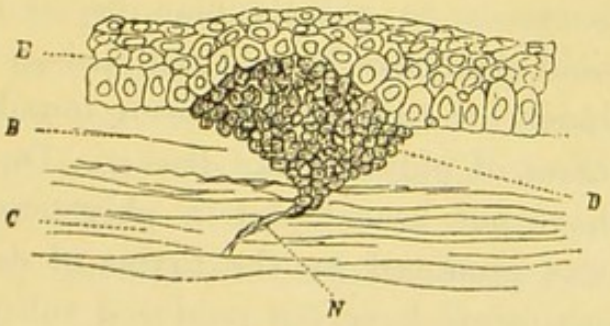


FIG. 44.

see, and the active withdrawal from the act of vision, may lead in a short time to a functional paralysis of the visual centres in the brain; and these centres may take some time to recover, or to re-learn, their functions, when the ground for the suspension of the latter has ceased.

As a result of frequent relapses of phlyctenular keratitis, a superficial pannus-like vascularisation may form in the cornea, in those parts of it which have been chiefly attacked. In many cases the cornea presents the appearance of ill-defined irregular opacities, due to the combination of fresh phlyctens with the nebula left by previous attacks of the disease.

Cause.—As already stated, this is a disease of childhood, although it is extremely rare in the first year of life. In adults it is uncommon.

The strumous constitution—as indicated by the swollen nose and upper lip, and sometimes by the enlarged lymphatics in the neck, and by the eczema—which is allied to, if not indeed a form of, tuberculosis, is that most liable to this affection. Often, however, it will be found in strong children with apparently perfect general health; but even in them there is probably some irregularity of nutrition, of which the great tendency to recurrence of the eye affection is evidence.

The suspicion that phlyctenular disease is often a manifestation of tuberculosis has been gaining ground. The evidence in favour of this view is:—That the instillation of tuberculin into the conjunctival sac sometimes produces a crop of phlyctens. (Consequently Calmette's ophthalmo-reaction should never be used where there is any tendency to phlyctenular disease.) That giant cells and epithelioid cells have been found (Leber) in phlyctens. That the opsonic index for tubercle has been found (Nias and Paton) to be low in cases of phlyctenular disease. On the other hand tubercle bacilli have not been found in phlyctens—yet it may be that the latter was produced by the toxins of dead bacilli—and inoculation experiments have not produced tuberculosis in animals. Tubercular disease in other parts of the body cannot always be detected in these patients, but tubercular cervical glands and tubercular disease of the bones are present in a fair proportion of the cases.

Treatment.—The solitary phlycten of the conjunctiva is best treated with a 2 per cent. yellow oxide of mercury ointment, of

which a portion of the size of a hemp-seed should be put into the eye with a small glass rod, once a day. To obtain the best result with this ointment, its base should consist of 10 parts of pure white vaseline, and one part each of anhydrous lanoline and water. The yellow oxide is to be freshly precipitated and in very fine powder, and when it has been well rubbed up with the water, the anhydrous lanoline and vaseline are added. This ointment contains no fatty substance, and consequently mixes with the tears and comes thoroughly in contact with the surface of the eye. Ordinary lanoline contains olive oil. The ointment should not be unnecessarily exposed to light or air. Or, quite a small quantity of pure calomel insufflated into the eye once a day will also cure; but this remedy should not be employed if iodide of potassium is being taken internally, for then iodide of mercury is liable to be formed in the conjunctiva.

The miliary phlyctenular conjunctivitis may be treated at first with cold or iced applications. Freshly prepared chlorine water (1 part Liq. Chlori., 9 parts water), to be dropped into the eye once a day, is recommended by some, and later on Liq. plumbi dil. or Sol. argent. nitr. (gr.v ad ℥j, and neutralised) applied to the everted conjunctiva; or, if the phlyctenular appearance predominate over the catarrhal, the yellow oxide of mercury ointment or insufflations of calomel may be preferred. Indeed, practically, the two latter remedies are applicable in all these cases.

When the cornea is slightly affected near the margin in cases of miliary phlyctens, insufflations of calomel, or the yellow oxide of mercury ointment, and warm fomentations, should be used.

Where a large pustule on the margin of the cornea has resulted in a deep ulcer, with tendency to perforate, and accompanied by much pain, paracentesis of the anterior chamber through the floor of the ulcer, the pupil having first been brought well under the influence of eserine to prevent prolapse of the iris, cannot be too strongly advocated. The good effect of this will be very soon apparent: the pain disappears, the patient sleeps, the ulcer becomes vascularised, and healing sets in. Cauterisation of the ulcer in an early stage with the galvano-cautery is also good practice; but in these cases paracentesis is preferable. Many surgeons trust too much to eserine, warm fomentations, and a pressure bandage.

For the fascicular keratitis the yellow oxide of mercury oint-

ment is again in its place. When the crescentic infiltration is very intense it is well to touch it with the galvano-cautery.

For the ring ulcer a pressure bandage, under which an antiseptic dressing (boric or salicylic acid, or perchloride of mercury) has been placed, is, perhaps, the best method of treatment. Warm fomentations promote vascular reaction, and may be used with benefit at each change of bandage.

For primary phlyctens of the cornea, in the form of the minute grey superficial infiltration or ulcer, nothing beyond atropine, with warm fomentations and a protective bandage to keep the eyelids quiet, should be used. When reparation of the ulcer has commenced, insufflations of calomel or weak yellow oxide of mercury ointment may be employed.

For the large infected phlycten, resulting in a large and deep ulcer, often situated at the centre of the cornea, with hypopyon and iritis, warm fomentations (camomile, or poppy-head, at 90° Fahr., for twenty minutes three times a day), atropine, boric acid as ointment or powder, and a protection bandage form the treatment in the early stages. Here, also, the ulcer may be punctured with the very best results in respect of hastening the cure, or the galvano-cautery may be used with advantage. In the stage of reparation the yellow oxide of mercury ointment or insufflations of calomel are very useful.

In nearly all cases of phlyctenular keratitis dionine (5 per cent. solution) aids the cure.

In all forms of phlyctenular ophthalmia those favourite remedies, blisters, setons, and leeching, should be avoided. The first two worry the patient, give rise to eczema of the skin, and are not to be compared in their power of cure with the measures above recommended; while leeching gives, at best, but temporary relief, and deprives the patient of blood which he much requires.

For relief of the blepharospasm, in addition to the use of atropine, plunging the child's face into a basin of cold water is a most efficacious means. The face is kept under the water until the patient struggles for breath, and this immersion is repeated two or three times in rapid succession, and used every day if necessary. It should always be used where the blepharospasm is severe, as the latter is not only distressing to the patient, but also an obstacle to the cure.

The general treatment, notwithstanding the so-called photophobia, should consist in open-air exercise before everything else, unless, indeed, there be an ulcer which threatens to perforate. It is not well to keep the eyes (unless there be a corneal ulcer), or patient's face, covered with bandages or shades, nor to confine him to a dark room. A pair of smoked glasses are the best protection from strong glare of light; and shady places can be selected when the patient is out of doors. Cold or sea baths, followed by brisk dry rubbing. Easily assimilated food at regular meal hours, but no feeding between meals. Regulation of the bowels. Internally: cod-liver oil, maltine, iron, arsenic, syrup of the phosphate of lime, and such-like remedies are indicated.

The great tendency to recurrence is one of the most troublesome peculiarities of all kinds of phlyctenular ophthalmia; and in order to prevent this, so far as possible, it is important, not only to improve the general health, but also to continue local treatment until the eye is perfectly white on the child's awaking in the morning, and even for fourteen days longer. This prolongation of the treatment will also assist in clearing up opacities, as best they may be. For this after-course of treatment calomel insufflations may be used.

Nothing can be done for the opaque scars left on the cornea by ulcers when all inflammatory symptoms have subsided. If the ulcer have been very superficial the resulting scar in young children may disappear in course of time. Deep ulcers cause more opaque and permanent scars, and ulcers which have perforated produce the greatest opacity. Some of the very disfiguring scars may be tattooed (chap. v.).

The degree of the defect of vision to which an opacity of the cornea may give rise depends, in the first instance, on the position of the opacity. If it be peripheral, the vision may be perfect; but if it be in the centre of the cornea, sight may be seriously damaged. Even a slight nebula, barely visible to the observer, will cause serious disturbance of vision if situated in the centre of the cornea; while in the same situation the very opaque scar of a deep ulcer will produce a proportionately greater defect. If a central, but not deep, ulcer should not become completely filled up in healing, and a facet remain, vision will also suffer much in consequence of irregular refraction of the light which passes through the facet, even though there may be but little opacity.

CHAPTER V.

DISEASES OF THE CORNEA.

The importance of a knowledge of the diseases and injuries of the cornea depends on their great frequency, coupled with the fact that nearly every one of them is liable to leave behind it some opacity, with resulting defect, or even complete loss of sight, and disfigurement of the eye.

Clinical Methods of Examining the Cornea.

1. By Diffuse Daylight. The patient is placed with his face towards the window, and the cornea is carefully inspected while he keeps both eyes open. His upper lid is then gently raised with the surgeon's thumb, and he is called on to direct his eyes upwards, downwards, to the right, and to the left, so that every part of the affected cornea may be seen under the most favourable and varied incidence of the light. Should there be much reflex blepharospasm, the instillation of cocaine, by producing anæsthesia of the cornea, assists the examination. With small children it is often necessary to adopt the plan illustrated by Fig. 26.

2. By Focal, or Oblique, Illumination. In the dark room the light of the ophthalmoscope lamp is focussed with a + 14·0 D lens on the cornea, which is thus seen brilliantly lighted up. The lamp must be placed in front of, and slightly to the left-hand side, of the patient, and about two feet from his eye. The lens is placed between the lamp and the eye, so that the light may be concentrated by it on the cornea.

3. By the Combined Focal Method—that is focal illumination as above, combined with the use, as a magnifying-glass, of a second + 14·0 lens. The second lens is held between the finger and thumb of the left hand some inches from the patient's eye, while the surgeon

places his eye at the focus of this glass, the cornea being at the same time illuminated by the light focussed on it with the other lens held between the finger and thumb of the right hand. Changes in the cornea are then seen magnified, and at the same time highly illuminated.

4. By the Ophthalmoscope with a + 18·0 or + 20·0 lens behind the sight-hole of the mirror. The surgeon proceeds as though he were about to examine the fundus in the erect image (p. 28). The cornea is illuminated from the mirror, and changes in it are magnified by the + lens through which it is inspected.

5. By Fluorescine. In cases of ulcer, or any abrasion of the corneal epithelium, when it is desired to ascertain accurately the whole extent of the loss of substance, or if there be some doubt as to the presence of such a lesion, an instillation of a drop of fluorescine solution (Fluorescin. gr. ij, Sodii Carb. gr. j, Aq. destill. ʒ ij) is used. About half a minute after the instillation, the whole region which is denuded of epithelium will be seen stained of a greenish yellow colour. In some instances where there is no true loss of substance, staining takes place if the epithelium be not sound. An ulcer, which in the process of healing has become covered with sound epithelium, will not stain, although there may still remain some loss of substance to be filled up. Fluorescine does not harm the cornea, nor interfere with healing of any diseased process in it, and the staining disappears after a short time. A pretty, and in some cases practically useful, method is v. Reuss's double staining. After the lesion has been stained, as above, with fluorescine, a drop of a 1 per cent. solution of methylene blue (medicinal) is instilled, with the result that the general floor of the lesion—*i.e.* the denuded corneal tissue—becomes blue, while the margin—*i.e.* the loosened epithelium—remains of the greenish-yellow colour.

The foregoing methods are in everyday use.

6. By the Corneal Microscope. This is an elaborate optical instrument, which forms the outfit of a well-equipped ophthalmic hospital, and is adapted for the minute study of diseased states of the cornea and iris. It is not needed for ordinary clinical work, and therefore a description of it will not be given here.

Inflammations of the Cornea.

From a clinical standpoint these inflammations will be most conveniently considered under the headings—(*a*) Ulcerative Inflammations, and (*b*) Non-ulcerative Inflammations.

(*a*) Ulcerative Inflammations of the Cornea.—Before an ulcer can form in the cornea, there must be a cellular infiltration of its tissue near its anterior surface; and this cellular infiltration is brought about, in most instances, if not in all, by the entrance into the cornea—through the blood, or through a traumatic loss of substance of the surface of the cornea—of certain micro-organisms:—pneumococci, diplobacilli of Morax, staphylococci, streptococci, bacillus subtilis, etc. One recognises the existence of an infiltration by seeing an opaque spot in the cornea, with a dullness of the layers over it, and often also of the corresponding part of the epithelium. Before long the epithelium covering the infiltration undergoes necrosis and comes away, and soon the intervening layers of the true cornea also break down, and in this way an ulcer becomes established.

But although all ulcers of the cornea originate in an infiltration, yet, once established, they assume great varieties of type, in consequence, probably, of varieties in the nature of the originating micro-organisms. Some ulcers are purulent, others non-purulent; some tend to spread over the surface of the cornea, others tend to go deep into it; the progress of some is very rapid, and of others exceedingly chronic; some attack by preference the central region of the cornea, while others are confined to its margin; some readily give way to treatment, and others are very obstinate or even incurable. Again, some ulcerative corneal processes are attended by much irritation: that is to say, circumcorneal injection, severe pain in and about the eye, great reflex blepharospasm, and lacrimation; whilst others, which may really be more severe processes in so far as the integrity of the eye is concerned, can run their course with hardly any injection of the eyeball, and with little or no distress to the patient.

Etiologically, corneal ulcers are primary or secondary. The primary ulcers are those in which the diseased process originates in the cornea, most commonly as the result of traumata, but also

in phlyctenular keratitis, or as the result of corneal abscess, or where the nutrition of the cornea is interfered with, etc. Secondary ulcers are those which are the result of disease elsewhere, usually in the conjunctiva, as in acute blennorrhœa and in conjunctival diphtheritis.

Corneal ulcers are more common in advanced than in early life. Indeed, in early life, unless in cases of infantile ulceration with conjunctival xerosis, of blennorrhœa neonatorum, and of phlyctenular disease, corneal ulcers are almost unknown. The greater liability to these affections in advanced life is due, it may be assumed, to a less active nutrition at that period in this already lowly organised part. Hence slight traumata, or the presence of a slight conjunctival

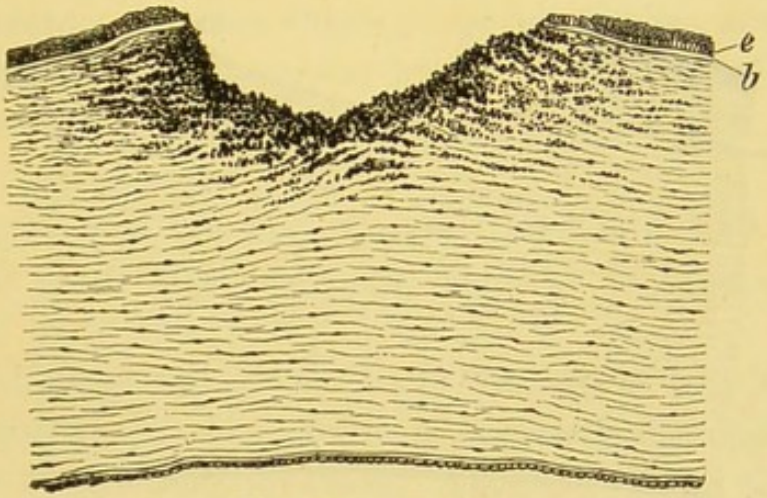


FIG. 45. (*Fuchs.*)

catarrh, which would have no ill effect in a young person, may form the starting-point of a corneal ulcer in an old person, or even in one of middle age. For the same reasons, corneal ulcers are much more common in the poorer classes than amongst the well-to-do; for their general nutrition is often defective, while they are more exposed to traumata than are the better classes.

The Diagnosis of the presence of a large corneal ulcer is simple. Inspection of the cornea in ordinary daylight at once reveals the loss of substance, more or less extensive, deep, or infiltrated. If the ulcer be very small and shallow the difficulty is greater, especially if there be much blepharospasm. An instillation of cocaine may be necessary to facilitate the examination.

It is obviously important to decide at the outset, for the purposes of prognosis and of treatment, whether a grey spot in the cornea

be an infiltration (a collection of cells which may shortly break down and become an ulcer), an ulcer, or a scar (the result of an ulcer, or other loss of substance). The surface covering an infiltration, although flush with the general surface of the cornea, has usually a steamy appearance, due to disorganisation of the corneal epithelium, and has no lustre. With an ulcer the appearances already described will be found. The surface of a scar is usually, although not always, flush with the general surface of the cornea, and it has a bright surface—*i.e.* covered with normal epithelium, not rough, irregular, nor even steamy. In cases of corneal infiltration, or ulceration, there usually will be more or less pericorneal injection, pain, and photophobia, while with a mere corneal scar

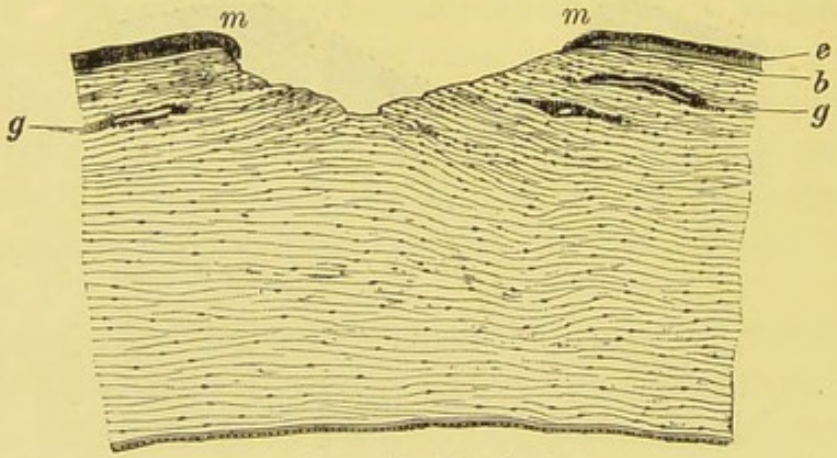


FIG. 46. (*Fuchs.*)

there will be no irritation of the eye. Fluorescine stains an ulcer, and sometimes an infiltration if it be near the surface, but not a cicatrix.

The presence of *Hypopyon* (*ὑπό, under ; πῦον, pus*) is the rule with several types of corneal ulcer, notably the deep ulcer, and the serpiginous ulcer. The term 'hypopyon ulcer,' which is so much used, should certainly be discarded, as hypopyon is not the characteristic of one type of ulcer. Hypopyon is a deposit of pus in the anterior chamber, and as the patient sits or stands it lies in the lowest part of the chamber, to which place it has gravitated. If the patient lie in bed, say on the side of the affected eye, the hypopyon will of course change its position, and gravitate towards the temporal side of the chamber. Sometimes the hypopyon is so small as to be detected with difficulty ; and again it may fill the whole anterior

chamber, completely obscuring the iris and rendering a diagnosis of the condition of the cornea difficult. It will be asked, From whence does the pus come which forms hypopyon in cases of corneal ulcers? It might be supposed that it is derived directly from the purulent floor of the ulcer, by passage of the pus-cells through the posterior layers of the cornea. But this is not so. No pus-cells do, or indeed can, pass through the membrane of Descemet. Moreover, copious hypopyon is often present, when the corneal ulcer is quite small and non-purulent. The pus-cells, which form hypopyon in cases of corneal ulcer, come from the iris, in compliance with the law which causes leucocytes to wander out of blood-vessels in the neighbourhood of an inflammatory focus, and to make their way towards that focus. When these leucocytes from the iris reach the anterior chamber they can go no farther, owing to the barrier imposed to their progress by the membrane of Descemet. The pus forming a hypopyon is sterile, unless the cornea be perforated.

The Dangers attendant upon Corneal Ulcers are, first of all, the opacities, the scars, which even the slightest of them are apt to leave behind.

Fig. 45 represents a section made through a deep ulcer in its progressive stage. At the margin of the ulcer the epithelium (*e*) and Bowman's membrane (*b*) cease. The floor of the ulcer is seen covered with pus, which also infiltrates the corneal tissue beneath the floor and around the margin. As soon as cure commences the floor of the ulcer begins to clear, *i.e.* it becomes gradually less covered with pus, until it is finally quite free from it, and *pari passu* the surrounding infiltration of the cornea is absorbed. Then the epithelium, growing in from the margin (*m m*, Fig. 46) all around, gradually carpets over the floor of the ulcer, and underneath this newly formed epithelium the new tissue, which is to close in the loss of substance, is laid down. This new tissue, however, is not normal corneal tissue, but is ordinary connective tissue, and is therefore opaque. Hence the deeper the ulcer, the more intense will be the resulting opacity. Bowman's membrane never becomes restored over the cicatrix.

The ulcers which are situated at the centre of the cornea, in the pupillary area, are more serious for sight than those situated peripherally, as can be readily understood. The opacity left by

a very superficial ulcer is slight, and is called a nebula ; a somewhat more intense opacity is called a macula ; and a very marked white scar is called a leucoma.

But a more serious danger connected with ulcers of the cornea than the opacities they leave behind is that of perforation of the cornea, to which some ulcers are very prone. The consequences of perforation are : prolapse of iris resulting in anterior synechiæ, adherent leucoma, or staphyloma of the cornea, and fistula of the cornea.

Treatment.—In the treatment of primary corneal ulcers the student will soon observe that a bandage, atropine, and warm fomentations play prominent parts ; and these routine measures alone are sufficient to produce cure in the less severe cases.

The bandage should be put on with firm pressure—but should not be made uncomfortably tight—the eye having been previously padded out, especially at the inner canthus, so that equal pressure may be exercised all over the globe. The support thus given to the cornea and front of the eye promotes the healing process, and the bandage is also useful by preventing the eyelids from rubbing over the ulcer, and by protecting it from foreign bodies. In those secondary ulcers, which are due to conjunctival processes, such as catarrhal conjunctivitis or blennorrhœa, a bandage is contra-indicated, because it retains the secretion, and would therefore do harm rather than good.

Atropine in sufficient quantities to keep the pupil dilated should be employed. Iritis very often attends severe corneal ulcers, and here the indication for atropine is obvious. But rest of the affected part is, we know, an important element in preventing or in curing any inflammation ; and in the affections we are now treating of, even if there be no iritis, atropine acts by procuring rest of the iris and of the ciliary muscle.

Myotics are preferred by some to mydriatics in the treatment of corneal ulcers, on the ground that the action of myotics in reducing the intra-ocular tension promotes healing, and that the more extended surface of iris—more extended absorbing surface—facilitates absorption of hypopyon. It is not certain that myotics do reduce the normal tension, and in these cases they undoubtedly increase the tendency to iritis. As to absorption of the hypopyon it will come about in due course when the cornea begins to recover. Yet

a clear indication for myotics is given by the presence of an ulcer near the corneal margin, which has a tendency to perforate, for here the myosis would assist in preventing prolapse of the iris, should perforation take place.

Dionine is useful in the treatment of many cases of primary corneal ulceration and other primary corneal diseases. Its physiological action is to cause dilatation of the blood vessels of the conjunctiva with great chemosis—although it does not act equally well in every eye—and its therapeutic effect is held to depend on this lymphatic flooding of the front of the eye. It is used in a 5 per cent. solution dropped into the eye once a day. If employed frequently it ceases to produce any reaction, and for this reason it may be desirable in some cases to use it once only on alternate days. It causes slight anæthesia of the cornea.

Warm fomentations promote the healing process by stimulating tissue-changes in the cornea. One usually orders them to be made with poppy-head water or camomile tea, although no doubt warm sterilised water would be equally efficacious. Hot solutions of 4 per cent. boric acid, or 1 in 5000 corrosive sublimate, may be used with advantage. A compress of cotton wool which has been dipped in the stupe at about 120° Fahr. is laid upon the eye, and frequently replaced by fresh compresses out of the stupe, so that the compress on the eye may always be hot. This is continued for half an hour at a time, and repeated every two or three hours. Or, the Japanese muff-warmer, or a special electric warmer, may be applied.

In an ulcer of a purulent or sloughing nature, the insufflation on its floor of very finely divided xeroform powder is useful, as is also the application of hydrogen peroxide.

When more active measures than the foregoing are called for, the actual cautery, curetting, paracentesis, and subconjunctival injections of oxycyanide of mercury (5 min. of a 1 in 5000 solution) have to be resorted to.

The actual cautery is much in use in the treatment of serpiginous and other infected corneal ulcers. It acts by destroying the micro-organisms, which keep the process going. Either a thermo-cautère, in the form of a very fine point, or the galvano-cautery (Fig. 47), the platinum wire being at a red-heat, may be employed. The eye having been cocainised, the red-hot point is brought into contact with the whole surface of the ulcer, so as to thoroughly destroy

its superficial layer, and special attention is given to any part of the margin of the ulcer where there is a tendency to spread to as yet healthy tissue. Fluorescine may be used to show the exact extent of the ulcerated surface. The cauterisation can be repeated as often as the state of the ulcer may make it desirable. It is sometimes well to perforate the cornea with the cautery, and to evacuate the aqueous humour and hypopyon; or this may be done with an ordinary paracentesis needle, after the cauterisation is completed. The cautery gives a good percentage of cures with the least amount of opacity.

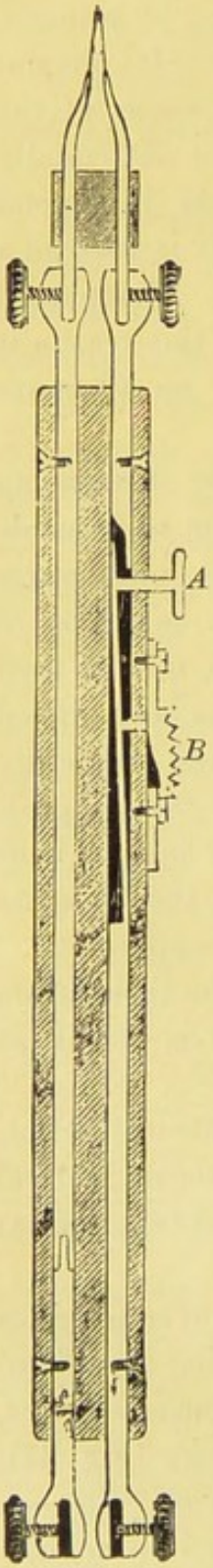


FIG. 47.

Thorough curetting of the floor of the ulcer with a small sharp spoon is a valuable method, either alone or prior to cauterisation.

Paracentesis of the anterior chamber through the floor of the ulcer is another most valuable therapeutic measure for some corneal ulcers, and deserves a more routine application in these cases than is accorded to it; the more so as the little operation is simple and dangerless. But there are two indications for its use which should be regarded as imperative—namely, (1) If there be great pain. Soon after the operation, which for a short time increases the neuralgia, the patient experiences great relief, and passes the first good night after many wakeful ones. (2) If perforation seem to be imminent. This may often be recognised by a bulging forwards of the thin floor of the ulcer; but sometimes it is not easily foreseen, and if there be any doubt on the point, paracentesis should be performed. It is important to forestall spontaneous perforation of the ulcer by this proceeding, because the opening that is made being

FIG. 47.—The bolt *B* being pushed forwards, the circuit is completed. By pressure on the button *A* the current can be momentarily intercepted during use of the instrument. There are other good patterns of galvano-cautery.

linear heals easily, and leaves but a slight scar without anterior synechiæ; while the natural opening would be a complete loss of substance, and would, therefore, the more readily involve adhesion of the iris in the resulting, and comparatively extensive, cicatrix. Other indications for the operation are increased tension, and the presence of a large hypopyon.

Paracentesis of the anterior chamber is best performed by means of a paracentesis needle (Fig. 48), which is a small somewhat shovel-shaped blade. If this be not at hand, a small keratome, or a broad needle, or a Græfe's cataract knife will answer the purpose. The eye having been cocainised, a spring lid-speculum is inserted, the eye is fixed with a fixation forceps, and the point of the paracentesis needle applied to the floor of the ulcer, in such a way that the plane of the little blade may be at an angle of about 45° with that of the floor of the ulcer. The point is pushed gently through the floor, and the plane of the blade is then immediately changed, so that, as the instrument is being advanced up to the hilt, it may be almost in contact with the posterior surface of the cornea. The instrument should be withdrawn very slowly, in order that the aqueous humour may flow off gradually, and not with a rush. If these precautions be taken, there need be no danger of injury to the crystalline lens, or of prolapse of the iris into the incision. Should prolapse occur, it can usually be reposed with the spatula. It may happen that when the needle has been withdrawn a considerable portion of the aqueous humour may remain in the anterior chamber, unable to escape owing to the valve-like closure of the wound. It should be evacuated by making the wound gape by gentle pressure with a spatula on its posterior lip. If it be desirable to tap the anterior chamber on the next day, this can be done by simply opening up the wound with a spatula, or with the probe-like instrument at the other end of the handle (Fig. 48), without the aid of any cutting instrument.



FIG. 48.

Subconjunctival injections of solution of oxycyanate of mercury (1 in 5000) or of solution of chloride of sodium (4 per cent.) enter largely into the therapeutics of corneal disease, and of disease in

the uveal tract. It is not necessary that the injections should be made under the capsule of Tenon as was at first supposed. The mode of action of these injections is not clearly understood. It is not due to the entrance of the preparations into the tissue of the cornea or interior of the eye, for only minimal quantities of even mercurial salts have been found in the vitreous humour. It was at first believed that they acted as lymphagogues, but their curative power is now held to depend on the vascular reaction to which they give rise. Of the oxycyanate of mercury solution 5 to 10 minims according as it can be borne, or of the saline solution 10 to 20 minims, are injected under the bulbar conjunctiva in the direction away from the cornea. Other solutions (sublimate, hetol, cyanate of mercury, iodipin, iodide of potash, etc.) have been employed, but these two are as efficacious as any. From 2 to 5 minims of a 1 per cent. solution of acoine may be taken up in the syringe with the main solution, just before the injection is made, in order to diminish the severe pain and irritation which come on afterwards, and last often for several hours. This pain may be much relieved by hot fomentations, but if it be very intense a hypodermic injection of morphia may be necessary. Or, if one or two drops of a 4 per cent. solution of dionine be instilled into the eye, followed a few minutes later by an instillation of a 4 per cent. solution of cocaine, a subconjunctival saline injection may be made almost painlessly. Considerable vascular injection and chemosis may be present next day, and the eyelids may be swollen and œdematous. The injection should not be repeated until the redness and œdema have almost subsided. Few eyes require, or can tolerate, more than two injections in the week. (See also chap. x.)

If the case do not come under the care of the surgeon until perforation of the ulcer with prolapse of the iris has taken place, the important question as to the best method of dealing with the condition is presented. If the loss of substance should occupy one third or more of the cornea with correspondingly large prolapse of iris, the development of a staphyloma is almost inevitable. Eserine is to be used to reduce the intra-ocular pressure, and a firm bandage is to be kept applied to the eye. And here transplantation of conjunctiva over the ulcer and prolapsed iris, to strengthen the cicatrix (p. 122), is indicated. But if the ulcer and prolapse be small, an attempt may be made to free the iris, so that no anterior

synechia may form, and in order that the cicatrix may be flat, and not raised over the surface of the cornea, and, consequently, exposed to injury. The importance of such an attempt lies in the fact that a corneal cicatrix with iris entangled in it—not merely adherent to its posterior surface—affords a constant source of danger, especially if situated near the margin of the cornea; for in such eyes, it may be years later, sudden and uncontrollable purulent inflammation of the iris and chorioid may come on from septic infection, after an apparently slight trauma of the cicatrix, and may rapidly end in total destruction of the eye. The surgeon's attention should therefore be directed to obtain at least as flat a cicatrix as possible, or, still better, a non-adherent cicatrix. The practice which is commonly followed, is to draw the freshly prolapsed portion of iris slightly forwards with a forceps, and to snip it off level with the surface of the cornea; and then with a spatula to endeavour to free the iris from any adhesions it may have formed with the margin of the ulcer. Atropine or eserine, according to the position of the ulcer, is then instilled, and a bandage carefully applied. This proceeding is only of use when a fresh prolapse can be dealt with, before cicatrisation sets in; and the result is often satisfactory in so far as the securing of a flat cicatrix is concerned, but an anterior synechia can rarely be avoided.

Da Gama Pinto's method for obtaining a non-adherent cicatrix is sometimes useful:—Having abscised the prolapsed portion of iris as above, and freed all adhesions to the margin of the ulcer with a spatula, he covers the opening in the cornea with a flap cut from the bulbar conjunctiva—and this flap should be twice as large as the opening, in order to admit of its shrinkage—and then pushes the flap into the opening with a blunt probe. A firm binocular bandage is applied—but no iodoform. The eye is not dressed until the third day, when the anterior chamber is often found restored, the iris all in its proper plane, and the conjunctival flap healed into the ulcer. Ultimately all trace of the flap disappears, and an ordinary non-adherent corneal scar is presented.

Kuhnt's method, too, for strengthening the cicatrix, where an extensive ulceration with prolapse is present, by means of a conjunctival flap, with single or double pedicle, which is drawn over the ulcer, is a valuable one. If, for example, the ulcer and prolapse be at *a* (Fig. 49), an incision *b c* is made through the conjunctiva

along the margin of the cornea, and an incision *d e* more peripherally, or it is perhaps better to make the peripheral incision first. The flap so outlined is dissected up, drawn over the cornea, ulcer, and prolapse of iris, and then secured in its new position by means of a suture (*f*, Fig. 50). In forming the conjunctival flap, care should be taken to obtain it with as little subconjunctival tissue adherent to it as possible. In a few days the flap becomes adherent to the ulcer and prolapse, and its upper and lower positions can then be released with the scissors. By this means a stronger covering for the ulcer and prolapse is provided, and the dangers of late infection and of staphyloma are minimised.

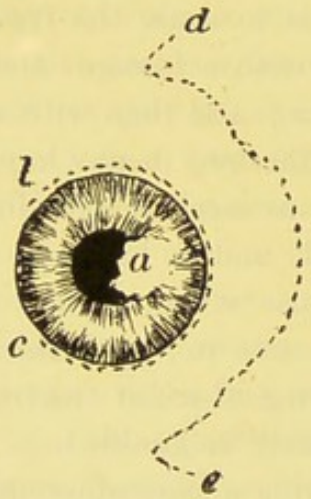


FIG. 49.

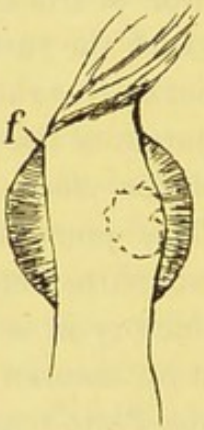


FIG. 50.

Different types of corneal ulcers are recognised and described. Of these the following are the chief :—

Simple Ulcer.—This may result from a slight trauma, or it may originate in a phlyctenula. It presents the appearance on the surface of the cornea of a minute and shallow depression with a grey floor. There is circumcorneal vascularity, especially at that part of the corneal margin nearest to which the ulcer is situated ; the pupil is apt to be contracted, although iritis is not present, and there is often a good deal of pain, lacrimation, and photophobia.

Treatment and Prognosis.—The eye is to be bandaged, warm fomentations applied several times a day, and a drop of solution of atropine instilled night and morning. When of phlyctenular origin, stimulation with the yellow oxide ointment is indicated. Dionine may be used. Cure, with slight opacity remaining, comes

about in a week or ten days. But, if it become infected, this form of ulcer may pass over to the deep ulcer.

Deep Ulcer.—This is a septic or infected ulcer, and commences in a septic infiltration of the cornea. It forms a tolerably deep pit in the cornea towards its centre, the floor of the ulcer being covered with purulent deposit and detritus, and the corneal tissue immediately surrounding it being somewhat infiltrated with pus. The ulcer is generally round, but it may assume any shape. Hypopyon is often present, and a marked tendency to iritis exists. The pain is usually very severe, violent frontal neuralgia being a common symptom.

This ulcer has no great tendency to spread over the surface of the cornea, but has a very decided tendency to perforate through it. As it does not generally attain wide dimensions, the perforation it may produce is small, and gives rise to a small adherent leucoma rather than to a staphyloma. It seldom causes complete loss of the eye.

Causes.—This form of ulcer is a frequent one in gonorrhœal ophthalmia and in blennorrhœa neonatorum ; and it may be caused by the lodgment of foreign bodies, and other injuries of the cornea.

Treatment.—If the ulcer be due to a conjunctival process, the latter should be actively treated, and the only attention needed for the ulcer is to anticipate with paracentesis a spontaneous perforation.

If the cause be other than conjunctival, a pressure bandage to give support to the ulcer is important, and periodical warm fomentations are most beneficial ; but where the cause is conjunctival (purulent conjunctivitis), neither a bandage nor warm fomentations can be used. Atropine should be instilled in all cases several times daily, and antiseptic applications, especially xeroform, are useful.

Paracentesis of the anterior chamber through the floor of the ulcer is a proceeding always followed by improvement in the condition of the eye, and is important as a preventive of natural perforation. The actual cautery, too, is in its place here, except when the ulcer is due to purulent conjunctivitis.

Fistula of the Cornea.—The deep ulcer when it perforates is the most common cause of fistula of the cornea. A fistula presents the appearance of a very small black spot near the centre of a leucoma, and is liable to form when the perforating ulcer is in the

pupillary area of the cornea, so that it cannot be perfectly closed by the prolapse of iris into it. In this position the ulcer closes by the slow growth of connective tissue from its margins, and sometimes this process does not go on to completion, and a small central fistula is left. Or, the perforation is so situated, that just a small tag of the pupillary margin of the iris is incarcerated in the cicatrix; and the pulling of the iris on this, as the pupil dilates, prevents complete closure of the orifice. Or, if the perforation be of wide area, with extensive iris-prolapse, the pressure of aqueous humour may cause a small rupture in the prolapse which may not heal again. Through the fistula, however it may occur, aqueous humour constantly trickles away, the anterior chamber remains very shallow or quite empty, the globe is soft, and gradually becomes softer; or, the fistula closes for a time, the eye then becoming of glaucomatous hardness, and the high tension ruptures the cicatrix, which again closes, and is again ruptured by high tension. Finally, sight is lost through secondary glaucoma, detachment of the retina, or severe uveitis or hæmorrhage.

Fistula of the cornea is very difficult of cure. The treatment consists in the use of a myotic to keep the intra-ocular tension low. With the same object an iridectomy is indicated, but is difficult of performance owing to the shallow anterior chamber. An iridectomy may also be indicated to withdraw a tag of the margin of the pupil, which may be engaged in the fistula. The margins of the fistula may be curetted, or cut away, or cauterised, but the close proximity of the lens must be borne in mind, lest its capsule be injured by these proceedings. After curetting, a conjunctival flap with pedicle may be transplanted over the opening (p. 122); the flap by healing to the curetted margin aids in the closure of the fistula. Or, into the opening, the margins of which have been previously curetted, a small flap of conjunctiva without pedicle may be pushed, which, healing in it, closes the opening.

Serpiginous Ulcer (Ulcus Serpens, Sæmisch's Ulcer).—This, also, is a purulent ulcer, a characteristic of which is its tendency to creep over the surface of the cornea, especially in some one direction, rather than to strike deep into its tissue. It originates in a superficial infiltration or abscess, which rapidly ulcerates. Its position is chiefly central, and it presents a greyish floor, which

is more intensely opaque at some places. One part of the margin takes the form of a curve, or of several closely placed curves, and becomes there yellowish-white in colour and somewhat raised, and the floor of the ulcer seems deeper in its neighbourhood. Immediately around the ulcer the cornea is slightly opaque, but farther out it is normal.

The degree of pain and irritation varies much, being almost absent in some cases, while in others it is intense. Iritis is apt to come on at an early period, and may pass into irido-cyclitis. Hypopyon is almost always present. On the posterior surface of the cornea, from the region corresponding with the ulcer on the anterior surface, a line of pus is sometimes seen extending down to the hypopyon, and this was formerly taken as a proof that the hypopyon was formed by direct transmission of the pus corpuscles through the cornea from the ulcer. The ulcer creeps over the surface of the cornea in the direction of the curved and more intensely infiltrated portion of the margin—the progressive margin—while the opposite side of the margin tends to become cleaner. At a still later stage the whole cornea is apt to become infiltrated, and the entire margin of the ulcer to extend, and the anterior chamber becomes quite full of pus. Perforation now takes place, or may do so somewhat earlier. If the perforation be small, an adherent leucoma results ; but if large, a staphyloma of the cornea gradually develops, or panophthalmitis may immediately follow on the perforation.

Causes.—Ulcus Serpens always has its origin in a trauma, which has produced, it may be, only an abrasion. In perhaps 50 per cent. of the cases chronic dacryocystitis is present, and in about 25 per cent. more there is ozœna, and a considerable proportion of them occur in the warm summer months. It is a disease of the poorer classes, is seldom seen in children, is most common between the ages of forty and seventy, and is more common in men than in women.

In most instances the pneumococcus—which is usually present in the discharge in chronic dacryocystitis—is the excitant of the typical ulcus serpens, but occasionally cases have been observed in which the pneumococcus was not present, and the diplobacillus liquefaciens, the streptococcus, the bacillus subtilis, or some rarer form of micro-organism, was the excitant.

Prognosis.—From the description given, it will be seen that the process is a severe one in very many cases, and the prognosis for vision, or it may even be for retention of the eyeball, very serious. Yet cases of a mild type do occur which soon give way to ordinary routine treatment, and leave only a relatively small and not very opaque, but centrally situated, corneal cicatrix, allowing of some useful vision, which may be improved by an optical iridectomy. Again, the prognosis depends very much upon the stage at which the case comes under care. The process can frequently be arrested at an early stage, while later it will resist every treatment, and will lead on to panophthalmitis, or extensive leucoma.

Treatment.—If the case be not severe, atropine, with protection of the eye, may cure in a few days, but it is not wise even in the apparently mild cases to trust to these measures. Warm fomentations should not be used, as they rather promote the activity of the diseased process; and the eye should not be bandaged, lest infective discharge be retained in the conjunctival sac. Antiseptic measures should always be employed from the beginning, the thorough, but localised, application of pure carbolic acid being probably the best of these means. The floor of the ulcer may be washed with a solution of sublimate 1 in 5000, or with hydrogen peroxide, or other antiseptic solutions. Curetting is not beneficial.

But it is in all respects wiser to deal with these cases, even the apparently mild ones, actively, as soon as the case comes under observation, and in anticipation of the time, which approaches rapidly, when treatment cannot be of any practical avail. If, as is so often the case, chronic dacryocystitis be present the lacrimal sac should at once be extirpated (*vide* chap. xviii.). At the same time one or other of the following local measures should be employed—the first is suitable to cases in which the infiltration is still confined to the superficial layers, where the products of disease can all be reached by the cautery; while the second is indicated in cases in which the deep parts of the cornea have become involved.

1. The Actual Cautery at a red heat is a valuable method of treatment for this ulcer in the early stages. It is the infiltrated and undermined margin of the ulcer which should be most thoroughly cauterised; but its floor, if much infiltrated, is also to be dealt with. The application of fluorescine just before the use of the cautery is valuable, as it enables the operator to discern clearly the

whole of the diseased part requiring cauterisation. Even the cautery is often ineffectual to arrest the progress of the ulceration.

At the thinnest part of the floor of an extensive serpiginous ulcer it is desirable to make a perforation through the cornea with the point of the cautery; or, when the cauterisation is finished, the cornea may be paracentesed with a broad needle in a sound region beyond the ulcer. The object is to reduce the intra-ocular tension, and thus promote the nutrition of the cornea.

Subconjunctival injections of a 1 in 5000 solution of cyanide of mercury, or of a 4 per cent. saline solution assist the cure (p. 119).

2. Sæmisch's Method consists in division (Keratotomy) of the ulcer with a Græfe's cataract knife. Cocaine having been applied, the point of the instrument is entered about 2 mm. from the margin of the ulcer in the healthy corneal tissue, and, having been passed through the anterior chamber behind the ulcer, the counter-puncture is made in the healthy cornea some 2 mm. from the opposite margin of the ulcer. The edge of the knife being then turned forwards, the section is slowly completed. The incision should divide the intensely infiltrated part of the margin in halves. The aqueous humour and hypopyon are evacuated, atropine is instilled, a bandage is applied, and the patient soon gets relief from pain. Every day, until healing of the ulcer is well established, the wound must be opened up from end to end with the point of a fine probe or spatula, the contents of the anterior chamber being thoroughly evacuated on each occasion, and atropine instilled. The result is that, in many cases, the progress of the ulcer is arrested, and healing sets in. The operation may be employed with advantage even in late stages of the process.

Römer has proposed, and both he and some others have carried out treatment of the serpiginous ulcer with an anti-pneumococcus serum. The treatment is rational, but it should be employed early; and alone it is hardly of sufficiently rapid action to be relied upon in these quickly destructive cases.

* **Diplobacillus Ulcer.**—This ulcer, which is not very common, bears some clinical resemblance to the ulcus serpens, and may be mistaken for it; but it is associated with very little pain or irritation, is less destructive, slower in its progress, and more amenable to treatment. Catarrhal conjunctivitis (p. 52) is often present, while dacryocystitis is absent. The history of a trauma is commonly

to be obtained. The definite diagnosis can only be made by a bacteriological examination of the secretion taken from the floor of the ulcer, in which the diplobacillus (Morax-Axenfeld) (p. 47) or the diplobacillus liquefaciens (Petit) should be found. In the initial stage, a central, or almost central, grey infiltration, often of very small size, appears near the surface of the cornea, surrounded by a delicate halo of less intense infiltration, and there is marked pericorneal injection. After a few days the ulcer becomes developed. It is 2 to 4 mm. wide, shallow, and covered with a greyish membranous exudation, which can be lifted off. Occasionally the floor is greyish-yellow, and deep. The margin is often slightly raised, and sometimes undermined. The superficial layers of the cornea around the ulcer are somewhat opaque, with stippling of the epithelium overlying them ; and, deeper in the cornea, radiating grey striæ reach into the healthy cornea, often nearly to its margin. Hypopyon is usually present. The severity of the corneal process in the later stages often alters the character of the conjunctivitis, when any is present, so that it can no longer be recognised as catarrhal. Occasionally small outlying infiltrations form in the cornea. The ulcer increases in size by extension of its margin in all directions, although in some cases this process, as in ulcus serpens, is mainly in some one direction. Only in the severest cases do infiltrations form in the deep layers of the cornea. A neglected case may lead to destruction of the eye through panophthalmitis, but careful treatment will save most of these eyes.

Treatment.—Sulphate of zinc is practically a specific for the cure of these ulcers. To effect a satisfactory result in a severe case it is necessary that the applications should be made with frequency, regularity, and thoroughness. A solution of sulphate of zinc of 1 per cent. should be dropped into the eye once every hour, or even more frequently ; and in the intervals an ointment consisting of ichthyol 1·5 per cent., and zinc sulphate ½ per cent., is inserted into the conjunctival sac. The ulcer may be touched with a cotton wool pencil soaked in the solution, and compresses saturated with the solution may be laid on the eye at intervals for twenty minutes. The treatment is often required to be continued for two or three weeks, or more. In rare cases the galvano-cautery, or Sæmisch's operation may be needed. Curetting is not advisable. The zinc treatment is in no way injurious to the eye, although temporarily

deposits of the salt on the ulcer do sometimes occur. The opacities left by a diplobacillus ulcer of the cornea are, in time, capable of much clearing.

* **Rodent Ulcer** (Mooren's Ulcer).—This is a rare and extremely dangerous form of ulcer of the cornea, and must not be confounded with the serpiginous ulcer. It is not a purulent ulcer.

The disease commences as a small—sometimes even pinhead-sized—grey infiltration near the corneal margin, not differing in appearance from many a harmless catarrhal infiltration. This rapidly ulcerates. Other similar infiltrations appear in the neighbourhood and at other parts of the margin, and ulcerate, and the ulcers coalesce into one, of which the advancing margin nearest the centre of the cornea is undermined. The undermined margin, under which a fine probe can be inserted, consists of partially necrosed corneal tissue, and presents the appearance of a narrow whitish line overhanging the line of active disease. The cornea beyond the margin of the ulcer is normal. The eyeball is injected. The ulcer does not go deeper than about one-fourth of the thickness of the cornea, and perforation seldom occurs. Occasionally a very small hypopyon is present, and occasionally too there is iritis. There is very great pain and photophobia in some cases, and in others hardly any.

Before long the ulcer in its oldest portion begins to be vascularised and to heal, and finally leaves an intense cicatrix behind. Gradually the ulceration creeps round the cornea, and at the same time advances towards its centre, by small infiltrations appearing just inside the opaque margin, which coalesce and soon break down, while healing is taking place in the oldest portions of the ulcer. This process goes on until, finally, the whole surface of the cornea has been eaten away, and cicatricial tissue substituted for it, its centre being the last place affected, and then vision will have become reduced to finger-counting or to perception of light.

The progress of the disease is very slow, many weeks or even some months often elapsing before the surface of the whole cornea has been destroyed, and the ulceration may become stationary for a time, only to start afresh without any apparent reason. Some clearing up of the corneal opacity may subsequently take place, but cannot be reckoned upon. Yet in a few cases, by gradual clearing of the cornea, fairly good vision has been regained in the

course of a year or two. The disease attacks both eyes in about one-fourth of the cases, although there may be an interval between the onset in each, of weeks, or months, or more. It attacks decrepit people of over middle life, but occurs also in young persons and in those of apparently robust health. Its etiology is obscure. No specific micro-organism has as yet been discovered as the immediate cause.

The onset at the edge of the cornea in the form of small grey infiltrations, the grey and shallow floor of the ulcer, its pale grey or almost white margin, the undermining of this margin (which may readily be ascertained by passing the point of a probe under it), and the steady advance of the ulceration towards the centre and around the edge of the cornea, are the characteristics of this disease.

Treatment.—Rodent ulcer is usually a most intractable disease, no reliable method of treatment, to which the majority of cases will respond, having been as yet put forward.

The general nutrition of the individual is to be improved, but reliance is mainly to be placed on local treatment, which should especially be directed to the undermined margin, or rather to the surface immediately underlying this, after the overhanging lip has been cut away with fine sharp scissors.

The galvano-cautery is much in use here, and it is important that the burning should be rather deep. Pure liquid carbolic acid applied with a fine bit of wood, the excess being taken up with a bit of blotting paper, is also useful. In a case under the care of one of us absolute alcohol applied to the ulcer (p. 136) produced a remarkable and rapid cure, so that a small central area of sound cornea was preserved ; and a second case has been similarly cured. Curetting, tincture of iodine applied with a camel's-hair pencil, sublimate lotion, with a bandage and the usual warm fomentations, may help in the treatment. The covering of the diseased part—after it has been well cauterised—or of the entire cornea, with a conjunctival flap, is worth the trial.

***Marginal Ring Ulcer** is a rare form, which commences as a clean-cut, or but slightly infiltrated, yet rather deep, ulcer at the corneal margin. Its tendency is to extend along the margin of the cornea ; and in some instances healing takes place in the older parts of the ulcer, while it is still progressive at the newer parts. It may extend all round the cornea, and finally give rise to complete

sloughing of the latter by cutting off its nutrition. This ulcer may result in children from a marginal phlyctenular infiltration (p. 104), but is more common in adults, or in aged people, whose nutrition has fallen very low.

Treatment.—The actual cautery. Paracentesis through the ulcer, eserine having been first instilled. Insufflation of xeroform. Warm fomentations. A dressing and bandage. Quinine, iron, and strychnine internally, with nutritious diet.

Absorption Ulcer (Facetted Ulcer, Superficial Transparent Ulcer) is the term applied to a certain definite superficial ulceration which is accompanied by but little opacity and by no vascularisation, and which is usually seated at or near the centre of the cornea, where it presents the appearance of a shallow pit 1 mm. or 2 mm. broad, with rounded margin, its floor being covered with epithelium. If the eye be exposed to cold, wind, or other irritation, some circumcorneal injection makes its appearance, and there is lacrimation; but these symptoms soon pass off again. The healing process may take months to be completed, and slight opacity remains. Often the defect is never quite filled up, but a small facet is left, which is liable to interfere with vision.

The absorption ulcer does not tend to perforate, nor to spread over the surface of the cornea.

It occurs chiefly in childhood, and probably indicates malnutrition of the general system; some observers, indeed, think there is a close relationship between it and phlyctenular ophthalmia. It is also seen in granular ophthalmia, with and without pannus.

Treatment consists in atropine, dionine, and protection, with a bandage in the early stages; and the yellow oxide ointment in the later stages. General treatment with suitable tonics is indicated.

Neuro-Paralytic Keratitis.—In paralysis of the Ophthalmic Division of the Fifth Nerve purulent infiltration and ulceration of the cornea with hypopyon are occasionally observed, or the process may be very superficial and aseptic. It was formerly believed that the fifth nerve had an influence over the nutrition of the cornea, and hence that neuro-paralytic keratitis is a trophic process; but an analysis of the recorded cases shows that the keratitis occurs only in irritative lesions of the fifth nerve, and that the development of the affection is assisted by the diminished reflex lid-action and secretion of tears, and consequent drying and disorganisation of

the corneal epithelium, which renders it possible even for septic infection of the cornea to take place. This disease, therefore, cannot be regarded as of neuropathic origin in the strict sense of the term.

That keratitis is not very common with paralysis of the fifth nerve is doubtless due to the moisture of the surface of the cornea being sufficiently maintained through the consensual action of the eyelids of the affected eye with those of the opposite eye; and, also, that reflex lacrimation of the affected eye, although in diminished degree, results from stimulation of the opposite cornea. Yet under certain conditions—*e.g.* if the nictitation be incomplete (partial paralysis of the facial nerve), or if there be some proptosis —the cornea may become dry, and keratitis may appear. In all the cases published of paralysis of each fifth nerve, keratitis appeared, for here the protection of the reflexes originating on the other side was not present. The absence of any ill-result to the cornea from the operation of extirpation of the gasserian ganglion on one side only for severe neuralgia is explained by what has just been stated.

The commonest causes of neuro-paralytic keratitis are intracranial tumours and fractures of the skull.

Treatment consists, in the milder cases, in protection of the cornea by keeping the eyelids closed with a bandage, or by fastening them together with a dermic suture. The severer cases of purulent infiltration or ulceration must, in addition, be dealt with on the lines laid down in previous pages for the treatment of those conditions.

* **Keratomalacia (Infantile Ulceration of the Cornea with Xerosis of the Conjunctiva)** is a very rare affection. It attacks some poorly nourished children early in the first year of life, making its appearance at or near the centre of the cornea. Iritis always supervenes in severe cases. That portion of the bulbar conjunctiva which is exposed in the palpebral aperture at either side of the cornea undergoes slight epithelial xerosis, similar to that in functional night blindness, due to retinal exhaustion. Sometimes the xerosis of the conjunctiva is absent. Ulceration of the cornea soon comes on, through necrosis of the layers lying over an interstitial infiltration; and this ulceration spreads until it involves the whole of the cornea, except a very narrow margin. Finally, perforation, with prolapse of the iris, and panophthalmitis may supervene.

Both eyes become affected as a rule, although the disease usually attacks one eye some time before its fellow. The patients almost always die of diarrhœa, pneumonia, etc.

Cause.—Streptococci have been found in the corneal ulcer and in the conjunctiva, while a general streptococcus invasion of the vascular system of the whole body is also present. To the latter circumstance are referred the conditions which lead to a fatal termination. Many of the infants attacked are syphilitic, but whether, as is held by some, the corneal process is a specific one, and not merely part of the general cachexia, is an open question.

Treatment is of little avail; but warm fomentations and the use of non-irritating antiseptic lotions, etc., are indicated, along with an antiseptic dressing. Such means as may possibly promote improvement of the general system are obviously called for. In cases of congenital syphilis, calomel internally is stated to have been of great service, not only to the general state, but also to the corneal disease.

Herpes Corneæ Febrilis.—Not only in herpes zoster ophthalmicus (chap. xvii.), but also in herpes febrilis (or catarrhalis) is a vesicular eruption liable to occur on the cornea. It is met with in any of the inflammatory affections of the respiratory tract, from a common cold, to severe pneumonia. It also occurs with whooping cough, and with intermittent and typhoid fever. It can also occur as a primary affection. It may be more common than ophthalmic practice would lead us to think, for it is the resulting ulceration which usually comes under our notice. The patient complains of the sensation of a foreign body in the eye, with lacrimation and photophobia, and these symptoms disappear when the vesicles rupture.

On the surface of the cornea of one eye is formed a group of clear vesicles, each from 0·5 to 1·0 mm. in diameter. They usually form in a line, which runs obliquely across the cornea, or sometimes in a vertical direction. Now and then they are arranged in trefoil shape or in a circle. The covering of the vesicles is short-lived, and, as already remarked, the resulting ulcer is that which the surgeon usually first sees. Even it, however, is thoroughly characteristic. On the surface of the clear cornea is an irregular loss of epithelium, along the margins of which may still sometimes be seen the shreds of the late covering of the vesicle. The margin

of the region which is bared of its epithelium is dentated, and can only be mistaken for a traumatic loss of epithelium. But the latter would not present the peculiar 'string-of-beads' appearance. The floor of the loss of substance is formed by the superficial layers of the cornea, and anæsthesia of the cornea is confined to this place, and does not, as in herpes zoster, extend to the rest of the cornea. The tension of the eye is generally reduced. Under favourable circumstances this loss of epithelium may be rapidly repaired; although even then more slowly than one of equal dimensions, but of traumatic origin. Usually the healing process is slow. Sometimes more or less intense opacities form in the area and at the margin of the ulcer, with hypopyon, iritis, etc., and the loss of substance becomes deep, with a dentated margin. This unfavourable course is the result of secondary infection of the ulcer.

Treatment at an early stage, before the vesicles have burst or the loss of substance has become infiltrated, consists in protection of the eye, and, when infiltration has set in, in disinfection, with protection. In obstinate cases 4 per cent. saline subconjunctival injections are often of use. If the vesicles give great pain they may be ruptured by dusting a little calomel into the eye, or by brushing it with a camel's-hair pencil wet with solution of boric acid, after which a well-fitting antiseptic dressing is applied. Cocaine should be used as sparingly as possible, owing to its ill-effect on the epithelium when used in excess. Atropine and warm fomentations are indicated, and a weak yellow oxide ointment is of use in some cases. Where the nostrils are affected, weak sublimate or other antiseptic washes should be applied to the Schneiderian mucous membrane.

* **Filamentary Keratitis.**—This is very rare. Its name is due to the fine threads, like twisted spun-glass, several of which hang from the surface of the cornea, and give the condition its characteristic appearance. These threads never reach a length of more than 3 or 4 mm., and are composed of twisted proliferating epithelial cells, each thread ending in a bulbous enlargement caused by degeneration of the epithelium. The condition may result from a superficial trauma of the cornea, or from a bullous or herpetic keratitis, also after several applications of absolute alcohol, when used for dendritic keratitis.

Treatment.—The instillation of a 3 per cent. solution of chloride of ammonium into the eye every two hours, by which the exfoliation

of the epithelial growth is promoted and hastened, produces a rapid cure. Protection of the eye with a dressing and bandage is important.

* **Bullous Keratitis.**—Bullæ very rarely form on the cornea. They are seldom the primary condition, but usually depend on a diseased process in the true cornea. This process may itself be a primary disease ; but more commonly it, too, is secondary to deep changes in the eye, such as absolute glaucoma, iridocyclitis, etc. Very rarely bullæ are seen on the cornea of an otherwise sound eye, in a person whose health is in a debilitated state. Bullæ on the cornea are sometimes caused by blows on the eye, or by direct traumata of the cornea. The formation of a bulla is attended by much pain and photophobia, which disappear as soon as the bulla ruptures. One, or more than one, bulla may form at a time. After a day or two the bulla ruptures, and its walls hang in shreds from the surface of the cornea, and may produce the appearance of filamentary keratitis, and the seat of the bulla presents shallow depressions. These losses of substance heal without leaving any permanent opacity. After an interval of days or weeks another crop of bullæ appears, and runs the same course.

Treatment.—The bullæ should be opened, and their walls snipped away with a scissors, and a bandage applied. The recurrent attacks may cease after a length of time ; but, if it be a secondary affection, treatment can influence it only by relieving the process in the cornea which gives rise to it. If it be a primary process, warm fomentations, atropine, and a bandage, with remedies directed to the correction of any fault in the general state of the health which may exist, are suitable.

* **Dendriform** (*δένδρον, a tree*) **Keratitis.**—This is a rather rare affection. It is a very superficial and chronic ulceration, with but little infiltration of its margins or floor, and presents the appearance of a fine groove, or grooves, on the cornea. It spreads chiefly over the central region of the cornea by throwing out branches on either side, while on the end of each branch there is usually a minute grey infiltration, and its true nature may easily be overlooked unless the cornea be examined by the combined focal method. Pain and irritation are sometimes severe, and again but slight or absent. Some slight permanent opacity may remain when cure has been effected.

Fig. 51 represents three of the most common forms of the

disease. At *a*, in the drawing on the left, there is a nebula where healing has set in, while in another part of the same cornea the process is in an active stage. In the central drawing, near the upper corneal margin, there is a fine herpetic-like eruption, and a long groove passing down from it. And, in the drawing on the right, the tendency to branch is well shown.

In cases which have been long neglected, and in which the disease has run riot over the cornea, no healing process having set in, the surface becomes dull grey and irregular, as though ploughed up, the primary characteristic appearances being lost by reason of the amount of disease present. The ulceration rarely becomes septic.

The Cause has not been definitely ascertained, but the peculiar

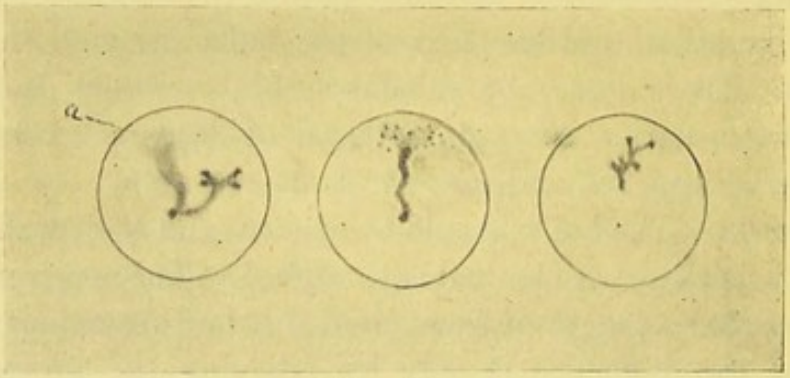


FIG. 51.

habit of the affection renders it almost certain that it is produced by a mould. The opinion is strongly held by some, that these ulcers result from a herpetic eruption on the cornea.

Treatment.—Curetting with a sharp spoon, with the subsequent application of 1 in 1000 solution of corrosive sublimate to the cornea, is recommended by some, also the application of pure carbolic acid to the ulcer with a fine camel's-hair pencil, care being taken to confine it to the ulcer. The actual cautery is sometimes useful. But these remedies often fail to produce a cure.

It was in the fourth edition (1892) of this handbook that attention was first directed to the value of the local application of absolute alcohol in this obstinate disease, and since then it has proved in our hands an almost certain, as well as a rapid, cure in nearly every case. A bit of matchwood is sharpened to a fairly fine point, and

around the latter a little cotton wool is rolled not very thickly. This is moistened with absolute alcohol, and the ulcer is then rubbed with the point with such pressure as to take away the epithelium, and, so far as possible, the rest of the corneal surface is avoided. Immediately afterwards the conjunctival sac is freely washed out with sterilised salt solution, to remove all surplus alcohol which would increase the subsequent pain. The application is painful even with cocaine. As a rule there is pain for some hours afterwards, and for this hot fomentations afford the best relief; cocaine is of little use. Usually one application is sufficient to produce cure, but some cases require it to be repeated after four or five days. It is not desirable to repeat the application more than once, or at most twice, as the corneal epithelium is then liable to become deranged, and filamentary and bullous keratitis may be produced.

The application of a fine point of sulphate of copper to the ulceration also produces some good cures. It is less painful than the alcohol, because its action is easily confined to the ulcerated part, but it is not so certain in its action.

* **Keratitis Aspergillina.**—This rare disease was described by Leber. The appearance presented is that of an ulcer from 3 to 5 mm. in diameter, occupying a rather central position in the cornea. The surface of the ulcer is of a pale greyish yellow, and is very irregular. A striking and characteristic appearance is the dryness of this surface, the copious discharge of tears flowing over it without seeming to wet it. The rest of the cornea is slightly opaque and dull, and there is a small hypopyon present. The conjunctiva is injected and swollen, and is covered with some mucous secretion. The eyelids are rather swollen. There is photophobia and often severe pain. Masses removed from the surface of the ulcer and examined with the microscope are found to be full of the aspergillus fumigatus. It may usually be ascertained that an injury has preceded the appearance of the ulcer.

Treatment.—The membranous mass which forms the floor of the ulcer should be peeled off, and the underlying surface cauterised and dressed with xeroform, after which a good and rapid cure takes place. Hot fomentations should not be used, as they promote the growth of the fungus.

Tubercular Ulceration of the Cornea. See p. 146.

(*b*) Non-Ulcerative Inflammations of the Cornea.

Abscess.—This affection is on the borderland between the ulcerative and non-ulcerative inflammations of the cornea; for in one case it results in an ulcer—usually the ulcus serpens—while again it runs its course without ulceration. The abscesses which are seated in the more superficial layers are those which go on to ulceration; those in the deeper layers are less likely to do so.

Abscess differs from infiltration in that the pus which forms it destroys the true corneal tissue—the fibrillæ and fixed corpuscles—and does not merely lie between them.

Signs and Symptoms.—The appearance presented is that of a yellowish circumscribed opacity, more intense at its margin than at its centre, seated at or near the middle of the cornea, and surrounded by a light grey zone. It is usually round in shape, but when situated near the edge of the cornea it is apt to be crescentic. The surface of the cornea just over the abscess is at first a little elevated over the general surface, but later on becomes flattened, owing to a falling-in of the normal layers anterior to the abscess; and the epithelium of the flattened part has a dull, breathed-on look. The rest of the cornea may also lose its brilliancy, although in a much less degree. Hypopyon and iritis are constant attendants upon corneal abscess. There is much injection of the conjunctival and ciliary blood-vessels. Severe pain in and about the eye, and blepharospasm, are common; yet occasionally a corneal abscess is attended by but little pain or other irritation.

Progress.—The abscess spreads through the cornea, usually in some one direction, and this direction is indicated by the yellowish opacity being more intense at the advancing side of the abscess. Before long, if the abscess be superficial, the layers of cornea covering it come away, and the condition is changed into that of the ulcus serpens already described (p. 124). The deeper abscesses spread through the cornea more or less widely, and ultimately become absorbed, without having caused ulceration. But even these abscesses leave considerable opacity behind. The process which ends in ulceration is the more common of the two.

Etiology.—Abscess is the result of infection of the cornea with pyogenic organisms, which reach it either from without, through

some traumatic loss of substance of the corneal epithelium, or from within, by the agency of the blood. The micro-organisms, which are introduced through a superficial loss of substance, may either have been on the foreign body which produced the injury, or they may have been present in the conjunctival sac, or in the lacrimal sac. Infection through the blood is occasionally seen in some acute exanthematous diseases, such as scarlatina, measles, and smallpox; more especially in the latter in its convalescent stage.

Treatment.—Atropine, warm fomentations, and a dressing. But if these mild measures do not in a day or so arrest the progress of the abscess, resort must be had either to the actual cautery or to Sæmisch's operation (p. 127).

*** Ring Abscess.**—Theterm abscess is hardly correct here, as the so-called ring abscess is in fact a purulent infiltration of the tissue of the margin of the whole cornea, or it may lie 1 mm. or 1·5 mm., inside the actual margin, and it quickly becomes an ulcer, so that the first stage is not often seen. The conjunctiva is chemotic, and from it there is a greenish yellow discharge. It is not a common affection, and is almost always caused by perforating wounds, including operation wounds, at any part of the cornea, and sometimes follows on perforating wounds of the sclerotic. It may also occur after spontaneous perforation of a corneal ulcer, the infection of an old incarcerated iris prolapse, or in metastatic ophthalmitis. Its progress is extremely rapid, leading to complete necrosis of the cornea and to panophthalmitis within a few days after the perforating injury is sustained, and often rendering excision or evisceration necessary almost as soon as the case comes under observation. In rare instances the process is less violent, and it may then be possible, by means of the cautery and careful dressing, to save some sight, or at least the shape of the eyeball. The micro-organism concerned is the bacillus pyocyaneus, which produces virulent toxine in large quantity.

Treatment.—Sæmisch's operation. Atropine, and careful cleansing of the floor of the ulcer and conjunctival sac with perchloride of mercury solution 1 in 2500.

Syphilitic Diseases of the Cornea. *Diffuse Interstitial or Parenchymatous Keratitis.*—This is by far the most common, and best known, of the syphilitic affections of the cornea. A very

similar disease is caused by tubercle (p. 146). The syphilitic form is most frequently met with between the ages of five and fifteen. It usually commences at some one part of the margin as a light greyish opacity, accompanied by slight injection of the ciliary vessels. The rest of the corneal margin soon becomes similarly affected; and then the opacity gradually extends concentrically into the cornea, or does so by sending in processes which afterwards become confluent. In this way the whole cornea becomes affected by degrees; and its epithelium acquires a breathed-on or ground-glass appearance. Occasionally the opacity commences at the centre, and not at the margin of the cornea, often in the form of small grey spots, and extends towards the margin, which it may not reach before clearing commences.

The opacity lies in the deep layers of the true cornea, and is slightly more intense here and there. It is sometimes only a very light cloud, or the cornea may be so opaque as to render the iris quite invisible. Along with the opacity, vessels form in the cornea in its posterior layers, but the degree of vascularisation varies much in different cases. In some the presence of vessels can only be ascertained by careful examination with a high convex glass (+ 16·0) behind the ophthalmoscope, or with the corneal microscope; while in others the new vessels are present in great numbers, and can be readily seen with the naked eye. In other cases close leashes of vessels near the anterior surface of the cornea follow the opacity, giving rise to the appearance known as the 'salmon patch.' The infinite variety in the degree of opacity and in the amount and arrangement of the vascularisation, results in great variation in the appearances in different cases.

When the whole cornea has become opaque, it begins to clear at the margin, and the central portion becomes even more opaque than the margin had ever been—a fact which shows that the very cells which entered the cornea at its margin have advanced to its centre. The clear margin gradually increases in width, until only a rather intense central opacity is left. This central opacity slowly breaks up, and becomes absorbed, but not always completely; and then considerable and permanent impairment of vision may remain. Even in the more peripheral portions of the cornea, in some cases, a faint maculated cloudiness may be found on careful examination, years after the active process has ceased.

In severe cases, iritis and chorioiditis are nearly always present, although the latter is not observable until the cornea has become clear enough to admit of an ophthalmoscopic examination. The disease, indeed, must be regarded, strictly speaking, as one of the uveal tract, to which the posterior layers of the cornea, which are mainly diseased, belong.

The two forms above described, one commencing at the margin, the other at the centre of the cornea, and more or less vascularised, but for the most part ultimately occupying the entire cornea, are those we are wont to find in children and young adults. But in older persons, up to thirty or thirty-five, milder forms of interstitial keratitis are met with. These rarely occupy more than a small region of the cornea, generally towards its centre, either as a patch or as a ring of opacity, and with little or no vascularisation.

The affection is often accompanied by a good deal of pain and blepharospasm, especially in the severe vascular forms, and there, too, the tension of the eye is apt to be temporarily reduced.

The acute stage of the disease lasts from six to eight weeks, or longer. But the entire process may not be completed for many months, and in one case at the Victoria Hospital the opacity did not begin to clear away for eleven months after the cornea was first attacked, the whole process extending over a period of two years.

In children both eyes invariably become affected, although not always at the same time, the onset in the second eye beginning often when the inflammation in the first eye has made some progress, or, perhaps, when the first eye has undergone cure. It is important, in the very commencement of treatment, to acquaint the patient or his parents with the likelihood of this course of events.

In adults usually one eye alone is attacked, iritis is rare, the duration of the process is comparatively short, and complete clearing up is relatively frequent.

Causes.—The affection is more common in girls than in boys, and most frequently appears during second dentition, when the upper incisors are being cut, or at puberty.

It depends upon some serious derangement of the general nutrition; and this, in about 70 per cent. of the cases, is inherited syphilis—a fact which was first pointed out by Sir Jonathan Hutchinson. The children are often thin, anæmic, and of stunted growth, with flat nose, cicatrices at the angles of the mouth, and

are frequently more or less deaf ; and the peculiarities of the incisor teeth, so well known from Hutchinson's description, are present in about one-half of the cases. That the spirochæte pallida is present in the cornea has been demonstrated microscopically.

Occurring in adults, the affection is rarely due to inherited syphilis, although acquired lues may sometimes be taken as its cause ; while, again, it will often be impossible to assign any origin for it other than the universal one of exposure to cold, etc. Some cases are due to tubercular disease (p. 146). While in some syphilis and tubercle are combined and the cases react both to Wassermann's and to the tuberculin tests.

Prognosis.—In children—in view of the possibility of an incomplete clearing of the cornea, as well as of the serious uveal complications liable to supervene, and which may completely annihilate vision—the prognosis must be guarded, although by no means hopeless, in those cases where the opacity is very intense, or where there is much vascularity. Yet, in the milder cases, a favourable prognosis may be given. The affection does very rarely recur.

In adults, as stated, the prognosis is much more favourable.

Treatment.—In the early stages no irritants should be applied locally. Atropine is important for the prevention of iritis or of posterior synechiæ ; and the use of radiant heat, in the form of hot poultices or fomentations, or the Japanese warmer, promotes the nutrition of the cornea and hastens the cure by absorption of the cellular elements which form the opacity. Dionine is often very useful. A dressing and bandage should be worn. Subconjunctival injections of the oxycyanide of mercury 1 in 5000, are often useful. When the acute stage is ended, dionine and the yellow oxide ointment may be employed with benefit for stimulating the absorbents to carry off what remains of the opacity. Massage may be used with advantage in both stages to disperse the infiltration. In severe cases a course of mercurial inunctions, continued for several weeks, is very advisable ; care being taken not to allow stomatitis to exceed moderate bounds. Salvarsan does not seem to act more rapidly in the cure of interstitial keratitis due to congenital syphilis than does an active mercurial treatment, but a few very good results have been obtained by it. In mild cases a tonic plan of treatment, with iodide of iron and cod-liver oil, is the most suitable.

Counter-irritation, in the form of blisters to the temple or a

seton in the scalp, is extensively employed by some surgeons. We do not use this treatment, as we doubt its value, and are loth to add to the worries inseparable from so wearisome a disease.

The following much rarer forms of syphilitic disease of the cornea are described :—

* *Specific Punctiform Interstitial Keratitis.*—Circumscribed, pinhead-sized, greyish infiltrations form at various levels in the otherwise clear stroma of the true cornea. They do not grow larger, nor suppurate. They form rapidly, and disappear rapidly when cure commences, leaving little or no opacity behind. The affection is not associated with iritis, but there is usually some ciliary injection. In somewhat similar cases the punctiform opacities are not so defined, but are surrounded by a halo of lighter opacity, and iritis is present. This affection is a manifestation of tertiary syphilis, and the punctiform opacities have been regarded as the products of a gummatous inflammation. The treatment would be iodide of potash internally, and locally atropine, warm fomentations, and a bandage.

* *Gumma of the Cornea.*—Some cases of true gumma of the cornea have been recorded. The growth appears as a pale grey or whitish elevation, more or less vascularised, on the cornea. The diagnosis depends very much on the patient being the subject of tertiary syphilis. The treatment is iodide of potash.

* *Keratomalacia* is also reckoned by some to be a syphilitic affection (p. 132).

* **Keratitis Profunda.**—This presents the appearance of a greyish opacity in the deep layers of the cornea at or near its centre, which gradually increases in intensity and extent, but never reaches the margin of the cornea. The epithelium of the cornea over the infiltration is dull and stippled. There is but little vascularisation, and no great tendency to inflammation of the uveal tract. After some weeks the infiltration gradually breaks up and becomes absorbed, leaving in severe cases a good deal of opacity, and in less severe cases a fairly clear cornea. The affection is seen only in adults, and its etiology is unknown, but rheumatism, malaria, and traumatism have been held accountable for it. It seems probable that it is the result of a localised derangement of the posterior epithelium of the cornea ; but if that be so, the ultimate cause of that derangement has not yet been suggested.

Treatment.—Atropine, warm fomentations, dionine, sub-conjunctival saline injections, and bandage, with care of the general health.

* **Guttate or Nodular Keratitis,** and **Grating-like or Reticular Keratitis.**—These were originally described as separate diseases by separate observers, but it is now recognised that they are essentially one and the same disease, and that merely an unimportant difference in the form of the appearances exists. This nodular or reticular keratitis—a satisfactory title is wanting—is a rare disease. Its presence is apt to be overlooked in the early stages; for by focal illumination the cornea may seem perfectly normal, and the rest of the eye, except perhaps for some slight distension of the anterior ciliary and larger conjunctival vessels, is healthy, and the eye is free from irritation. The patient merely complains

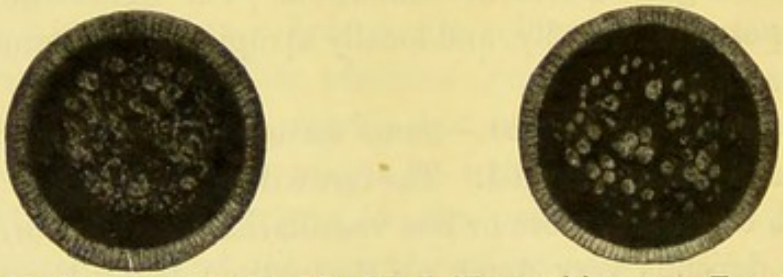


FIG. 52.—Nodular Keratitis. Mr. W. J. Hancock's case. *Trs. O. S.* xxv.

of slight burning sensations, especially during use for near work, of some photophobia, and of somewhat diminished acuteness of vision. Transmitted light from the mirror displays in the illuminated pupillary area of the cornea a number of small opaque patches of all shapes, occupying the most central position, while between them, and sometimes reaching out more towards the periphery of the cornea, but often leaving a clear zone inside its margin, innumerable very fine dots are present—nodular keratitis. In some cases the opaque patches are absent, while a number of fine forked lines are seen in the early stage outside the central region, which at first is occupied by fine dots alone. At a later period, the arrangement of the radiating forked lines assumes a somewhat reticulated appearance, like that of a grating, and they extend to the centre of the cornea—reticular or grating-like keratitis. The corneal microscope shows that these dots, patches, and lines

are greyish, and situated close under the epithelium. The surface of the latter is, in the early period, in no way altered.

Gradually the diseased appearances increase in amount, the anterior ciliary vessels become more distended, vision sinks lower, and the patient may sometimes complain of slight pain, with lacrimation, and swelling of the eyelids; but more commonly there is no irritation. The lines, dots, and patches now begin to show slight elevations on the cornea, although covered by epithelium. At a still later period the opacity in the centre of the cornea becomes more intense, a marginal zone of the cornea remaining fairly clear. At this stage the diagnosis may again become doubtful, owing to the amount of the disease which obscures the characteristic appearance.

Both eyes are always affected, either simultaneously, or with a short interval. The disease is exceedingly intractable and chronic, lasting many years, and finally causing much loss of sight. Most of the cases observed have been in young adult males, and it often attacks more than one member of a family, in one or in succeeding generations—it is, in fact, one of the family diseases. No relation to syphilis or other constitutional disease has been made out.

Treatment.—Treatment, so far, has proved of little, if any, benefit. Yellow oxide of mercury ointment, warm fomentations, galvanism, and hydrate of chloral eye-drops have been used. Dionine and subconjunctival injections should also be given a trial.

***Discoid,** or **Annular, Keratitis** (Keratitis Disciformis of Fuchs). —This disease occurs for the most part in persons of middle age, and frequently commences with slight defects of the epithelium caused by traumata or by herpes. It has also been seen by Schirmer

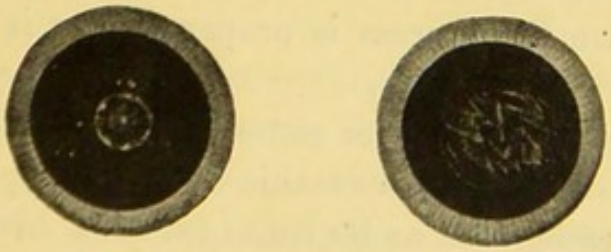


FIG. 53.—Forms of Discoid Keratitis. (After Schirmer.)

in connection with vaccine vesicles on the eyelids or conjunctiva. It is characterised by a delicate grey disc, which is situated deeply in the true cornea, at or near its central region, and which is marked

off sharply all round from the normal peripheral portion of the cornea by a more intensely narrow grey margin or ring ; or, outside this ring, there may be another or even two more peripheral rings, concentric with each other. With the corneal microscope grey striæ can sometimes be seen in the opacity which may radiate out into the clear cornea, parallel with each other or crossing at various angles, similar to those which occur in some other keratitides. The surface of the affected region is dull and its sensation diminished. In the course of the malady, which may run over several months, slight superficial ulcerations occur, and finally a rather intense opacity is left at the seat of the disease. The uveal tract is not usually implicated, but in rare instances the presence of some punctate deposits may be detected.

Treatment is of little avail. It should consist in atropine, bandage, hot fomentations, sub-conjunctival saline injections, and dionine.

Tubercular Keratitis.—Tubercular disease of the cornea presents itself in several forms :—

1. Pale yellow nodules which appear at the corneal margin, extend to its deep, but not to its deepest, layers, and protrude slightly over its surface, accompanied by ciliary injection. These nodules advance towards the centre of the cornea, become confluent, and finally undergo absorption, leaving an intense opacity behind ; or they may break down into ulceration, which may occupy the greater part of the corneal surface. The ulcer never perforates, and after a time healing takes place with cicatricial opacity, which may clear up to a great extent. This is the only truly primary form of tubercular disease of the cornea, no other part of the eye being affected, and it is rare. In the other forms of tubercular corneal disease the process is propagated to it from neighbouring parts.

2. Diffuse interstitial (or parenchymatous) keratitis. In about 70 per cent. of the cases of this affection syphilis, congenital or acquired, is recognised as its cause (p. 139). It is held that of the 30 per cent. which remain most, if not all, of the cases depend on tubercle, but without the presence in the cornea of tubercular nodules. Tubercular disease of the anterior uveal tract (p. 183) co-exists ; and, presumably, the corneal affection is the effect of toxines diffused in the cornea from the angle of the

anterior chamber. This form is capable of complete retrocession.

3. Greyish sclerotising opacities caused by tubercular nodules, which grow into the corneal margin in its deepest layers from the ligamentum pectinatum. These opacities occur at several parts of the periphery of the cornea ; and, by throwing forward tongues, they slowly spread into the cornea. Although the process may cease at any point, the cornea remains very opaque at the parts attacked, with resulting disfigurement or loss of sight.

4. Miliary tubercular nodules may form in the cornea in connection with tubercular episcleritis at the corresponding portion of the corneal margin, and may spread further into the cornea. These nodules do not ulcerate, and ultimately they disappear, leaving opacity behind.

5. Pannus, ulcers, and granulations, as the result of tubercle of the conjunctiva. The ulcers sometimes perforate. In the scrapings from tubercular ulcers the tubercle bacillus may be found.

Treatment.—For tubercular ulceration, curetting, with the insufflation of xeroform, or, should these fail, the cautery. For the other forms a course of tuberculin is indicated (p. 189).

Keratitis Punctata.—Until recent years this term was only given to a condition which occurs in cyclitis, in irido-cyclitis, and in sympathetic ophthalmitis, and which is not a primary disease of the cornea, and therefore does not come within the scope of this chapter. It will be considered under those headings (p. 192) ; and it need only here be stated that it consists in the deposit, in the form of fine dots on the back of the cornea, of lymph derived from inflamed portions of the uveal tract, mainly from the inflamed ciliary processes. For it the term ' punctate deposits ' is to be preferred to keratitis punctata.

*Fuchs has described a form of keratitis which he terms *Keratitis punctata superficialis*, and which has a good claim to that name. It begins with the symptoms of an acute conjunctivitis, but there is decided pericorneal injection, while the conjunctiva is not much injected, nor is the discharge mucous or purulent, but is rather an abundant lacrimal secretion. There is photophobia and pain. Either at the same time, or some days or weeks afterwards, minute grey spots may be seen in the most superficial layers of the cornea, the epithelium over the spots being somewhat raised up, giving a

dull appearance to the corneal surface. The spots are often arranged in groups or rows, and may be scattered over nearly the entire cornea, or else confined to its central region. There may be but a few of them, or there may be a hundred or more, and one or both eyes may be affected. The initial irritative symptoms soon disappear; but the spots themselves remain for many weeks, or even months, and finally fade away completely. The disease is more common in young people than in later life, and occurs usually in connection with a catarrh of the air passages; but it must not, by reason of this, be confounded with herpes of the cornea. The spots are often very faint, and hence can easily be overlooked, unless searched for with the combined focal method. In this country the affection is rather rare, but several cases of it have come under our notice.

The Treatment should consist in atropine, dressing and bandage, yellow oxide of mercury ointment, massage, and warm fomentations. To hasten the cure, in some long-drawn-out cases, removal of the corneal epithelium, which is to a great extent the seat of the disease, has been recommended.

Sclerotising Opacity of the cornea sometimes complicates scleritis, affecting the margin of the cornea in the neighbourhood of the scleral affection, but not extending more than 2 to 3 mm. into the cornea, except in very severe cases. It is an intense white opacity situated in the true cornea (Plate II. Fig. 5), and is apt to remain as a permanent opacity, even when the scleritis undergoes cure. In such cases of sclero-keratitis iritis is often present.

Treatment.—Atropine, warm fomentations, massage, sub-conjunctival saline injections, and the treatment of whatever constitutional derangement of health (rheumatism, syphilis) may be held to have given rise to the scleritis.

Ribandlike Keratitis (Transverse Calcareous Film of the Cornea; Calcareous Film of the Cornea).—This is a degenerative alteration of the cornea which occurs chiefly in eyes destroyed by severe intra-ocular processes, such as irido-cyclitis, sympathetic ophthalmitis, glaucoma, etc.

It also occasionally occurs as a primary disease in some persons of advanced life. In these latter instances glaucoma often comes on at a later period, or the corneal disease may be followed by irido-cyclitis, or central chorioiditis. It seems probable that,

in these primary cases, the cause of the degeneration is simply a loss of vital energy in the corneal tissue, due, it may be, to vascular changes.

The disease occupies that transverse strip of the cornea which is uncovered in the commissure of the eyelids during waking. It usually commences on the inner margin of the cornea, but soon appears at the outer margin, and advances from each direction towards the centre, where the two sections join. It presents the appearance of a greyish-brown opacity, with, in most cases, white calcareous deposits in and under the epithelium. In blind eyes which are constantly rolled upwards, the opacity is found, not in the central transverse section of the cornea, but in the exposed lower third. The opaque masses consist of carbonate and phosphate of lime. Leber puts forward the view that an abnormally abundant supply of phosphate of lime in the blood, and nutritive fluid of the cornea, is the cause of this condition, the rapid evaporation on the exposed part of the cornea being the reason why the deposit takes place there. The deposit is at first in Bowman's membrane, but later on it may appear in the anterior layer of the true cornea, and in the epithelium.

Treatment.—Some improvement may be effected by scraping away the chalky deposit.

Ectasies of the Cornea.

Staphyloma of the Cornea is the result of a perforating ulcer of the cornea, and the methods for obviating its occurrence have been set forth at p. 120.

The ulcer, having healed, may present a weak cicatrix, which becomes bulged forwards by even the normal intra-ocular tension. If the iris be not incarcerated in this cicatrix the anterior chamber will be made deeper. But staphyloma corneæ, in which the iris is incarcerated, is the more common condition. When a corneal ulcer is large, a correspondingly large portion of iris is liable to become prolapsed into it, and to form a bulging mass. This may burst and collapse, and a flat cicatrix may be formed ; or, if it do not rupture, it may form what is termed a partial staphyloma of the cornea and iris, the latter becoming consolidated by the formation of a layer of connective tissue over it (Fig. 54).

If the whole, or a very large part, of the cornea be destroyed by an ulcer, the iris is completely exposed. It soon begins to be covered with a layer of lymph, which gradually becomes converted into an opaque cicatricial membrane. Should this not be strong, the normal intra-ocular tension is sufficient after a time to make it bulge ; or, increased intra-ocular tension may arise in consequence of further changes within the eye, and then bulging of the pseudo-cornea all the more surely comes on, and the condition is termed total staphyloma of the cornea, although obviously the term is somewhat strained, as in fact there is no cornea. Such a staphylomatous cornea is intensely white, and would correctly be called a leucomatous staphyloma. Sometimes a total staphyloma has a lobulated appearance, owing to the pseudo-cornea having some of its fibres stronger than others ; and hence the name given to the condition (from *σταφυλή*, *a bunch of grapes*), and which has in time become applicable to almost any bulging of the cornea or sclerotic. Such staphylomata are apt to increase gradually to a very large size.

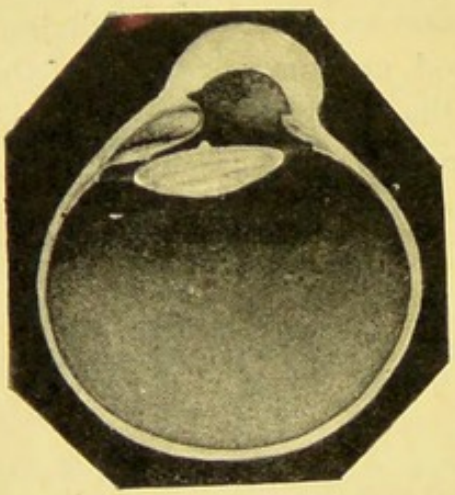


FIG. 54.—Almost total staphyloma of cornea, with great thickening of its cicatricial tissue.

Treatment.—In cases of partial staphyloma, where a clear portion of the cornea remains, an iridectomy is frequently indicated for the reduction of the tension—so that further bulging may be arrested—as well as for the sake of the artificial pupil, which may improve sight, in cases where the normal pupil is obliterated by corneal opacity.

When, sight having been lost, the staphyloma is very prominent, or when total staphyloma is present, enucleation of the eyeball, or one of the following operative measures, must be adopted.

Abscission.—A cataract knife being passed through the base of the staphyloma, with its edge directed upwards, the upper two-thirds of the staphyloma are separated off, while the remaining third is detached by means of scissors. If the lens be present it

must now be removed. The wide opening becomes filled up with granulations, and becomes cicatrised.

In de Wecker's method the opening is closed with conjunctival sutures. The operation is commenced by separating the conjunctiva all round the margin of the cornea, and by then loosening it from the eyeball nearly as far back as the equator. Four sutures (*a*, *b*, *c*, *d*) of different colours are then passed through the conjunctiva about 2 to 3 mm. from the margin of the wound, as represented in Fig. 55. In order to keep the field of operation clear, the ends of two of these sutures are laid over on the nose, while the others are laid over on the temple. The staphyloma is now abscised, and the sutures drawn together and tied.

The foregoing and other methods of abscission are only applicable where the tension is either low or normal. If it be high, the liability to intra-ocular hæmorrhage during the operation makes enucleation, evisceration, or Mules' operation more suitable proceedings. Indeed, probably most surgeons would now employ one of the two latter operations in all these cases.

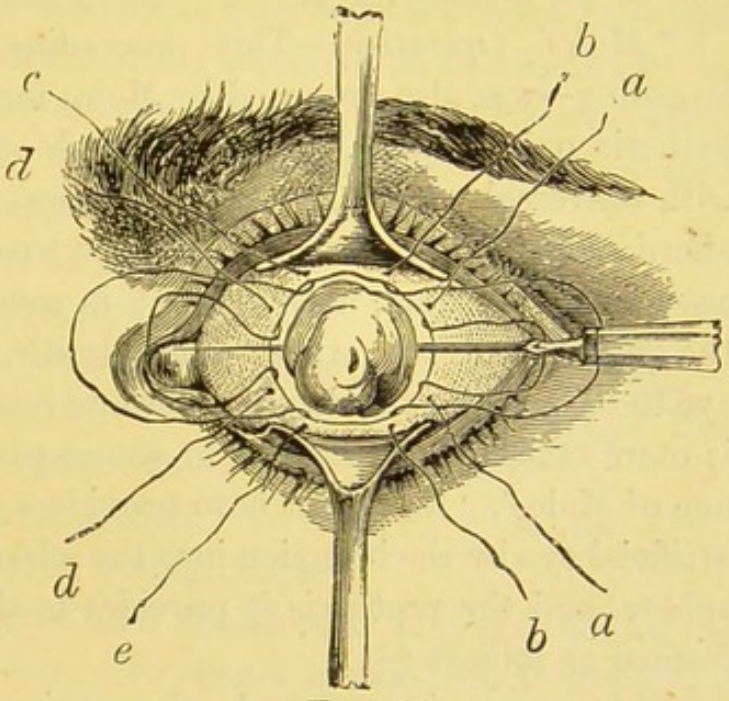


FIG. 55.

Evisceration was proposed about the same time by the late Prof. Græfe of Halle, to obviate meningitis after the removal of suppurating globes; and by the late Mr. Mules, of Manchester, chiefly to take the place of enucleation in cases of sympathetic ophthalmitis. Practically all surgeons are now opposed to its employment in the latter cases, but for staphyloma of the cornea it is not open to objection.

The cornea is removed by making an incision with a Græfe's knife, so as to include one half of the corneo-scleral margin, and by completing the circumcision with scissors. All the contents of the globe are then evacuated by means of Mules' scoop, care being taken

to remove the chorioid unbroken by carefully peeling it from the sclerotic margin backwards, until it is only held at the lamina cribrosa. The scoop is then used to lift out the separated unbroken chorioid and the other contents of the globe.

Finally, the margins of the sclero-conjunctival wound are drawn together with a few points of suture. The whole proceeding should be done with strict antiseptic precautions, chief among which is the free use of irrigation with a 1 in 5000 solution of corrosive sublimate before, during, and after the operation, the interior of the globe being most carefully washed out with the solution in a full stream. The result is a fairly good and freely movable stump for the application of an artificial eye.

* *Mules' Operation.*—This proceeding—a modification of the foregoing—was also proposed by Mules for cases of threatened sympathetic ophthalmitis, and, like simple evisceration, has not met with universal acceptance in those cases, because it is held not to afford sufficient protection against sympathetic ophthalmitis. In cases of staphyloma, however, and in some other conditions where the questions of sympathetic ophthalmitis, or of a new growth in the eye to be operated on, do not enter into consideration, no proceeding is more satisfactory, at least in young persons, than this beautiful one of Mules'. Its object is to provide a still better stump for the artificial eye by the insertion into the scleral cavity of a hollow glass sphere, and the prothesis it provides is almost perfect. It is performed as follows :—

The cornea is removed—the conjunctiva having first been freed from the scleral edge towards the equator of the eyeball—and the contents of the eyeball evacuated, as in simple evisceration. The opening is now enlarged vertically, to admit of the introduction of one of the glass spheres. This introduction is best effected by means of a special instrument designed for the purpose by Mules. The spheres are made in several sizes to suit different cases, and it is not desirable to use the largest which will fit into any given eye. The sphere having been inserted, the margins of the sclerotic opening are united vertically by some points of interrupted suture, for which purpose silk or hemp is preferable to catgut, as the latter is apt to undergo absorption before complete union has taken place. The conjunctival opening is then closed by another set of sutures placed at right angles to the sclerotic line of closure. Similar antiseptic

precautions are required, as in simple evisceration, and all bleeding should have ceased in the cavity before the glass sphere is inserted. Before the lids are closed the anterior surface of the globe is well covered with boric acid or xeroform. A firm antiseptic bandage is applied. The eye is not dressed for forty-eight hours, and subsequently once every twenty-four hours, using the sublimate solution freely. There is generally some reaction, consisting of chemosis, swelling of the eyelids, and pain, and sometimes these symptoms are very marked, especially if too large a sphere have been employed. In the course of a week or so this all passes off, and a very perfect stump is obtained.

The danger that the glass sphere may be broken by a blow upon the eye has been put forward as an objection to this method; but no case of the kind has as yet been recorded, although the operation has been in use for many years. Silver spheres, instead of those of glass, have been sometimes employed to obviate the danger referred to.

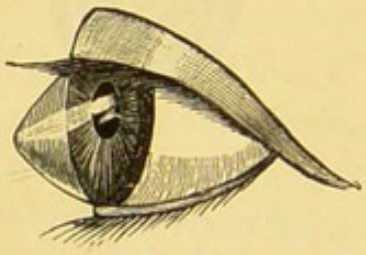


FIG. 56.

We recommend this procedure, and use it frequently. With a well-fitting glass eye, the cosmetic result it gives is infinitely better than that produced either by excision or by evisceration of the eyeball. It is more uniformly successful in young people than at more advanced ages, and therefore it is better not to use it in persons over twenty-five. To ensure success it is an important point that the glass globe be not too large—it should be an easy fit for the cavity of the sclerotic. In case the sutures give way, and the sclerotic opening gapes, an attempt may be made to reclose it with new sutures, but this is not often successful. As a rule the glass globe must in that event be removed, and the case then becomes one of simple evisceration.

*__Conical Cornea,__ or __Keratoconus.__—In this condition the cornea is altered in shape to that of a cone, as represented in Fig. 56. If the apex be touched with a probe its extreme thinness may be ascertained. The cornea remains clear, except sometimes just at the apex of the cone, where a slight nebula may be present. The position of the apex of the cone is usually not quite central, and is then most commonly either in the lower outer, or lower inner, quadrant of the pupil. The condition is easy of diagnosis in its advanced

stages by mere inspection of the cornea, especially in profile, but in its commencement it may not be so readily detected.

In the early stages, when the light is thrown on the cornea from the ophthalmoscope mirror, the corneal reflex will be noticed to be smaller at the centre, owing to the greater curvature there, and a dark shadow, circular or crescentic in shape according to the incidence of the light, appears between the corneal margin and the corneal centre. When the fundus is examined, its details will be seen distorted.

In some extreme cases the patient observes a pulsating alteration in the size of the objects looked at. This is due to the pulsation of the apex of the cone, imparted to it by the intra-ocular circulation, and is comparable to the pulsation of an unclosed fontanelle of the



FIG. 57.—A, Reflected image of Keratoscope on normal cornea. B, reflected image at apex of cone in conical cornea. C, Reflected image slightly eccentric in conical cornea.

skull. Objectively the pulsation can be seen with the corneal microscope.

On examining the cornea with the keratoscope[1] (Placedo's disc) the corneal reflex, instead of bein g normal, as at A (Fig. 57), is altered as at B or C.

With the astigmometer, the portions of the images on the apex are smaller and overlap, while the more peripheral portions may only touch, or may even not come into contact.

The process begins in early adult life, progresses slowly, never leads to rupture or ulceration of the cornea, and, finally, after many years, ceases to progress, but does not undergo cure. Both eyes are apt to become attacked, one after the other. The disturbance of

[1] The keratoscope is a disc made up of concentric black and white circles. These circles are not equidistant, but their radii are calculated according to the law of tangents, so that, when reflected on a normal spherical cornea, they appear in the image to be equidistant.

vision is very great, owing to the extreme irregular astigmatism produced.

The change is due to a gradual and slowly advancing atrophic process in the cornea, at or near its centre, in consequence of which the normal intra-ocular tension acts on it so as to distort it into the conical form.

The *Pathogenesis* of the condition is not clearly understood. It is probably due to a congenital defect at the centre of the cornea, which only in later years shows itself in this way.

Treatment.—In the early stages, or in slight cases, an improvement in vision may be obtained by means of concave spherical or sphero-cylindrical glasses; for, as is evident, the change in shape of the cornea must cause the eye to become irregularly myopic. The refraction of the central portion of the cornea may be ascertained by retinoscopy, with the aid of a stenopæic disc in the trial frame. At a later period these glasses are of little use. Hyperbolic lenses have been employed, but, although they may raise the acuteness of vision, there are obvious difficulties in the way of the practical every-day use of them. A stenopæic slit renders assistance in some cases, especially in reading.

It is upon operative measures, with the object of flattening the cornea, that we must chiefly rely for any practically useful improvement in sight.

Von Græfe's Method consists in the production of an ulcer on the apex of the cone, and the resulting cicatricial contraction. From the surface of the cornea, a little to one side of the apex of the cone, a morsel of corneal substance is removed with a cataract knife, care being taken not to open the anterior chamber. On the second day after this proceeding the wound is touched with mitigated lapis (solid), and this is repeated every third day for a fortnight or three weeks. Paracentesis of the anterior chamber is then performed through the floor of the ulcer, and the aqueous humour is evacuated every second day for a week, after which the healing process is allowed to take its course. A bandage must be worn during the whole course of the treatment. Finally, when the contraction and consequent flattening are completed, a narrow optical iridectomy may be necessary, in consequence of the central, or almost central, and rather intense corneal opacity.

Sir William Bowman's Method consists in cutting a disc on the

apex of the cornea, but not through its whole thickness, with a small trephine, and in then dissecting off this disc with forceps and cataract knife. Cicatrisation of the wound produces the desired flattening of the cone.

Stanford Morton employs a modification of an operation described by Higgens. He excises an elliptical piece from the apex of the cone by transfixing it from above downwards, about midway between its base and apex, with a long narrow rigid Græfe's knife, of which the edge is directed forwards and inclined slightly to the right. The knife is pushed onwards until it cuts its way out a little to the right of the apex of the cone, the aqueous escaping at the same time. The flap thus formed is then lifted up well with a fine forceps, and the knife—with its edge now turned to the left—is passed beneath the points of the forceps, and by cutting forwards the flap is excised. The sides of the wound should be steep and incline towards each other at an angle of 30° to 45°. The apex of the cone being usually somewhat downwards and inwards, or downwards and outwards, from the centre of the cornea, it is important, in order to prevent an anterior synechia, to avoid carrying the incision too far downwards. The eye should be well soaked with atropine, both before and after the operation, and a firm compress kept on for some time after the wound has healed.

Multiple Puncturings of the apex of the cone with a fine cataract needle have been employed. The summit of the cone is transfixed from three to six times at each sitting, and this may be repeated at intervals of two weeks or more. The first effect of the punctures is to allow some of the aqueous humour to escape, and then the eye is firmly supported with a bandage. The pupil is kept under the influence of eserine. Eventually a network of cicatricial tissue forms, which flattens the cone without giving rise to much corneal opacity.

A satisfactory proceeding, and the one now most commonly adopted, is the application of the electro- or thermo-cautery at a red heat to the apex of the cone. By this means a contracting cicatrix is produced, which brings about a general flattening of the cornea, while the operation is practically free from risk. The cauterisation must be strictly confined to a small area at the apex of the cone, and the cornea should not be perforated with the cautery. The operation may be repeated over the same area at intervals of ten to fourteen days, to bring about a more intense cicatrix.

Sir Anderson Critchett lays much stress on the graduated application of the cautery. He first applies the cautery at a black heat to the whole area intended to be cicatrised; within this area a little more is destroyed at a slightly increased heat, while the very apex is touched with a cautery at a dull red heat. One sitting is sufficient.

After the cicatrisation following on cauterisation is completed, the scar is to be tattooed, and an optical iridectomy will usually be required, especially if the cone has been quite central. The cases in which the apex of the cone has an eccentric position are those most benefited by cauterisation, because the resulting scar interferes less with vision than where it is central.

***Atrophic Degeneration of the Margin of the Cornea** (Marginal Groove of the Cornea, Marginal Ectasy of the Cornea).—This rare disease occurs in persons of advanced life, and is always associated with an arcus senilis. It is at first a shallow groove situated either immediately outside the arcus—that is, between it and the margin of the cornea—or on the arcus, or immediately inside the latter. The inner margin of the groove is steep, while its outer, or peripheral margin passes gradually to the level of the cornea. In its early stages the floor of the groove is slightly, and its inner margin more markedly, nebulous, but at a later period it becomes quite pellucid. So that, if it occupy the arcus, the latter may disappear; and at no time is there any disturbance of the epithelium covering the groove. Fine vessels often extend into the groove from the conjunctiva. The groove usually commences in the upper margin of the cornea, and sometimes extends around the whole margin. In the course of time—it may be some years—the thin floor of the groove is pressed forwards by the normal intra-ocular tension, and a pellucid bulging, or ectasy, takes the place of the groove. Disturbance of vision is not complained of until ectasy comes on, and it is caused by the resulting astigmatism (against the rule). Slight irritation of the eye—epiphora and photophobia—is present in some cases. The disease is held to be a localised atrophy of the cornea, due to fatty degeneration.

Treatment is not indicated until vision is deranged in the stage of ectasy. Cylindrical glasses may then prove of great use. In many advanced cases the galvano-cautery may be applied to the protruding part, or it may be abscised and covered with a conjunctival flap.

Tumours of the Cornea.

Primary tumours of the cornea are extremely rare. Epithelioma and sarcoma have their origin not in the cornea, but in the limbus of the conjunctiva (p. 100). Dermoid tumours are usually seated partly on the conjunctiva and partly on the cornea (p. 98). Yet a very few cases of papilloma, epithelioma, and fibroma are recorded as taking their origin in the cornea. Corneal cysts also occur.

Injuries of the Cornea.

Foreign Bodies in the Cornea, such as morsels of iron, stone, coal, etc., are amongst the most common of all accidents to the body. The pain caused by these foreign bodies is very considerable, as can be understood, when the rich nerve-supply of the surface of the cornea is considered.

The dangers which may follow on the presence of a foreign body in the cornea depend partly upon whether or not the foreign body carries infection, and partly upon the depth at which it is buried in the cornea. The deeper a foreign body lies, the more difficult will be its removal, and the greater must be the laceration of the cornea caused by that proceeding. A foreign body which carries infection will be more likely to set up serious inflammatory reaction than one which is aseptic, or nearly so. For this reason it is important to ascertain, if possible, the origin of the foreign body, although an apparently aseptic origin must not set at rest all fear on this point. Atoms of hot metal or glass are, from their temperature, aseptic.

Many foreign bodies are so small as to defy detection, until the cornea is searched with the oblique illumination—an aid which should always be made use of, when the symptoms or history in the remotest degree suggest the presence of a foreign body.

A foreign body which lies quite superficially in the epithelium is easily removed by gentle wiping with a clean camel's-hair pencil, or soft cloth. Those which lie deeper require instrumental interference, in the following manner :—

The eye having been thoroughly cocainised, the patient is seated, and leans his head against the chest of the surgeon, who stands behind him (Fig. 58). With the index-finger of the left

hand the surgeon then lifts the upper lid of the injured eye, pressing the margin of the lid upwards and backwards, while with the second finger he depresses the lower lid in a similar manner. By this means the eyelids are held open, and also, to a great extent, the motions of the eyeball are controlled. The foreign body is now to be pricked out of the cornea with a special needle, with as little injury of the general surface as possible, the patient all the while directing his gaze steadily at some given point. If the foreign body be deep in the layers of the cornea, it must be dug out, as it were; and a minute gouge is made for this purpose. In the case of a morsel of iron or steel which has lain for some time in the cornea, a small ring of rust will be seen surrounding the late seat of the foreign body after its removal. This rust-ring is in the true cornea, and must be carefully scraped away, or the recovery, by necrosis of the affected part, will be much slower, and the resulting opacity much greater.

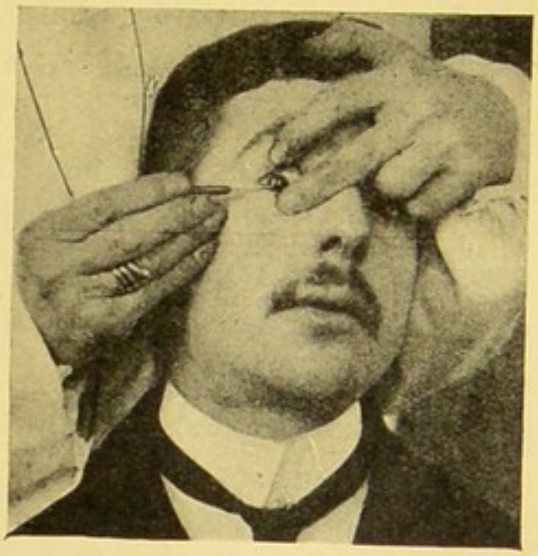


FIG. 58.

Care must be taken not to infect the cornea in the removal of a foreign body, and consequently thorough aseptic precautions must be taken, especially as regards the instrument used. After the foreign body is removed, the place where it was seated should be washed with a 1 in 5000 solution of corrosive sublimate. A dressing is worn until the epithelium is regenerated—*i.e.* for a day or two.

The magnet is of no use for the removal even of superficially seated foreign bodies of steel or iron in the cornea.

Sometimes a foreign body in the cornea will be long enough to protrude somewhat into the anterior chamber, and there is danger that, in the attempts at removal, it may be pushed into the anterior chamber. In such cases it is necessary to pass a keratome through the cornea, and behind the foreign body, so as to provide a firm base against which to work, or the keratome may be made to push the foreign body forwards.

The wing-cases of small beetles and scales of seeds may get into the eye, and adhere to the cornea, usually at the limbus, by their concave surface for several days, or even for weeks.

Simple Traumatic Losses of Substance, or **Abrasions,** of the surface of the cornea, involving the most anterior layers of the true cornea, or perhaps merely the epithelium, are very common from rubs or scratches with branches of trees, finger-nails, etc., etc. There is much pain, photophobia, and lacrimation ; the most superficial lesions being the most painful, owing to laceration of the nerve-endings in the epithelium. These injuries heal readily if the eye be protected with a dressing ; but when neglected, or if septic matter have been introduced when the injury occurred, or if it be present in the conjunctiva or lacrimal sac, these losses of substance are capable of forming the starting-point of corneal abscess (p. 128), ulcus serpens (p. 124), etc. The condition of the lacrimal apparatus and of the conjunctiva should be noted, so that, if necessary, the suitable measures may be taken to obviate infection from those regions. In addition to the dressing and bandage, atropine and dionine should be used, along with a weak sublimate ointment inserted into the conjunctival sac ; but no cocaine, which desiccates the epithelium and interferes with repair. The bandage should be continued for some days after the loss of substance has been repaired.

* A remarkable condition known as **Recurrent Abrasion,** or **Disjunction of the Cornea** (and also as Traumatic Keratalgia, and Recurrent Traumatic Keratalgia), is sometimes observed to follow upon abrasions of the cornea. Healing of the primary lesion having taken place in an apparently normal manner, the patient, after an interval of days, weeks, or even months, on awaking in the morning, is seized with severe pain, similar to that experienced on the occasion of the injury. On examination of the eye a loss of the epithelium, which may be greater or less in extent than was the primary loss, is found at the seat of the original lesion, or, what is remarkable, it may have taken place elsewhere on the cornea. Or, more rarely, instead of a loss of epithelium, the latter may be raised up like a vesicle, or bulla. Examination of such cases has shown that the epithelial covering of a great part of, or of the whole of, the cornea may be easily lifted off with a forceps ; in short, that the cohesion between epithelium and Bowman's membrane far

beyond the immediate seat of the original lesion has become imperfect. Care of the eye by means of a dressing enables the renewed loss of substance to be rapidly repaired ; but, after a period of quiescence, another attack takes place on awaking in the morning, or in the course of the night, and such attacks may continue to recur, even for several years. It is characteristic of the affection that the attacks always take place on awaking—a circumstance which is explained by the slight adhesion between palpebral conjunctiva and corneal epithelium formed during sleep, so that on the lifting of the eyelid the loosened epithelium is torn away, or lifted in a bulla-like shape. There is some loss of sensation of the surface of the cornea. After one of these attacks, examination of the corneal surface by the usual methods may fail to reveal the presence of a loss of substance, and then it may be discovered by means of transmitted light from a plane mirror, which will display the defect as a black mark. The corneal microscope, too, is useful here.

The cause of disjunction of the cornea has not been definitely ascertained. The view has been put forward, and there is good evidence in support of it, that the affection is due to a very slight degree of œdema of the cornea of neurogenic origin, a derangement of the peripheral endings of the fifth nerve in the cornea having been produced by the original injury.

Treatment.—Cocaine, owing to the disorganising effect it has on the corneal epithelium, is not to be used at all, or as sparingly as possible. A carefully applied dressing is important, and should be worn for long—it may be weeks—after the recurrent lesion seems to be quite well. An operative measure—namely, the removal with the forceps of the entire corneal epithelium or as much of it as easily comes away—is very effectual. The denuded region is soon again covered over with epithelium, and this new growth adheres in a healthy manner to its bed. Some surgeons remove the loosened epithelium with a camel's-hair pencil moistened with chlorine water, and others take it away with a curette. The insertion into the conjunctival sac of an non-irritating ointment every night at bed-time is a most useful adjunct in the treatment by dressing or operation.

Blows on the Eye, amongst other lesions, are liable to cause Corneal Bullæ, the walls of which consist of Bowman's membrane

and the epithelium. In some cases these bullæ contain blood, derived no doubt from the ruptured canal of Schlemm. Such bullæ may also form after burns with lime, etc.

Another condition caused by blows on the eye is *Hæmorrhagic Discoloration* of the true cornea, which presents a greenish or a reddish-brown colour in the cornea. Hæmorrhage in the anterior chamber is always present at first. At first, too, the discoloration occupies the whole cornea, and after a time begins to clear up from the margin towards the centre. The prognosis for vision is good, if the eye be otherwise sound, but the absorption of the colouring matter in the cornea is excessively slow, and as much as two or three years or more may elapse before the process is complete. Treacher Collins has ascertained that the peculiar discoloration in these cases is due to the presence of hæmatoidin, which he believes enters the cornea from the hæmorrhage in the anterior chamber through Descemet's membrane by a process of diffusion. He did not find any red blood-corpuscles in the cornea.

Injuries of the Cornea with Caustic Substances.—The caustic substances which need enter into consideration here are those that most commonly come in contact with the cornea and conjunctiva, either accidentally or maliciously. They are lime, ammonia, and caustic potash ; also nitric acid, sulphuric acid, and acetic acid. The subjects of these accidents suffer great pain, and on presenting themselves soon afterwards the eyelids, even if not injured, are found to be swollen and discoloured, and it is difficult to open them in order to examine the state of the eye. There is chemosis, and great irritation.

Burns of the cornea from lime or mortar, or whitewash containing lime, are not uncommon amongst those engaged about lime-kilns, or in the building trade. The lime destroys the cornea more or less deeply, with resulting more or less intense permanent cicatricial opacity. The lime, moreover, enters into chemical combination with the corneal mucin or albumen, which causes further opacity.

As soon as possible after lime has entered the eye, it should be removed as thoroughly as possible by means of forceps and free washing out with water ; or, better still, with saturated solution of sugar, which forms, with whatever loose lime may be present, a substance that can be more readily removed.

The removal of such albuminate of lime as remains fastened deeply in the cornea is difficult to effect; but when the immediate irritation has somewhat subsided, the eye having been cocainised, a bath should be applied to it consisting of a warm 4 per cent. solution of chloride of ammonium, to which has been added an equal part of a 0·02 per cent. solution of tartaric acid. The strength of the chloride of ammonium solution can be gradually increased to 10 per cent., as the patient is able to bear it, the strength of the tartaric acid solution remaining unaltered. The application may be made by means of an eye-bath; or, if this be not available, it can be poured into the eye, the lower lid being drawn away from the latter, while the patient holds his head thrown back, so that the eye may be covered with the solution as completely as possible. The application is to be continued for half an hour at a time, and it should be repeated many times a day.

The treatment of injuries with ammonia, caustic potash, and other metallic caustics, is the same as that of injuries with lime.

Burns of the cornea with nitric, sulphuric, acetic, and other caustic acids are treated with a ½ per cent. solution of caustic potash as a bath, or poured into the eye as above described, the eye having been cocainised.

It is hardly necessary to state that, in burns with such chemical substances, the destruction of the corneal tissues is too often so rapid and extensive, that no measure avails to avert a degree of opacity of the cornea that must be seriously detrimental to vision, particularly in view of the interval which in most instances elapses between the accident and the treatment of the injury. And not only is the cornea rendered opaque, but the inevitable injuries caused at the same time to the conjunctiva by the caustic, give rise to more or less symblepharon (chap. xvii.). In the severest cases, suppuration of the cornea comes on, and the eye is lost through panophthalmitis.

Perforating Injuries of the Cornea.—In these cases the injury done is rarely to the cornea alone, and at the first inspection the attention of the surgeon is occupied less with the state of the cornea than with the question as to whether, and to what extent, deeper parts of the eye (iris, lens, vitreous humour, etc.) are involved. Another very important point, which has often to be decided, is whether or not the foreign body, which has perforated the cornea,

is contained in the eye. But these matters belong to future chapters.

A perforating wound of the cornea, which does not involve any other part, is serious in proportion to its extent, and to the probability of its being infected. Every perforating corneal wound is followed by loss of the aqueous humour, which flows away through the opening, and by consequent collapse of the anterior chamber; but this in itself is not a serious event. Short wounds close almost at once (and through them indeed very little of the aqueous humour may flow off), the aqueous humour is rapidly restored, and no harm is done to the eye beyond a slight opacity, which, if in the pupillary area, may cause some defect of vision; or, should the wound be situated more peripherally, and should the iris have lain against the cornea for a while, an anterior synechia may form.

Long wounds, which may even occupy the cornea in its entire diameter without directly involving any other organ of the eye, are almost certain to be complicated by prolapse of the iris between the lips of the wound; and, when healing takes place, the prolapsed portion becomes permanently incarcerated in the cicatrix. At the least, this incarceration causes irregularity in the curvature of the cornea, and consequent irregular astigmatism. But it may be the starting-point of a staphyloma of the cornea, it may become the cause of glaucomatous intra-ocular tension, or, if at any time a slight trauma with loss of substance of its surface should occur, it may take on septic inflammation, which may spread rapidly to the deeper uveal structures, leading to panophthalmitis and loss of the eye.

Treatment.—In small uncomplicated perforating wounds, without prolapse of iris, where the aqueous humour has not yet formed, atropine should be freely used if the wound be towards the centre of the cornea, or eserine if it lie towards the periphery, with the object of preventing adhesions of the iris to the posterior aspect of the wound, and a dressing and bandage should be applied to the eye.

In recent injuries of this kind, in which there is a prolapse of the iris, the prolapsed portion, if not very large, may sometimes be reposed with a spatula or fine probe, aided by the action of atropine or eserine, according to the position of the wound. But in many instances this attempt will prove futile, while in those in which there is suspicion of septic infection, it is unwise to make it. In

either circumstance the prolapsed portion of iris should be snipped off at its base. It is not enough to abscise a portion of the summit of the prolapse. The prolapsed iris must be seized with an iris-forceps, drawn forward so as to loosen, so far as possible, any adhesions between it and the lips of the wound (or the adhesions may previously be separated by a probe passed round the edges of the wound), and cut off close to the cornea. This affords the best hope that the iris may recede into the anterior chamber, without any of it becoming incarcerated in the corneal wound while healing. In badly lacerated wounds it is sometimes desirable to transplant conjunctiva over them (p. 122) in order to promote the healing process and to consolidate the cicatrix.

In cases which are not recent, the adhesions between cornea and prolapsed iris will have become so firm, that it will not be possible to separate them by any means, and the prolapse must be allowed to become cicatrised over, the tension of the eye being kept low by means of eserine, and transplantation of conjunctiva being performed, to the end that a firm and flat cicatrix may be obtained.

Opacities of the Cornea.

Nebula, Macula, Leucoma.—These terms are applied to opacities of varying degrees in the cornea, which are the result of some diseased process, or which are consequent upon an injury. The term nebula is used for very slight opacities, often discernible by oblique illumination alone. Macula indicates a more intense opacity, recognisable by daylight. Leucoma is a completely non-translucent and intensely white opacity, the result almost always of an ulcer, which has destroyed most of the true corneal tissue at the affected place; indeed, it is often the result of an ulcer which has eaten its way quite through the cornea. In these latter cases the iris may have become adherent in the corneal cicatrix, and then the term Adherent Leucoma is employed.

Eyes with an old-standing nebulous condition of the cornea are often myopic, and concave glasses sometimes aid the vision. It is probable that this myopia is caused by the habitual close approximation of objects to the eye, owing to the diminished acuteness of vision from the opacity of the cornea.

Treatment.—Little or nothing can be done to reduce these

opacities. In slight and fresh cases, massage with the yellow oxide of mercury ointment may render them less intense.

In case of a nebulous cornea, a stenopæic apparatus often improves the sight. This consists of a metal plate with a small central hole or slit, which is placed before the patient's eye in a spectacle-frame; and by this arrangement a large portion of the rays which pass through irregular parts of the cornea, and which merely confuse the sight, is cut off. Should the opacity be dense, and situated in the centre of the cornea, portion of the margin having remained clear, an iridectomy will in some instances improve the sight.

The Operation of Tattooing is a valuable proceeding for improvement of the appearance of the eye in cases of leucoma, and is frequently employed for that purpose.

It is also useful for improvement of the sight, where the nebula occupies only part of the pupillary area of the cornea. In these cases, much disturbance of vision is caused by the dispersion of the light which makes its way through the nebula; and when, by tattooing the scar, all light is prevented from getting through, brighter and distincter vision is enjoyed with that part of the cornea, opposite the pupil, which is absolutely clear.

The material used is fine Indian ink rubbed into a very thin paste. The eye having been cocainised, the leucoma is spread over with this paste, and then covered with innumerable punctures by means of de Wecker's multiple tattooing-needle, or with an ordinary discission needle, each stab of which carries into the cicatricial tissue some of the black pigment. The coloration continues sufficiently intense for some months, but then often begins to get pale, owing, probably, to the pigment falling out of the punctures. A method of tattooing, by which the pigmentation lasts longer, is performed with de Wecker's single grooved needle. The pigment is placed in the groove of the instrument, which is then passed into the leucoma, a long canal being made in a plane parallel to its surface. On withdrawal of the needle the pigment remains behind. A large number of such canals must be made in close proximity to each other, until the desired intensity of colour is obtained. Some operators remove the corneal epithelium over the part to be tattooed, in order to facilitate the entrance of the colouring matter into the true cornea.

In tattooing the cornea, the eye must not be fixed with a toothed forceps, or else the conjunctiva may be tattooed. A forceps armed

with rubber is used, or the eye can be fixed by the surgeon with his fingers, which at the same time take the place of a speculum (Fig. 58).

* *Transplantation of a Portion of Clear Cornea* from a freshly enucleated human eye has been performed by many ophthalmologists, in cases where the cornea is leucomatous, or at least so opaque as to render the sight of the eye useless, and, consequently, where no gain to sight can be obtained by means of an artificial pupil. Very many of these operations have been perfectly successful in a surgical sense—*i.e.* in so far as the healing-in of the transplanted flap was concerned; but, with a few exceptions, they all ended in disappointment, in consequence of the flap not retaining its transparency. In the course of a week or two the transplanted portion invariably became as opaque as the leucoma had been before. The mode of proceeding consisted in removing a portion of the leucoma with a special trephine, and in then cutting a disc with the same instrument out of the clear cornea taken from an eye which is about to be excised, and inserting it into the opening in the opaque cornea.

Various theories were put forward to account for the occurrence of the opacity in the transplanted flap, but it is tolerably certain that the essential points to be attended to for a successful issue of the operation are:—The employment of the cornea of a young person from which to form the flap. The exact fitting of the flap, obtained by means of a Hippel's trephine (5 mm.), into the diseased cornea, in the centre of which an opening with the same trephine is made. The keeping of the flap warm in gauze soaked in warm saline solution. The avoidance of all instrumental contact with the flap—it should be slipped into its place by aid of the gauze. Attention to these points enabled Zirm to restore useful sight to a blind eye.

Löhlein has successfully performed the following operation for corneal transplantation:—From the opaque cornea a rectangular flap extending from the upper to the lower margin is removed. The width of the flap is about 5 mm., while its thickness depends on the depth in the cornea to which the opacity is estimated to extend, but the cornea must not be perforated. The parallel boundaries of the flap are defined by drawing across the cornea from its upper to its lower margin a fork-like instrument at the end of each prong of which is a small circular knife, with which there is but little danger of the cornea being perforated. At the lower end the incisions are

carried a few millimetres beyond the corneal margin into the conjunctiva. At the upper end of the double incision a short but thick conjunctival flap is prepared up. This conjunctival flap is then seized with a forceps, which is of about its own breadth, a Græfe's cataract knife is passed behind it, and with short strokes is made to enter the scleral tissue at the limbus; so that, along with the conjunctival flap already formed, a narrow band of scleral tissue is obtained. The forceps now seizes this scleral band, and the edge of the knife is reversed, and, with sawing motions, is made to cut through the substance of the cornea at the required depth, taking with it the flap of corneal tissue originally delimitated. At the lower corneal margin a narrow band of scleral tissue, and a short thick conjunctival flap are formed by the knife in cutting out. The corneal flap is left *in situ*, while, in a precisely similar manner, and with the same forked instrument, a similar flap is taken from the clear cornea of an eye which is about to be excised. This second flap is then spread out on the wounded surface in the first eye, the utmost pains being taken that during the transfer the flap suffers not the slightest bruising or other injury. The flap is fastened in its place by three or four points of suture at either end, the needles being passed through the narrow bands of scleral tissue, and the episcleral tissue of the eye. The conjunctival flaps are spread over the sutures. Only warm normal saline solution is to be used for douching the field of operation.

Arcus Senilis (Gerontoxon).—This is a change which is developed in the cornea without previous inflammation. It presents the appearance of a greyish line all around and a little inside the margin of the cornea, most marked above and below, and never advancing farther towards its centre. It is more common in elderly people, but is sometimes seen in youth, and even in childhood. No functional changes are caused by it, nor does it interfere with the healing of a wound which may be made in that part of the cornea. Arcus senilis is caused by a peculiar fatty degeneration of the corneal cells and fibrillæ.

CHAPTER VI.

DISEASES OF THE SCLEROTIC.

Inflammation of the sclerotic is not a common disease, although the diagnosis "scleritis" is often made by inexperienced persons, every redness of the white of the eye being taken for inflammation of the sclerotic. Iritis, cyclitis, and sometimes conjunctivitis, as well as scleritis, cause redness of the white of the eye.

The differential diagnosis of scleritis from conjunctivitis is easily made (apart from other symptoms), by observing whether the congested vessels can be moved over the affected part or not—if they can be so moved, the conjunctiva is the affected membrane. In iritis and cyclitis the ciliary injection is confined to the part immediately surrounding the cornea. In iritis, moreover, the appearance of the iris itself is conclusive; and in scleritis, as will be seen just now, the appearances are characteristic.

Scleritis attacks only that part of the sclerotic which is anterior to the equator of the eyeball, and it is either superficial or deep. The superficial form is known as episcleritis. Yet it is not always possible to distinguish between these two forms in a given case, as the appearances in the early stages are very similar. They are probably only different degrees of the same disease. But the necessity of admitting the existence of two forms depends upon the different course they each take; the superficial form being a relatively harmless disease, while the deep form entails serious consequences.

Episcleritis.—Of this two kinds are recognised:—1. Periodic Transient Episcleritis (Fuchs), or Hot Eye (Hutchinson). 2. Episcleritis of the usual type.

Periodic Transient Episcleritis is characterised by frequently recurring attacks of inflammation of the episcleral connective tissue, giving rise to a vascular injection of a violet hue, but without

any catarrhal or other secretion, or any hard infiltration, as in episcleritis of the usual type. It rarely attacks the whole sclerotic at one time, but is commonly confined to a quadrant or more, and wanders from one place to another. When the attack subsides, there is no stain left. The attack may be confined to one eye, or it may be in both, or it may affect sometimes one eye and sometimes the other. Pain, lacrimation, and photophobia are present in varying degrees. Sometimes there is swelling of the eyelids. Occasionally the iris and ciliary body become inflamed, and also the cellular tissue of the orbit, with resulting exophthalmos. The attacks last from one or two days to several weeks, and may recur once or twice a year and at intervals of only two or three weeks. Patients are usually liable to the disease for several years of their life. It attacks adults of middle age for the most part. Some assign gout as the cause; while others do not find any symptoms of that diathesis in their patients. Rheumatism and malaria seem sometimes to produce it, and some observers hold that episcleritis and scleritis are frequently of tubercular or of syphilitic origin. It is probable, too, that it may be caused by a gonococcus toxæmia, even long after the primary disease has been cured.

Treatment.—The long continuance of most of the cases shows that treatment has but little influence over the disease. Quinine and salicylate of soda internally are the remedies likely to be of use, with local warm fomentations, dionine, and a protective dressing during an attack.

Episcleritis of the usual type. This appears as a circumscribed purplish, rather than red, spot (Plate II. Fig. 5), close to, or 2 to 3 mm. removed from, the corneal margin. It is often unattended by pain, unless when the eye is exposed to irritating causes, and need not be elevated above the level of the sclerotic; but in severe cases there is a decided node at the affected place, with more or less pronounced pain, which is increased on pressure. All the symptoms disappear in the course of a few weeks, and reappear at an adjoining place; and in this way, in time, the whole circumference of the sclerotic will have been attacked. The duration of the affection is usually long; and, in those instances where the entire sclerotic becomes affected by degrees, the process may last for years, on and off. Both eyes are often affected. The disease is liable to leave behind it a dusky discoloration of the sclerotic

where each node was seated, but otherwise no harm to the eye ensues. The patient should, as soon as possible, be informed of the tedious nature of the affection. Very mild attacks of episcleritis will be met with, which pass away in a few days, and do not recur.

Causes.—The affection is often of gouty or rheumatic origin. It occurs sometimes in persons of tubercular or syphilitic constitution; and it is more frequent in senior adults than in children or young people, and more commonly attacks women than men.

Treatment.—Local treatment should be confined to protection with dressing and bandage, warm fomentations, and dionine. In addition to these, massage should be used, if there be not too great tenderness on pressure. Leeching at the external canthus is of use when the pain is severe. As regards internal remedies, where a syphilitic taint is present, mercury should be employed; if struma, cod-liver oil, maltine, etc.; or if, as is most frequently the case, rheumatism be the source of the evil, large doses of salicylate of sodium (say 20 grains four times a day) will often be found to act well. Salicylate of lithium is recommended in preference to the sodium salt by some. Iodide of potassium in large doses (20 grains four times a day, or more frequently) is a useful remedy in some cases of this obstinate disease.

Deep Scleritis.—Here the whole of that part of the sclerotic which forms the front of the eye is more likely to be affected than in the milder forms; although cases often enough occur where only an isolated node is present at one time.

The progress of the case alone it is, which can render the diagnosis between this and the milder forms certain, and hence the importance of a guarded prognosis in the early stages of every case of scleritis. The chief characteristics of deep scleritis are:—1. Localised congestion and swelling which does not soften or caseate. 2. Discoloration of the sclera. 3. Sclerotising opacities of the cornea. 4. Frequent relapses. In this deep form changes—thinning and softening—of the scleral tissue take place, which render the latter less resistant, and consequently dispose it to become ectasied even by normal intra-ocular tension. The result of this is a bulging (staphyloma) of the anterior part of the eyeball (p. 175). This bulging produces myopia, and has a deleterious effect upon the sight; but, at a later period, vision is often wholly destroyed by secondary glaucoma.

It may happen, that the thinning, etc., of the sclerotic affects only a portion, and not the whole, of its anterior surface; and in such a case the resulting staphyloma will be confined to that part of the sclerotic. A staphyloma, whether total or partial, presents a bluish-grey appearance, due to the uveal tract shining through the thinned sclerotic.

In deep scleritis, either with or without staphylomatous changes, the process often extends some distance into the deep layers of the cornea, giving rise to sclerotising opacity (Plate II. Fig. 5). Iritis, punctate deposits on the back of the cornea indicating cyclitis, chorioiditis, and opacity of the vitreous humour are not uncommon complications, especially in strumous subjects.

Causes.—Young adults are the most common subjects of deep scleritis, and it attacks females more often than males. Syphilis, congenital or acquired, rheumatism, gout, tubercle, and disturbances of menstruation are the most common assignable causes, but it is probable there are others which are as yet undefined.

Treatment.—There are few diseases less amenable to treatment. When any definite cause can be assumed to be present, the remedy suitable to it is of course indicated. Besides this, a dressing of a thick layer of cotton wool to be constantly worn when only one eye is affected, warm fomentations, dionine, dry cupping on the temple, or the artificial leech, complete rest of the eyes, and protection with dark glasses are to be recommended.

When all acute inflammation has passed away, an iridectomy is sometimes indicated—either for optical purposes, when the pupil is obstructed by corneal opacity, or for the purpose of reducing glaucomatous tension, or of diminishing a staphyloma.

*** Syphilitic Gumma of the Sclerotic.**—This is rare. The diagnosis depends to a great extent on the history and co-existing signs of syphilis. The appearance usually presented is that of one or more rounded tumours, of sizes which may vary from that of a pea to that of a hazel nut. These tumours are covered with a highly injected conjunctiva, through which the yellowish colour of the gummata shines. They are seated close to the corneal margin—and, consequently, give rise to opacity in the neighbouring sector of the latter—but may extend as far as the equator, or even farther back. As a rule there is much pain in the eye and head. Iritis, retinitis, and vitreous opacities may form complications. In

advanced stages the sclerotic may be perforated, or become staphylomatous, and the gumma may extend to the interior of the eye, producing detachment of the retina, and atrophy of the eyeball.

Treatment.—In the early stages, an energetic mercurial treatment is capable of producing such perfect cures, that not even a slight discoloration of the sclerotic remains.

*** Tubercle of the Sclerotic.**—Apart from those cases of more or less diffused episcleritis and scleritis which may be due to tubercle, the only form in which primary tubercle of the sclerotic occurs is as a small tubercular abscess or cyst, and such cases are rare. In one which occurred at the Victoria Hospital the small sub-conjunctival elevation (Fig. 59) was situated about 4 mm. from the lower margin of the cornea. It was 4 mm. broad at its base, and towards its apex was of a pearly white colour, while the vessels of the conjunctiva covering it were much injected. The abscess was incised, and its cavity in the substance of the sclerotic thoroughly curetted, after which a rapid cure took place. Examination of the contents of the abscess demonstrated the presence of the tubercle bacillus.

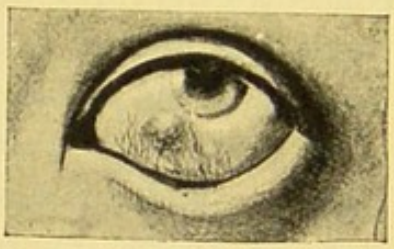


FIG. 59.

But in the majority of cases of tubercle of the sclerotic, the disease is an extension from the root of the iris, or from the ciliary body, where it has had its primary seat. Gradually the sclerotic becomes thinned by the tubercular disease, staphyloma forms, and finally rupture may take place. In these cases, if the disease be not too advanced, treatment with tuberculin may be tried, but in later stages excision of the eyeball is indicated.

Tumours of the Sclerotic, as primary growths, are exceedingly rare; but fibroma, sarcoma, and osteoma have been so observed.

Pigment Spots of a yellowish-brown colour are often seen in the sclerotic close to the corneal margin. They are congenital, and of no importance. Occasionally a black pigmented patch may be associated with pigmented sarcoma of the ciliary region.

Injuries of the Sclerotic.—Ruptures and perforating wounds are those which have to be considered. Mere losses of substance may be said not to occur.

The danger attendant upon a rupture or perforating wound of

the sclerotic—apart from the loss of the contents of the eyeball, which is often associated with it—consists in the possibility of infecting organisms being introduced into the interior of the eye, and there setting up serious inflammatory reaction.

Ruptures of the Sclerotic are caused by blows on the eye, and are often indirect; thus, if the blow be received below the cornea, the rupture may take place above the cornea.

A common cause of sclerotic ruptures amongst the agricultural population is a blow from a cow's horn, while the animal is being tied up or fed in the byre, and these cases are well known in ophthalmic hospitals. Blows with the fist produce similar injuries. The lower and outer part of the orbit is the least prominent, and therefore the eye is least protected here, and hence it is commonly driven upwards and inwards by the blow, and the sclerotic usually ruptures from 2 mm. to 5 mm. from the upper and inner margin of the cornea, and concentrically with the latter. Often the conjunctiva is not ruptured, but bridges over the opening in the sclerotic. Some of the contents of the eyeball may have been forced out through the rupture —*e.g.* portions of the uvea, iris, and ciliary body, the vitreous, and the lens; and it is sometimes difficult at first to ascertain the exact state of affairs, by reason of extravasated blood in the anterior chamber, under the conjunctiva, and in the tissues of the eyelids.

Treatment.—When the conjunctiva is not ruptured, it is often advisable to confine treatment to the application of a dressing, for the covering conjunctiva acts as a protection against infection of the wound. Where serious damage has not been done to the retina, fair or even good vision may be regained in many of these cases, which at first sight seem almost hopeless; and, should perception of light be present, one may reasonably conclude that the retina is not detached. When the lens has been dislocated under the conjunctiva, —from whence it can be removed, after the sclerotic opening has closed—the patient will of course require a glass, as after cataract operation, to give him the best vision.

Perforating Wounds of the Sclerotic.—A large and gaping perforating wound is easily recognised. A portion of the chorioid, ciliary body, or iris, according to the position of the wound, probably lies in it, or part of the vitreous humour may be found in it; while the vitreous humour, as seen through the pupil, will be full of blood (hæmophthalmos), and blood may be present in the anterior chamber

(hyphæma, *ὑπό, under ; αἷμα, blood*), especially if the wound be far forwards. Small wounds may be concealed by sub-conjunctival hæmorrhage, and here reduced tension of the eyeball is sometimes a valuable diagnostic sign.

When inflammatory reaction follows upon one of these injuries it may be either of the purulent or plastic form. In the former case all the contents of the eyeball take part in the suppuration, and we term it panophthalmitis, phthisis bulbi being its ultimate result. In the plastic form, the iris and ciliary body alone are implicated, and sight is slowly lost ; the eye here, too, becoming phthisical. Of the two, the latter process is the more serious, as it is prone to give rise to sympathetic ophthalmitis—a danger which is not associated with the eye lost through panophthalmitis.

Where the wound has been produced by a small foreign body, which has remained in the interior of the eye, the position is much more serious, and this subject will be discussed in chap. x.

Treatment.—A clean-cut perforating wound of the sclerotic may heal without inflammatory reaction, even when portions of the uveal tract or vitreous humour are prolapsed into it, these prolapsed parts becoming incarcerated in the cicatrix. In cases where the wound is small (say less than 3 mm.), no suture need be used : a carefully applied dressing and bandage will be sufficient to promote the natural tendency to healing. But, where the wound is large and gaping, any prolapsed chorioid, etc., must be freely irrigated with sublimate lotion, 1 to 5000, and completely reduced—or if the prolapsed parts, or portion of them, cannot be reduced, they must be abscised—and the margins of the wound drawn together by a few points of fine silk suture passed through part of the thickness of the sclerotic ; or, the sutures may be passed through the conjunctiva at some distance from the edges of the wound, the traction on the conjunctiva being often sufficient to close the scleral wound. A dressing is applied to each eye, and the patient is confined to bed.

But, if the injury be such—very gaping wound, much loss of contents of the eyeball, or extensive intra-ocular hæmorrhage—as to render restoration of useful sight, or at least retention of the shape of the eyeball, beyond reasonable hope, it is wiser to remove the eyeball at once, rather than to run the risk of sympathetic ophthalmitis without compensating advantage.

Staphyloma of the Sclerotic.—The sclerotic may become ectasied

(staphylomatous) either uniformly or in the form of localised bulgings. The most common condition under which we see a uniform stretching of the membrane is in myopia, where the posterior pole of the eyeball and its neighbourhood become distended as will be described in chap. xv. In buphthalmos the whole sclerotic is stretched and the cornea participates in the distension (chap. viii.). Localised staphylomata of the sclerotic occur only in the anterior segment of the eyeball, and are due to thinning, and consequent diminished resistance, so that the affected part can no longer withstand the normal intra-ocular pressure. This thinning is the result of deep scleritis (p. 171), gummata, or tubercular disease. After a time, high intra-ocular tension—brought on by closure of the angle of the anterior chamber, resulting from the distortion of the eyeball, or from complete ring synechiæ (p. 180) in cases complicated with iritis—may become a second factor in the process.

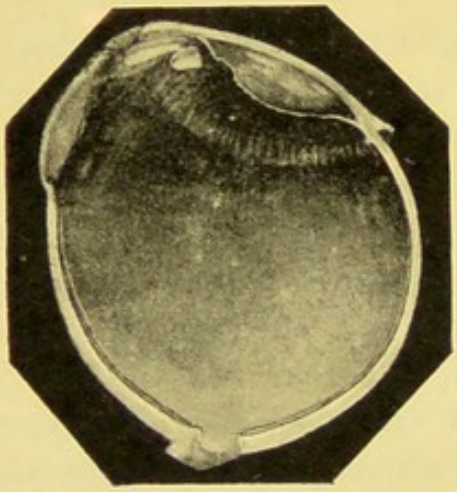


FIG. 60.—Anterior or ciliary staphyloma of the sclerotic. Cupping of the optic disc due to high tension.

These ectasies or staphylomata are of a bluish-black colour, owing to the uvea, or the atrophied remains of it, shining through the thin layer of sclerotic. The staphylomata occupy either the equator of the eyeball near the insertions of the muscles (equatorial staphyloma), or they are situated in the portion of the sclerotic close to the cornea, where it is lined by the ciliary body (anterior or ciliary staphyloma) (Fig. 60). The former can be observed only when the eye is turned well over to the opposite side. The anterior staphylomata may also be single or multiple, and in the latter case they may become confluent and extend all round the cornea. A variety of the anterior staphyloma is termed intercalary staphyloma, to indicate that it has its origin in the narrow space between the ciliary body and the root of the iris.

Treatment.—For equatorial and anterior staphyloma, if the tension of the eye be high, an iridectomy, if it can be performed,

is indicated, and by means of it the progress of the distension may be arrested, and vision preserved. Should an iridectomy be impracticable, excision of the eyeball will often have to be advised for the relief of pain, which is sometimes present, or to get rid of the inconvenience caused by the large size of the eyeball, or on æsthetic grounds.

* **Congenital Defect of the Sclerotic.** *Coloboma.*—This forms an ectasy of the sclerotic commencing below the posterior pole of the eye, and extending forwards towards the ciliary region. It is accompanied by coloboma of the chorioid, and sometimes of the iris and lens as well, and is due to imperfect closure of the chorioidal fissure.

CHAPTER VII.

DISEASES OF THE UVEAL TRACT.

Inflammations.

The iris, ciliary body, and chorioid [1] together form the uveal tract. If it be remembered that they closely resemble each other histologically, that their blood supply is identical, and that they form with each other a continuous membrane, it is a matter of surprise that any one of these three divisions of the uveal tract can undergo inflammation while the others remain healthy. Yet this is by no means uncommonly the case. But it is more common for at least two of them, and especially the iris and ciliary body, to be simultaneously inflamed (*irido-cyclitis*) ; and the entire uveal tract may be affected at one time (*irido-chorioiditis*—by which term it is implied, not only that the iris and the chorioid are diseased, but also the intervening portion of the tract, the ciliary body). If all three portions be affected, one of them may be much more affected than either of the others. Or, commencing in one portion, the inflammatory process often spreads to one or both of the other portions.

Clinically we cannot always know whether only one or more than one division of the uveal tract is in a state of inflammation. This uncertainty is particularly liable to arise when there is severe acute iritis ; for then the symptoms present might all be derived from the inflammation of the iris alone, while the contracted and obscured pupil, opacity in the aqueous humour and cornea, and irritability of the eye, render impossible a diagnosis of chorioiditis by the ophthalmoscope ; and, whether in health or disease, the position of the ciliary body puts it always out of reach of ophthalmoscopic examination. Yet it may be taken for granted, that in every rather

[1] χόριον, *the chorion ;* hence chorioid, *like the chorion.*

severe case of iritis, particularly in those of syphilitic origin, more or less cyclitis is also present; while a deep anterior chamber, diminished tension, tenderness on pressure, or punctate deposits on the posterior surface of the cornea increase the suspicion. In most cases of very slight iritis there is probably no cyclitis.

It is only after the acute inflammatory symptoms have subsided, and the pupil has become clear, that disseminated changes in the chorioid, opacities in the vitreous humour, and even retinitis and optic neuritis, which may lead to optic atrophy, can be discovered, with their corresponding depreciation of vision.

It is convenient, in a systematic consideration of inflammation of the uveal tract, to discuss it under the separate headings of iritis, cyclitis, and chorioiditis.

Inflammation of the Iris. Iritis.—Iritis is acute or chronic. Again, iritis is primary or secondary. In primary iritis, the iris is the original seat of the disease, and is not a result of some other diseased process in the eye. In secondary iritis, the inflammation has been caused by disease of the cornea or sclerotic, or is the result of swelling of an injured lens, the presence of an intra-ocular tumour, etc.

Acute Iritis.—*The Objective Signs of Acute Primary Iritis*, more or less marked according to the severity of the case, are :—(*a*) loss of lustre and of distinctness of pattern of the iris; (*b*) change in colour of the iris; (*c*) functional disturbances (impaired mobility) of the iris; (*d*) contraction of the pupil; (*e*) circumcorneal injection of the ciliary vessels.

(*a*) The loss of lustre and of distinctness of pattern is due to an alteration in the endothelium, which covers the surface of the iris, to the presence of lymph in the iris and on it, and to cloudiness of the aqueous humour through which the iris is seen—caused by inflammatory products held in suspension—and often, also, to some cloudiness of the cornea. (*b*) The change in colour is due to hyperæmia of the iris, as well as to the presence of the inflammatory products; a blue iris becomes greenish, a brown iris yellowish. (*c*) The impaired mobility, and the (*d*) contracted pupil, are due to hyperæmia, to spasm of the sphincter iridis, and to posterior synechiæ, (*e*) The circumcorneal, or ciliary, injection (Plate II. Fig. 2) is due to engorgement of the episcleral branches of the anterior ciliary arteries which supply the iris.

Exudation of inflammatory products is present, in greater or less

degree, on either surface of the iris, and in its stroma ; in the pupil, or rather on the anterior capsule of the lens in the pupillary area, and—when, as so often happens, cyclitis is associated with iritis—in the aqueous humour, and on the posterior surface of the cornea. As a consequence of the exudation in and on the iris, in addition to change in colour, and loss of pattern, the iris is often slightly swollen.

Posterior synechiæ [1]—*i.e.* adhesions between the iris and the anterior capsule of the lens (Plate II. Fig. 2)—occur as a result of inflammatory exudation on the posterior surface of the iris, or on its pupillary margin. The presence of posterior synechiæ is ascertained by observing the play of the pupil when the eye is placed alternately in strong light and in deep shadow, or by observing the effect of a drop of atropine solution on the pupil, the latter dilating only at those places where there are no synechiæ. The pupillary margin may be adherent at one or two points only ; or there may be broad synechiæ occupying at least a fourth, or a third, or even more of the margin of the pupil ; or there may be both small and broad synechiæ present ; or, finally, the entire margin of the pupil may be adherent. If the entire pupillary margin have become adherent, the condition is termed complete posterior synechia (or circular posterior synechia, ring synechia, or exclusion of the pupil) ; and in such cases, especially if of some standing, atropine has no effect on the pupil. When complete posterior synechia has developed, the iris after a time becomes bulged forwards like the sail of a ship in the wind, by reason of accumulation behind it of aqueous humour, which now cannot escape into the anterior chamber, and this condition is known as iris bombé : it is very liable to cause high tension of the eye (Secondary Glaucoma).

If the area of the pupil be filled with exudation—lying on the anterior capsule of the lens—circular synechia being usually also present, the condition is known as occlusion of the pupil.

Total posterior synechia is that condition in which the whole posterior surface of the iris is adherent to the capsule of the lens. It is rarely the result of ordinary iritis, but is seen frequently in sympathetic ophthalmitis.

Exudation of inflammatory products into the anterior chamber

[1] συνέχειν, *to bind together.*

causes turbidity of the aqueous humour, and sometimes these products sink to the bottom of the chamber and form a pseudo-hypopyon. In some rare cases. the exudation in the anterior chamber takes the form of a jelly-like mass, which may resemble a dislocated crystalline lens. On the posterior surface of the cornea, in some instances, exudation fastens itself as punctate deposits (so-called keratitis punctata), and these, and turbidity of the aqueous humour, indicate that the ciliary processes are involved in the inflammation.

The Subjective Symptoms of Acute Primary Iritis are :—(*a*) pain, (*b*) lacrimation and photophobia, (*c*) and dimness of vision. (*a*) The pain is due to irritation of the ciliary nerves in the inflamed part. Yet this pain is not always so much in the eye itself, as in the brow over it, in the corresponding side of the nose, and in the malar bone, and may extend to the whole side of the head. It varies in its intensity and is often more severe at night. Some forms of iritis are usually attended by much pain, while others are free from it. (*b*) The lacrimation and photophobia are reflex effects from irritation of the fifth nerve, they are often absent, and are rarely present to such a degree as in some corneal affections. (*c*) The dimness of vision is due to one or other or to all of the following :—turbidity of the aqueous humour, punctate deposits on the posterior surface of the cornea, exudation of lymph on the pupillary area of the anterior capsule of the lens, opacities in the vitreous humour.

A grave mistake into which beginners often fall is to take a case of iritis to be one of conjunctivitis or scleritis (see pp. 43 and 169), the "redness of the white of the eye" being that which misleads. The appearance of the iris itself—normal, or exhibiting the signs of iritis—will chiefly assist in the diagnosis. Moreover, the pain in iritis is of neuralgic character, but in conjunctivitis, if there be any pain, it is similar to that caused by a foreign body in the conjunctival sac. In iritis there is no discharge, while in conjunctivitis the eyelids are gummed in the morning by muco-purulent secretion. The vascular injection in iritis is of the pericorneal ciliary vessels, but in conjunctivitis of the conjunctival vessels (Plate II.). In iritis, however, it often happens that there is conjunctival as well as ciliary injection. But, as already stated, *the appearance of the iris itself is the most valuable guide in the diagnosis. Look at the iris. If the opposite eye be healthy, compare the iris in*

the affected eye with that in the healthy eye. These are important precepts in the diagnosis of iritis.

Etiology of Acute Primary Iritis.—By far the most common cause of acute primary iritis is syphilis, probably 50 per cent. of the cases being due to it. Other causes are gonorrhœa, tubercle, rheumatism, diabetes, enteric fever, pneumonia, influenza.

Syphilitic Iritis.—It is usually in the secondary stage of acquired syphilis, along with, or following on, the papular skin eruption, that one sees iritis; and, in the majority of cases, there is no characteristic appearance to indicate its specific nature, this diagnosis depending upon the general history, or on the presence of other signs of syphilis. The plastic inflammatory exudation is present mainly on the surface of the iris, and along the pupillary margin, and often also in the pupil. The loss of lustre and of distinctness of pattern are well marked, and there is considerable change in colour. Posterior synechiæ always form, and it is occasionally in these cases that the gelatinous exudation in the anterior chambers mentioned above is seen. The circumcorneal injection is generally well marked, sometimes causing elevation of the limbus of the conjunctiva, and even general, although slight, chemosis. The degree of irritation (pain, photophobia, and lacrimation) varies considerably, and is often slight, even where the appearances in the iris are well marked.

Late in the secondary stage of syphilis, or within a year or so after the primary infection, a form of iritis may occur which can, indeed, be recognised as syphilitic. It is characterised by the formation of circumscribed nodules, or small condylomata, of a yellowish-red colour, the rest of the iris being apparently intact (Plate II. Fig. 2). These nodules vary in size from that of a hemp-seed to that of a small pea, and are situated usually at the pupillary margin, occasionally at the periphery of the iris, and very rarely in the body of the iris. There may be but one nodule present, and there are seldom more than three or four. This form is not common.

Occasionally iritis occurs in the tertiary stage of syphilis, and then sometimes with the formation of inflammatory tumours in the iris, which are to be regarded as gummata.

In inherited syphilis, iritis does sometimes occur without interstitial keratitis (p. 141), but is more frequently seen in

conjunction with the latter. Childhood and youth are the periods of life in which it is observed.

Gonorrhœal Iritis.—This is not uncommon, and probably many cases of iritis reckoned as rheumatic are in fact due to gonorrhœa. The appearances are very similar to those of the iritis which occurs in secondary syphilis, but punctate deposits on the posterior surface of the cornea are more common in the gonorrhœal cases. Iritis does not attend on, nor immediately follow, a gonorrhœa ; but an attack of gonorrhœal arthritis, usually of the knees, always intervenes, and the interval between the attack of arthritis and the attack of iritis may be very lengthened—extending even to years.

Tubercular Iritis.—Tubercle occurs in the iris in three forms ; of these, one, the conglomerate or solitary tubercle of the iris, will be described under the heading of New Growths of the Iris. It is not usually associated with iritis. The other forms are properly regarded as tubercular iritis. They are :—

a. Very fine miliary nodules which occur in the iris, chiefly at the angle of the anterior chamber, or near the pupillary margin, where they give rise to posterior synechiæ. They are of a yellowish-grey colour, or, by reason of vessels which may form in them, they may be reddish, or cinnamon coloured. There is some iritis, and often, also, punctate deposits on the back of the cornea indicating engagement of the ciliary body. The process runs a sluggish course, and is not painful ; the nodules increase in size slowly, cease to grow, become smaller, and finally disappear. This form of tubercular iritis has been termed by Leber attenuated tuberculosis of the iris, and its prognosis is favourable, although some derangement of sight may remain as a result of the iritis. The disease is often binocular.

b. The second, and more common, form of disseminated tuberculosis of the iris is also associated with iritis, accompanied with much ciliary injection. But in this form, along with small nodules, there are some of larger size—so large, sometimes, as to touch the back of the cornea. They are of a pale buff colour, and may be scattered over the whole iris, although their seat of election—a rather important point for the diagnosis—is the angle of the anterior chamber. This form is frequently, and in our experience at the Victoria Hospital commonly, associated with tubercular disease of the true cornea (tubercular kerato-iritis), which is manifested by a

diffuse haze in the deep layers of the cornea, and by the presence, in the same layers, of scattered small and large greyish-yellow infiltrations, each of them surrounded by a less intense halo. A vascular network, derived from the deep marginal vessels, forms about these corneal infiltrations. Punctate deposits are present on the back of the cornea, and the aqueous humour may be hazy; and if the vitreous humour can be examined, it, too, may be found more or less opaque. This form usually goes on to complete loss of sight if untreated. At a late period, the growth of tubercle ceases, and the shape of the eyeball, with more or less opaque cornea, may be retained; or caseation, followed by phthisis bulbi, may result. One or both eyes may be attacked. Pain is not a prominent symptom—in many cases there is none.

The diagnosis of tuberculosis of the iris cannot be made off-hand from the presence of nodules in the iris, as nodules occur in other forms of iritis, notably in some cases of syphilitic iritis. The syphilitic condyloma is of a yellowish-red, while the tubercular nodule is of a greyish-red or of a buff colour, and often presents a somewhat translucent appearance. Those cases of nodular iritis which are accompanied by infiltrations in the deep layers of the cornea, as above described, can be regarded with great certainty as tubercular. But the history of the patient—exclusion of syphilis, acquired or congenital—his present state as regards tubercle elsewhere in the system, and the family history as to tubercle must be investigated. As tubercle of the iris commonly occurs in childhood or in early youth, the exclusion of acquired syphilis is not often difficult, and the presence or absence of the stigmata of congenital syphilis decides the diagnosis in that respect. In leucæmia, and in pseudo-leucæmia, iritis with formation of nodules occurs, and also in ophthalmia nodosa (p. 84).

Signs of former, or of existing, tubercular disease elsewhere in the body are obviously of great value for the diagnosis, for intra-ocular tuberculosis is always a secondary or metastatic condition, the primary focus being elsewhere in the system. Should no such focus be found, it must be remembered that it is possible for a small tubercular deposit to be present in the body, which may cause no symptom, and which may escape detection by physical examination; in short, intra-ocular tuberculosis, although not the primary focus, may be the first indication of tubercular infection.

The microscopical examination of a portion of the iris removed by iridectomy is conclusive for the diagnosis, if tubercle bacilli can be found in it, but this is rarely so. An inoculation experiment, by the insertion of a portion of the iris into the anterior chamber of a guinea-pig's eye, gives a more certain result. Neither of these measures, however, is admissible, as iridectomy is liable to cause the iritis to take on renewed activity.

Gourfein has proposed, and successfully practised, drawing off the aqueous humour from the tuberculous eye with a fine hypodermic syringe, and injection of it into the anterior chamber of a guinea-pig's eye, where it gives rise to tubercular iritis. This proceeding is harmless, but is only of use in fresh cases.

Finally, for diagnostic purposes a hypodermic injection of tuberculin may be used. Of Koch's old tuberculin a dose of 1 m.gr. of the dry substance is injected. If the disease be tubercular, a sudden and decided rise of temperature may take place, and as rapidly subside; and occasionally there is a passing local reaction in the eye. If there be no increase of temperature, a double dose is given the next day but one. But if there have been a slight elevation of temperature, even if it be only $\frac{1}{4}$ degree, the dose is not increased, and after the temperature has again become quite normal, the same dose is repeated. It will often be noted that the second reaction which now occurs—although the dose is the same—is more marked than the first. This, in Koch's opinion, is an exceedingly characteristic occurrence, and may be taken as an unfailing sign of the presence of tuberculosis. But if no reaction follows on the low doses, then a dose of 5 m.gr. and finally, if necessary, one of 10 m.gr. is given, or, to make quite sure, this last dose may be repeated. If then there be no reaction, the presence of tubercle may be excluded. The reaction may be looked for in from twelve to eighteen hours after the injection. This method is the one we employ. Von Pirquet's Cuti-Reaction may be employed.

Calmette's Ophthalmo-Reaction cannot be recommended for diagnostic purposes in cases of tubercular disease of the eye; for, unless in perfectly healthy eyes—and sometimes even in them—it is liable to set up troublesome and even serious diseases of the conjunctiva or cornea. When this method is employed, care should be taken that the preparation of Koch's old tuberculin employed is perfectly fresh.

Rheumatic Iritis.—This is usually of the form which is common in the early secondary stage of syphilis (p. 182), but it is accompanied by circumcorneal injection, which is great in proportion to the other signs of iritis present. The pain is often peculiarly severe, and again the attack may be painless. Iritis is not found in association with acute rheumatic arthritis, but rather with the sub-acute articular rheumatism, which attacks now one joint and again another through several months of the year, in the winter and spring. Rheumatic iritis is very liable to recur.

Treatment of Acute Primary Iritis.—A mydriatic is in all cases the most important means. Most commonly a solution of atropine (Atrop. sulph. gr. iv., Aq. dest. ℥j) is used as eye-drops. An atom of sulphate of atropine in substance, placed in the conjunctival sac, gives a very active reaction. It is also used in the form of ointment (Atrop. sulph. gr. iv., vaselin ℥j), and in gelatine discs.

By paralysing the sphincter iridis, atropine provides rest for the inflamed iris ; and, if adhesions have already formed, the dilatation of the pupil may break them down, while if none be as yet present, the dilatation will greatly aid in preventing their formation. Again, owing to diminished volume of the iris, its vessels contain less blood, and the hyperæmia of the inflamed part is reduced. Yet in cases of irido-cyclitis, where the cyclitis is the prominent factor, atropine does not always promote the cure, for by depleting the vessels of the iris it engorges those of the ciliary body.

To produce a maximum effect on the pupil, where it is desired to break down adhesions, six drops of the atropine solution should be instilled into the eye, with an interval of from five to ten minutes between each ; and in this way the atropine from each drop has time to make its way into the anterior chamber, and finally the accumulated effect of all six is obtained. More than one drop can hardly be retained in the conjunctival sac at a time. The use of cocaine (2 per cent.) along with atropine ensures a maximum dilatation. A drop of the atropine solution into the eye from once or twice to four times a day is required, in order to maintain the desired dilatation of the pupil *ad maximum*, in a severe case.

Some individuals are peculiarly susceptible to atropine poisoning, of which the symptoms are :—dryness of the throat, fever, fullness in the head, headache, delirium, coma. The antidote is morphia, of which $\frac{1}{4}$ grain used hypodermically neutralises $\frac{1}{30}$ grain of atropine

in the system. Atropine poisoning can occur by the introduction of the solution into the stomach through the lacrimal canaliculi, nose, and fauces ; and to prevent this the finger of the patient may be placed in the inner canthus, so as to occlude both canaliculi during, and for some moments after, the introduction of the drop into the eye.

After use of atropine in some persons the skin of the lower eyelid, or of both eyelids, becomes eczematous, red, swollen, and painful ; and in other cases after long use follicular conjunctivitis is induced. If these complications occur, solution of scopolamine $\frac{1}{4}$ per cent. should be substituted for atropine, and suitable remedies used for skin or conjunctiva.

In old people tenesmus and retention of urine sometimes result from use of atropine.

Atropine, while it is so useful in the treatment of inflammations of the iris, ciliary body, and cornea, is of no benefit in many other diseases of the eye, and is positively harmful in some of them. It is necessary to make this statement very explicitly, for many medical men, who have not devoted attention to the subject of eye-disease, include atropine in every eye-lotion they prescribe. If the disease prescribed for be conjunctivitis, the atropine is calculated rather to increase than to relieve the conjunctival affection ; while, if the patient be advanced in life, there is always the danger that a tendency to glaucoma may be present, and in such a case the dilatation of the pupil caused by the atropine will be sufficient to bring on an attack of acute glaucoma. It falls to the lot of most ophthalmic surgeons to be called, at one time or another, to a case of acute glaucoma caused by the use of atropine in this thoughtless manner.

Dark protection spectacles should be worn by patients suffering from iritis ; and in severe cases, especially in cold weather, the eye should be covered with a thick pad of cotton wool, and the patients should be confined to a dark room, and even to bed.

Hot fomentations—every two hours for twenty minutes—are of benefit in all forms of acute iritis, and they relieve pain. Dionine is also useful in relieving pain, and seems to promote the cure. If the pain be severe at night a hypodermic injection of morphia may be given. Should there be much irritation, pericorneal injection, or chemosis, leeching at the external canthus over the orbital margin

is of use. Occasional gentle purgatives are desirable. Blistering on the temples, or behind the ear, has been a favourite item in the treatment of iritis; it adds to the annoyance of the patient, and as a remedy it is valueless.

In addition to the foregoing measures which are applicable in all cases, the special etiological moment must be considered in the treatment of each case, as follows :—

Treatment of Syphilitic Iritis.—As it is important to obtain rapid absorption of the inflammatory products so abundantly thrown out, and which would soon cause extensive damage to the eye, the system should be put under the influence of mercury as quickly as possible, by the use of mercurial inunctions; or by small doses of calomel internally; or by intra-muscular injections, 1 grain of metallic mercury being injected once or twice a week in the form of a cream made with lanolin as recommended by Lambkin. The reports published of the effect of salvarsan in syphilitic iritis are very favourable. When the acute symptoms have passed away, an after treatment with iodide of potassium should be employed.[1] In iritis due to congenital syphilis, mercury is not generally indicated, but the syrup of the iodide of iron, and a general tonic treatment is preferable. In cases of acquired syphilis, as there is a marked tendency of iritis to relapse, it is important that, for some weeks after the acute stage has passed, the pupil should be kept under the influence of atropine, the eyes protected with dark glasses, and the internal administration of iodide of potassium continued.

An attack of syphilitic iritis may last from two to eight weeks, and cases which seem to be slight—*i.e.* where the pupil dilates well and rapidly to atropine, and where but little lymph is thrown out—sometimes cause disappointment by their slow recovery. It is possible that an attack of iritis, if carefully treated from the beginning, may leave the eye in as healthy a condition as before, but it is more common, in spite of every effort, to find isolated posterior synechiæ, or a circular synechia, left behind. The presence of a few isolated synechiæ, if the pupil be clear, is in itself harmless to sight; but, if relapse should take place, and fresh adhesions form, a complete posterior synechia (p. 180) going on to iris bombé may

[1] Iodide of potassium must not be prescribed in conjunction with treatment by injections of metallic mercury.

ultimately be established. Complete posterior synechia may of course result from the first and only attack of iritis.

In some cases of iritis, the vitreous humour becomes more or less opaque, and this condition does not always disappear as the iritis gets well; indeed, it may not be possible to ascertain its presence until after the inflammatory process in the iris has subsided. In these cases the ciliary body has participated in the inflammation, although there may have been no punctate deposits on the cornea. Again, there may have been some chorioiditis and retinitis during the attack. Great and permanent deterioration of vision may result from such complications; and this emphasises the importance of a cautious prognosis at the commencement.

In complete posterior synechia, after the acute iritis has subsided, an iridectomy is indicated to restore communication between the posterior and anterior chambers. For the treatment of opacities in the vitreous humour see chap. x., and of syphilitic chorioretinitis see chap. xi.

Treatment of Tubercular Iritis.—Cases of attenuated tuberculosis of the iris simply require local treatment with atropine, hot fomentations, and protection spectacles.

In the treatment of the more pronounced form of tubercular iritis, the tubercular infection must be combated, and the chief therapeutic measure of value for this purpose is inoculation with tuberculin. The method we employ at the Victoria Hospital is as follows:—

The preparation used is Koch's Tubercle Bacilli Emulsion. The patient's temperature having been ascertained to be normal, a hypodermic injection of 1 c.c. of the 'fifth dilution,' representing 0·000005 m.g. of the bacillary substance, is given. The temperature is taken every two hours, and if in the course of twenty-four hours there be no reaction, an injection of 1 c.c. of the 'fourth dilution,' equal to 0·00005 of the bacillary substance is given. The dose is thus gradually increased at intervals of one or two days, unless the temperature be raised, until the original liquid is reached, 1 c.c. of which contains 5 m.gr. of the substance. When the higher doses are given, the intervals should be considerably longer, and if, after any dose, a rise of temperature of 0·5 a degree or more take place, the previous dose is repeated, and an increased dose is not given until a general reaction ceases to be caused. In the majority of cases treated,

marked improvement became apparent within a few weeks, the nodules in the iris becoming smaller and less vascularised, the deep-seated corneal infiltrations thinner, the punctate deposits fewer, and the eye less irritable and injected, until finally, with continued treatment, all tubercular deposits and infection disappeared, leaving only such permanent damage to the eye and sight—due to corneal changes and pupillary occlusion—as may be proportional to the duration and severity of the disease before treatment took effect. The treatment is a protracted one, as long as six months, possibly, being needed to effect cure in a severe case.

Valuable adjuncts in the treatment with tuberculin are local hot fomentations, with the administration internally of citric acid—a decalcifying agent, to reduce the coagulability and viscidity of the blood—cod-liver oil, and syrup of the iodide of iron.

On the question as to whether an eye which is disorganised by intra-ocular tuberculosis beyond hope of recovery should be excised, opinions are divided. Were the eye the primary focus, excision might be indicated in even a less advanced stage. But cases are on record in which, soon after excision of a tubercular eyeball, death from tubercular meningitis, or from acute miliary tuberculosis, took place ; and which were therefore suggestive of dissemination of the tubercle as direct result of the operation. We can offer no experience of our own in this connection, but it would seem that there is a risk in removing the eyeball in these cases. Where excision is not undertaken, extension of the disease to the optic nerve, and so to the brain, is exceedingly rare.

For Rheumatic Iritis the general treatment is the same—salicylate of soda, aspirin, etc.—which is found useful for rheumatic symptoms in other parts of the body.

In Gonorrhœal Iritis, too, treatment with salicylate of soda is the most successful. Injection of the gonococcus serum has given good results in the few cases so far reported.

Chronic Iritis.—Practically the only *objective sign* of a slight case of chronic iritis is posterior synechiæ with, it may be, some slight pupillary exudation. Or, in addition to posterior synechiæ, there may be punctate deposits. Or, the latter may be present without synechiæ, when the case is to be regarded rather as one of chronic cyclitis. In the severer cases, the stroma of the iris is distinctly altered as regards colour and pattern, there are abundant

deposits on the back of the cornea, and opacities in the vitreous humour. There is no pericorneal injection in chronic iritis, or, at most, it is slight, occasional, and ephemeral.

The chief, or only, *subjective symptom* in chronic iritis is defective vision, and this it is which brings the patient for advice ; for there is little or no pain, photophobia, or lacrimation. On examination, some of the above-mentioned objective signs are found, and inquiry elicits the fact that, except for gradual failure of sight, the patient has had little trouble beyond an occasional ' cold ' in the eye—*i.e.* slight ciliary injection—which lasted a few hours, or a day or so at a time, in the course of preceding years.

The slighter cases of this affection which are confined to the iris, and do not run a long course, may not cause serious loss of sight. The more severe cases, accompanied by cyclitis and punctate deposits, are liable to be complicated with high tension (secondary glaucoma), owing to blocking of the angle of the anterior chamber with exudation, which seriously endangers vision.

In the severest cases the whole uveal tract is involved, and the term Chronic Uveitis becomes applicable to the condition. The exudation of inflammatory products is very great, with the following results :—marked punctate deposits—giving rise to parenchymatous opacity of the cornea—turbid aqueous, atrophy of the iris, posterior synechiæ going on to exclusion of the pupil, often occlusion of the pupil, iris bombé, opacity of the vitreous humour, cataract, atrophy of the chorioid and retina, high tension owing to iris bombé, absolute blindness, staphyloma of the globe—or, in the last stages, the eye may become phthisical instead of staphylomatous. In some few cases iris bombé may not come on, and complete blindness may not result, rendering the prospect of a cataract extraction fairly good.

Pathogenesis.—Chronic Iritis and Chronic Uveitis frequently occur, or rather commence, in youth, and are more common amongst females than males. The severe cases may continue intermittently for many years before complete blindness is reached. Syphilis is not often a cause of chronic uveitis. Tubercle is now held to be its cause in a considerable proportion of the cases, and it is necessary to give diagnostic injections of tuberculin to decide the diagnosis (p. 185). Auto-infection, derived from the mouth or intestine, is also held to account for a large number of cases.

Treatment of Chronic Iritis and of Chronic Uveitis.—In addition to the usual local measures—atropine, hot fomentations, dionine, protective dressing—sub-conjunctival saline injections (chap. x.) are indicated. Paracentesis of the anterior chamber (p. 119) may also be used with advantage, and can be repeated about once a week. It may be assumed that the hyperæmia of the uveal tract, which immediately follows the operation, promotes the access of anti-bodies and other healing substances to the diseased membrane.

If the disease be due to tubercle, a course of treatment with tuberculin (p. 189), concurrently with the above local treatment, is indicated. Or, if auto-infection be the cause, the teeth and gastro-intestinal tract must be put into healthy condition.

Inflammation of the Ciliary Body : Cyclitis.—*Acute Cyclitis*, as has been stated, attends all cases of severe acute primary iritis, and often many of the slighter cases, whatever be their etiology, a fact which has been demonstrated by pathological examination. Yet, very frequently, there are no clinical signs of its presence, or they are masked by those of the iritis. The most common clinical sign of cyclitis in these cases is fine punctate deposits—often so fine as to be discernible only with the combined focal method, or with the corneal microscope—on the back of the cornea, with, it may be, slight turbidity of the aqueous humour, and occasionally the formation of a small pseudo-hypopyon. The ciliary processes it is which secrete the aqueous humour ; and, when they are inflamed, the inflammatory products are liable to pass from them, and to appear in the above forms in the anterior chamber.

Owing to gravitation, the lower quadrant of the cornea is the part on which the punctate deposits are usually precipitated. The part of the cornea which is thus affected is often of a triangular shape, the base of the triangle corresponding with the lower margin of the cornea, the apex being directed towards the centre of the cornea, with the finer dots near the apex. The triangular shape results from the motions of the eyeball. In many cases, however, nearly the whole cornea is more or less affected.

In cases where the punctate corneal deposits continue for a length of time, permanent secondary changes in the true cornea take place—in consequence of the resulting degeneration of the endothelium on the posterior corneal surface—and a consequent triangular opacity at the lower part of the cornea will ever

afterwards indicate the nature of the process which has gone before.

Opacities in the vitreous humour—which is also nourished by the ciliary processes—especially in its anterior part, are another frequent result and sign of cyclitis.

But acute cyclitis is sometimes seen without iritis. Its signs, in a severe case, in addition to those above mentioned, are :—Marked circumcorneal injection, pain on pressure of the ciliary region, deep anterior chamber owing to hyper-secretion of the aqueous humour or to retraction of the root of the iris, and œdema of the upper lid. There is danger of increase of the intra-ocular tension, owing to the tendency to blocking of the angle of the anterior chamber with inflammatory exudation.

In some cases the inflammatory products are thrown out abundantly behind the iris in the posterior chamber, causing a total posterior synechia (p. 180) with the result that the posterior chamber becomes completely obliterated ; and, consequently, the anterior chamber, especially at its periphery, is made excessively deep, and the pupil dilated. In these cases the intra-ocular tension is reduced. Severe cases of cyclitis, or of irido-cyclitis, when they continue for long, very often become complicated with cataract, owing to derangement of the nutrition of the lens. In consequence of shrinking of the vitreous humour, detachment of the retina is another frequent complication of these cases. Finally, shrinking of the globe (phthisis bulbi) is in many instances the ultimate result.

In *Chronic Cyclitis* the circumcorneal injection is slight. The anterior chamber is often at first deeper than normal, owing to hyper-secretion of aqueous humour from the ciliary body ; there are punctate opacities on the posterior surface of the cornea ; and the anterior part of the vitreous humour is filled with fine dust-like opacities. Iritis may come on (chronic irido-cyclitis), and glaucomatous increase of tension, owing to blocking of the angle of the anterior chamber. Unless increase of tension give rise to it, pain is not often present.

Syphilitic Cyclitis.—Unless when associated with syphilitic iritis, syphilitic cyclitis cannot be recognised as such.

*Syphilitic Gumma of the Ciliary Body.—This is rare, and belongs to the tertiary stage of syphilis, although it is sometimes seen much earlier. It is always preceded by acute irido-cyclitis

of the usual plastic type. It appears at first as a small circumscribed nodule with smooth round surface slightly raised over the surface of the sclerotic in the ciliary region. It sometimes increases in size very rapidly—and is then attended by violent iritis and much pain—and again but slowly. It may attain the size of a pea, or even of an almond, and may extend some way around the cornea, presenting a reddish, yellowish, or bluish colour. After a time, in the less severe cases, the gumma becomes smaller and disappears, leaving a dark cicatrix in the sclerotic. But in other cases it breaks through the sclerotic, although very rarely through the conjunctiva, by destruction of tissue; and when this has taken place the tumour grows smaller and undergoes absorption, and the eye becomes phthisical. The gumma may also grow into the anterior chamber, and but rarely into the vitreous humour. The interval between the appearance of the gumma and completion of the process is from a few days in the very acute cases, to several weeks in the more chronic cases. The bulbar conjunctiva is hyperæmic, and often chemotic. In the cornea there is generally a slight diffuse opacity with stippling of the epithelium, and there may be posterior punctate deposits.

The severe acute cases are accompanied by intense interstitial keratitis, œdema of the upper lid, and violent pain. The mildest cases may end with retention of fair vision, but in most instances serious damage to sight results; while, in very many, vision is totally lost, and the eye becomes phthisical. In many of the recorded cases the eye was excised in the acute inflammatory stage on account of agonising pain.

* Tubercular Cyclitis.—This is frequently associated with tubercular iritis, although its presence cannot be clinically detected. Yet in some cases the disease in the ciliary body assumes the form of a large nodule, or even a tumour of considerable size—or there may be more than one of these—and causes staphylomatous bulging at the corneo-scleral margin, which may go on to rupture externally.

Treatment of Cyclitis.—This follows very much the lines of the treatment of iritis. Atropine, by paralysing the ciliary muscle, acts favourably on the disease. On the other hand, if the pupil be dilatable, atropine causes engorgement of the ciliary body by the blood driven out of the iris. Consequently, its effect on the symptoms must be watched, and it may become necessary to

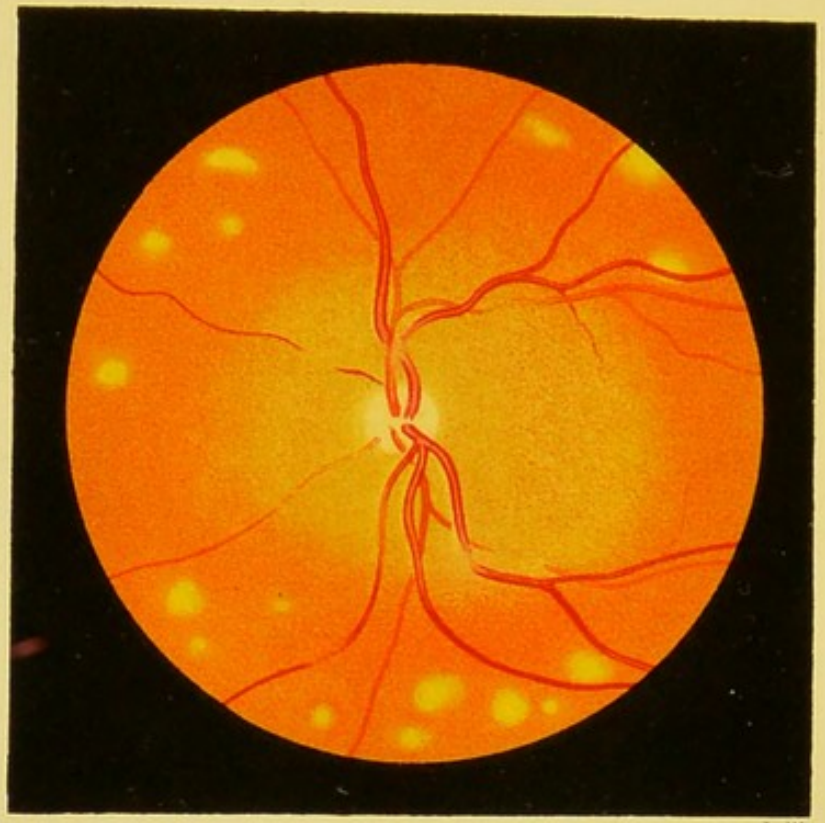


FIG. 1. Chorioido-Retinitis (Specific).



FIG. 2. Disseminated Chorioiditis.

PLATE III

(*To face page* 195)

FIG. 1.—Chorioido-Retinitis in an early stage. A central area of haziness extends around the disc and macular region, rendering the outline of the form indistinct, and concealing the retinal vessels in places. The veins are somewhat engorged. Soft-edged yellowish white spots of chorioidal exudation are visible farther out towards the periphery. A retinal vein passes over one of these spots.

FIG. 2.—Chorioido-Retinitis in a later stage. The retinal haze has disappeared. Irregular patches of atrophy of the chorioid are scattered over the periphery, some of them bordered by pigment. Spots of black pigment surrounded by a narrow yellow zone are also to be seen. The chorioidal vessels are rendered visible close to the disc, owing to atrophy of the pigment-epithelium.

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(To face page 189)

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dispense with its use, and even for a time to substitute a myotic. Hot fomentations to the eye, and a warm bandage, and, in acute cases, leeching at the external canthus are serviceable.

In chronic cyclitis sub-conjunctival injections of normal solution of salt are indicated ; and, if the intra-ocular tension become high, paracentesis of the anterior chamber should be performed.

In syphilitic gumma of the ciliary body an active mercurial treatment is necessary. Salvarsan is very effectual. In tubercular disease, treatment with tuberculin affords the best prospect of cure.

* **Inflammations of the Chorioid** (*χόριον, the chorion*, hence chorioid, *like the chorion*).—There are two chief forms of inflammation of the chorioid, the exudative and the purulent.

Of the exudative form, again, there are several kinds, namely—disseminated chorioiditis, central senile guttate chorioiditis, central chorioiditis, and syphilitic chorio-retinitis.

Disseminated Chorioiditis.—The usual Ophthalmoscopic Appearances of this disease (Plate III. Fig. 2) consist either in round white spots of different size with irregular black margins, or in small spots of pigment, these changes being surrounded by healthy chorioidal tissue ; or, there may be few or no white patches, but rather spots of pigment surrounded by a pale margin. The retinal vessels are seen to pass over the patches. The number of these patches or spots varies according to the intensity of the disease. Their position is at first at the periphery of the fundus only, but later on they appear also about the posterior pole of the eye.

These appearances, however, represent a rather late stage of the disease, the early stage coming but rarely under observation. It consists in small circumscribed plastic exudations into the tissue of the chorioid, which, if seen with the ophthalmoscope (Plate III. Fig. 1), give the appearance of pale pinkish-yellow or greyish spots behind the retinal vessels. These exudations may undergo absorption, leaving the chorioid in a fairly healthy state ; but, more usually, they give rise to atrophic cicatrices, in which the retina becomes adherent, with proliferation of the pigment-epithelium layer in their neighbourhood, and hence the white patches with black margins above described. It is this form of chorioiditis which, in its earliest stages, is often associated with inflammatory processes in the iris or ciliary body, either as a primary or secondary affection.

But, again, in many instances the disease does not extend beyond the chorioid.

Sometimes, in addition to the above changes, the pigment-epithelium layer all over the fundus becomes atrophied, exposing to view the vascular network of the chorioid, while here and there small islands of pigment are present.

Opacities in the vitreous humour are sometimes found.

Symptoms.—Diminution in the visual acuity, especially if the macula be involved. There also may be subjective sensations of light or colours, positive scotomata (dark areas visible to the patient), and distortion of objects (metamorphopsia), or alteration in their size (megalopsia and micropsia). Night-blindness is not uncommon.

Causes.—Disseminated chorioiditis is due to acquired syphilis in a considerable number of the cases, and possibly in some it may be tubercular. But in a very large proportion of cases no ascertainable cause exists; and these cases, there is reason to suspect, are congenital, and probably many of them are dependent on an inherited syphilitic taint. In eyes with congenital cataract, patches of chorioiditis are often found.

Prognosis.—Disseminated chorioiditis is always a serious and very chronic disease, fresh spots of exudation making their appearance from time to time, and complete recovery cannot be looked for. The degree of defect of sight it may cause in the early stages depends much on the extent to which the region of the macula lutea has been involved. In advanced cases the optic nerve and retina become atrophied, and still later the lens becomes cataractous.

Treatment.—In fresh cases due to acquired syphilis, a prolonged but mild course of mercurial inunctions is the most suitable measure, to be followed by a lengthened course of treatment with iodide of potassium. Where an inherited syphilitic taint is suspected, iodide of iron or iodide of potassium internally may be of use. Both in the acquired and congenital cases salvarsan will be of service. If tuberculosis be the cause, a course of tuberculin inoculations should be employed; while, in the cases due to other causes, small doses of perchloride of mercury may be given; and in all cases sub-conjunctival injections of 4 per cent. solution of common salt are indicated. Dark protection spectacles should be worn, and absolute rest of the eyes from all near work insisted upon, so long as the disease is active.

*Central Senile Guttate Chorioiditis.—Under this name an appearance has been described by Mr. Waren Tay and others, which consists of fine white, pale yellow, or glistening dots, best seen in the upright image, and situated chiefly about the macular region, or between this and the optic papilla. These dots are due to colloid degeneration with chalky formations in the vitreous layer of the chorioid, which give rise to secondary retinal changes. The appearances must not be confounded, as they sometimes have been, with those of retinitis punctata albescens (chap. xi.), which is an entirely different disease. The functions of the retina usually suffer in a marked manner, so that a partial central scotoma may be produced; but some cases have been observed, in which vision was but little, or not at all, affected.

This disease attacks both eyes, either simultaneously or with an interval, and is most often seen in persons of advanced life, although it is also found in middle age, and even in youth.

Treatment is of no avail.

*Central Chorioiditis.—This is an exudation at the macula lutea, without any similar disease elsewhere in the fundus. Absolute central scotoma is its prominent symptom, and syphilis its usual cause.

Treatment.—Active mercurialisation; and, where this can be adopted early, the prognosis for recovery of sight is fairly good. Sub-conjunctival salt injections aid the cure.

Syphilitic Chorioido-Retinitis.—See Syphilitic Retinitis, chap. xi.

Purulent Chorioiditis.—This consists at first in a purulent extravasation between the chorioid and retina, and into the vitreous humour, recognisable by the yellowish reflection obtained from the interior of the eye on illuminating the pupil with the ophthalmoscope mirror. The eyeball may become hard, the pupil dilated, and the anterior chamber shallow. Purulent iritis with hypopyon soon comes on, and the cornea may also become infiltrated and slough away. There is usually considerable chemosis, and the eyeball is pushed forwards by inflammatory œdema of the orbital connective tissue. The eyelids are swollen and congested. There is intense pulsating pain in the eye, and radiating pains through the head; and in this stage all the tissues of the eyeball are engaged in the purulent inflammation, and the condition is termed Panophthalmitis.

Purulent chorioiditis does not reach this latter stage in every case, but may remain confined chiefly to the chorioid, vitreous humour, and iris. The pain in these cases is not severe; and when the affection occurs in children it may be mistaken for glioma of the retina (chap. xi.); indeed, the name 'pseudo-glioma' has, unfortunately, been given to it. It must, however, be stated, that very recent investigations go to show that pseudo-glioma has its origin in the retina rather than in the chorioid. It is distinguished from glioma by the muddy vitreous usually present with it, by the posterior synechiæ, and by the retraction of the periphery of the iris, with bulging forwards of its pupillary part.

Causes.—The most common causes of purulent chorioiditis are: perforating wounds of the eyeball, whether accidental or operative; foreign bodies piercing and lodging in the eyeball; and purulent keratitis. It may also come on suddenly in eyes which are the subjects of incarceration of the iris in a corneal cicatrix, through infection of the incarcerated iris.

Again, it is seen as embolic or metastatic chorioiditis, in connection both with epidemic and sporadic cerebro-spinal meningitis (chap. xiii.); in some cases of metria, similarly as purulent retinitis (chap. xi.); in pyæmia of the ordinary type; and in endocarditis.

In infancy and childhood, besides its occurrence with cerebro-spinal meningitis, it has been known to be caused by, or associated with, inherited syphilis, measles, bronchitis, diarrhœa, hooping-cough, and omphalo-phlebitis; and some infective blood-disease is the fundamental cause of the process in every case, although it is not always possible to determine its source.

Prognosis.—The ultimate result in the vast majority of cases is loss of sight, with phthisis bulbi. The severe cases go on to rupture of the eyeball through the cornea or sclerotic, after which the pain subsides. It would seem from the description of authors who have seen much of epidemic cerebro-spinal meningitis, that a certain number of cases of irido-chorioiditis occurring in the course of that disease do recover with retention of good sight.

The shrunken eyeballs produced by panophthalmitis are not generally painful on pressure. They are not very liable to give rise to sympathetic ophthalmitis, and the latter statement is also true of the acute purulent process itself. It is cases of traumatic plastic irido-chorioiditis which produce sympathetic ophthalmitis.

Treatment may be said to be powerless in this disease. The utmost one can do is to endeavour to diminish the pain in the very severe cases by warm fomentations, poultices containing conium, hypodermic injections of morphia, or, finally, by eviscerating the suppurating contents of the scleral cavity.

Excision of the eyeball should not be undertaken during purulent chorioiditis in the acute stage, as it may cause purulent meningitis.

Sympathetic Ophthalmitis, and Sympathetic Irritation.

Introductory.—By the term Sympathetic Ophthalmitis we understand a general plastic uveitis (plastic inflammation of iris, ciliary body, and chorioid) of one eye, which has been caused by a plastic uveitis of the other eye, the latter condition being most commonly due to a perforating trauma, or other perforation of the eyeball. Or, the sympathetic ophthalmitis occasionally consists in an optic neuritis or chorioiditis.

Purulent uveitis (panophthalmitis) of one eye does not cause uveitis, either plastic or purulent, of the other eye.

There are no such diseases as sympathetic cataract, conjunctivitis, detachment of the retina, keratitis, scleritis, etc.

The term 'sympathetic' in this connection is an old one, and probably would not be employed had the disease to be named at the present time.

Sympathetic ophthalmitis is not a fifth-nerve reflex phenomenon. It is, as stated, a uveitis, and often also an optic neuritis, which has arisen by transmission of certain, as yet, undetermined micro-organisms, from the injured eye, in which uveitis has been set up, to the sympathising eye. No sympathetic uveitis can be developed in the second eye, until after uveitis in the first eye has commenced. A perforating injury of the eyeball, or other perforation, which does not produce uveitis in that eye, does not give rise to sympathetic ophthalmitis in the fellow eye. Yet, traumatic uveitis in the injured eye does not cause sympathetic ophthalmitis in every case.

The eye which has received the perforating injury is spoken of as the exciting eye, and its fellow, which becomes the subject of sympathetic ophthalmitis, as the sympathising eye. The eyes are also

spoken of as the injured eye, and the sympathising eye; also as the first eye, and the second eye.[1]

While sympathetic ophthalmitis is not a reflex condition, there is an affection known as sympathetic irritation, which is a true fifth-nerve reflex neurosis. These two affections, although sometimes closely associated clinically, are quite distinct from each other.

Before treating of sympathetic ophthalmitis, it will be convenient to state what is necessary concerning sympathetic irritation.

Sympathetic Irritation.—This may be caused by almost anything which produces irritability of the ciliary nerves in the first eye—*e.g.* foreign bodies on the cornea or under the upper lid, losses of substance of the corneal epithelium, anterior staphyloma, acute glaucoma, iritis, dislocation of the crystalline lens, etc.

The most common symptoms of sympathetic irritation of the second eye are: photophobia, lacrimation, vascular injection of the front of the eyeball, and accommodative asthenopia, and, in a well-marked case, these symptoms become intensely distressing to the patient. Neuralgia in the orbit and brow, and retinal asthenopia sometimes occur.

Amongst the many causes of sympathetic irritation is an irritable shrunken globe, whether the latter condition be the result of a uveitis from a perforating injury, or of an idiopathic uveitis; and an irritable shrunken globe may give rise to sympathetic irritation in the fellow eye at any time, even after many years. Having remained quiet for so long, the shrunken eye begins to lacrimate, and becomes painful and injected. A fresh injury to the stump may be the cause of this, or it may be ossification of its chorioid, and the irritation, whatever its cause, may be transmitted to the sound eye.

But sympathetic ophthalmitis also is often caused by a shrunken fellow eyeball, in which uveitis is present (*vide infra*); and of great importance is the question: What relation, if any, has sympathetic irritation to sympathetic ophthalmitis in such cases? Is sympathetic irritation to be regarded as a reliable and essential premonitory symptom of sympathetic ophthalmitis? The answer is

[1] German and French authors term the injured eye the sympathising eye, and the second eye the sympathised eye.

in the negative. Sympathetic irritation may last an indefinitely long time, without being followed by sympathetic ophthalmitis. Further, although some sign or signs of sympathetic irritation often do precede the onset of sympathetic ophthalmitis, yet in many cases every such sign is wanting. In view of the latter fact, it is, therefore, wrong to postpone a prophylactic enucleation, until sympathetic irritation shows itself.

Treatment.—When sympathetic irritation is caused by an irritable shrunken globe on the opposite side, it can be immediately relieved by removal of the stump. Rest in a dark room and sedative measures, while they may seem to cure, merely lead to disappointment, owing to the almost certain return of the symptoms, when the eye is brought into use again. Moreover, as sympathetic irritation does often precede sympathetic inflammation, it is wise to enucleate the exciting stump in order to assure the safety of the second eye.

SYMPATHETIC OPHTHALMITIS. **Diagnosis.**—The inflammation of the uveal tract in the sympathising eye has no characteristics which enable us to make the diagnosis 'Sympathetic Ophthalmitis,' for precisely the same plastic or sero-plastic uveitis, as the case may be, is seen under other conditions ; nor is the state of the first eye, taken alone, a certain guide. To arrive at a diagnosis, it is necessary to weigh the following data, and to take them collectively into consideration :—

1. The condition of the exciting eye, and the nature of the injury to, or disease of, that eye.
2. The condition of the sympathising eye.
3. The interval that has elapsed between the injury to the exciting eye, and the onset of the uveitis in the sympathising eye.
4. The state of the general system.

1. *The Condition of the Exciting Eye.*—As already stated, perforating injuries, or perforating corneal ulcers, of the first or exciting eye, which are followed by plastic uveitis, are by far the most common causes of sympathetic ophthalmitis. The position of the wound in the eye has no influence in the production of sympathetic ophthalmitis. Uveitis in the injured eye is due to infection of the wound by micro-organisms derived from the foreign body, or instrument, which has caused the wound, but sometimes perhaps from the surface of the eye, or from the atmosphere.

Either a purulent uveitis, or a plastic uveitis, may result from the injury.

Purulent uveitis of a not very pronounced type (purulent infiltration of the vitreous humour, iritis, hypopyon) is very occasionally followed by sympathetic ophthalmitis, but, and it is a remarkable clinical fact, the marked purulent uveitis, which is called panophthalmitis (p. 197), may be said never to give rise to it. It is obviously not a pyogenic micro-organism which causes sympathetic ophthalmitis—for, if it were, the latter would be a purulent process—but it is some specific micro-organism ; and it can hardly be doubted that in those rare instances in which sympathetic ophthalmitis has followed on slight purulent uveitis, this specific organism has been present in the injured eye along with the staphylococcus.

If the infection of the injured eye be purulent, the inflammatory reaction in it comes on within the first thirty-six hours after the injury ; while the fibrinous or plastic inflammatory reaction, which is so dangerous in relation to sympathetic ophthalmitis, and which is caused by the specific organism, declares itself in the injured eye less quickly and more insidiously.

In the case of the latter infection, the injection and irritation—immediate results of the injury—disappear in a few days, but soon return. The pupil then begins to dilate less well to atropine, the tissue of the iris becomes less distinctly seen, some punctate deposits appear on the posterior surface of the cornea, a few posterior synechiæ form, and opacities appear in the vitreous humour. At first there is little or no pain, either spontaneously or on pressure. Then more synechiæ form, the iris stroma becomes more indistinct and discoloured, often of a dull greenish or yellowish grey, and the pupil becomes occluded. The anterior chamber becomes shallower than normal, and the intra-ocular pressure is diminished. Sight is much impeded by exudation in the pupil and by opacities in the vitreous, and, in case of detachment of the retina from shrinking of the inflammatory products in the vitreous humour, it may be reduced in a marked degree. There now is often pain on pressure of the eyeball, and the latter soon begins to be diminished in size and becomes soft to the touch, while the pressure of the tendons of the orbital muscles on this soft eyeball gives rise to deep furrows on its surface. In short, the injured eye has now become phthisical, and sight is quite lost. This entire process may be completed in

three or four weeks, or it may occupy a considerably longer time.

The danger of sympathetic ophthalmitis supervening on a perforating injury of the first eye commences with the onset of plastic uveitis in the injured eye—although the inflammatory process in the second eye does not develop until after a certain interval (*vide infra*)—and this danger is present, not only all through the acute process in the injured eye, but also after this has subsided, and when the eye has become shrunken, and even for many years more.

Shrunken eyeballs, as just stated, are liable to cause sympathetic ophthalmitis. Pain on pressure of the ciliary region in them, showing, as it does, the presence of inflammation of the ciliary body, is an important danger-signal; but the absence of pain on pressure is not conclusive of the absence of cyclitis, for the latter may exist to only a slight and yet dangerous degree, or the ciliary body may be detached and out of reach of pressure.

The presence of a foreign body in the interior of the injured eye does not necessarily lead to sympathetic ophthalmitis by the inflammatory reaction which it may cause; for an aseptic foreign body in the eye will cause an active inflammatory reaction; yet this latter, not being of bacterial origin, will not in its turn give rise to sympathetic ophthalmitis. There are, however, few foreign bodies, except atoms of hot metal, which can be guaranteed as free from infective material; hence, as a rule, the presence of a foreign body within the eye augments the danger of a perforating injury.

As in accidental perforating injuries, so also the wounds made in the sclerotic or cornea in surgical operations, especially in cataract extractions, may be followed by plastic uveitis, which will produce sympathetic ophthalmitis. In consequence of the thorough antiseptic measures now in use, inflammatory processes after cataract extractions are very much less common than they used to be.

Perforations caused by ulcers of the cornea sometimes give rise to uveitis, which may be followed by sympathetic ophthalmitis; but this is a rare event, although some iritis is present with almost every severe corneal ulcer, and especially with those which tend to perforate. It is not easy to assign a reason for the rare occurrence of sympathetic ophthalmitis in these cases.

In how far plastic uveitis of the first eye, which is not due to

perforating injuries or ulcers, is capable of being the cause of sympathetic ophthalmitis is an important question.

Intra-ocular tumours, which have not yet perforated the sclerotic, especially sarcoma of the chorioid, very occasionally set up a uveitis, which leads to sympathetic ophthalmitis. In these cases necrosis of the tumour has generally set in.

Ruptures of the eyeball from blows, which usually occur in the ciliary region, without rupture of the conjunctiva—sub-conjunctival ruptures of the sclerotic—sometimes come under our notice (p. 174). These injuries almost invariably run a course free from inflammation or even irritation of the injured eye, owing to the unbroken conjunctiva, which covers the rupture, and prevents the access of infecting bacteria; and, consequently, they may be said not to cause sympathetic ophthalmitis. It is probable that in the few cases of this injury in which uveitis in the injured eye and sympathetic ophthalmitis in the second eye appeared, some small opening in the apparently sound conjunctiva existed.

Cases of gonorrhœal ophthalmia have been published in which sympathetic ophthalmitis came on. But these were all cases in which ulceration, followed by perforation of the cornea, took place; and, hence, in which infection by bacteria other than the gonococcus was quite possible.

2. *The Condition of the Sympathising Eye.*—The diseased process in the second or sympathising eye, as has already been stated, is, with certain rare exceptions, an inflammation of the uvea, of a plastic or fibrinous type, but never purulent, and almost always begins in the uvea, or, at any rate, is commonly first discovered there as iritis.

In the rare exceptions referred to, optic neuritis is the first sign of sympathetic ophthalmitis, uveitis coming on subsequently; and, yet more rarely, optic neuritis has been seen as the one and only sympathetic inflammation, the uvea remaining unaffected. It is, however, held by some, that optic neuritis would be found to be the first sign in the sympathising eye in nearly all cases if it were possible to examine them before opacities in the vitreous humour, and exudation in the pupil, interfere with an ophthalmoscopic diagnosis.

The appearance of the optic neuritis, or papillitis, as seen in these cases, consists in hyperæmia of the disc, without much swelling of the latter, but with slight woolliness of its margin, the opacity

spreading a short distance into the surrounding retina. The veins are distended, and the arteries are normal. The sight is considerably affected, and there is often rather severe headache. The remedy for sympathetic papillitis, occurring alone, is removal of the exciting eye, and a few days after the operation the beneficial effect on the optic nerve inflammation begins to show itself.

There are no reliable premonitory symptoms of the attack of uveitis in the sympathising eye. As already stated, in many cases sympathetic irritation does precede the first signs of sympathetic uveitis, but it does not always do so ; and when sympathetic irritation does appear, it need not always indicate the approach of sympathetic uveitis.

The early signs of the actual presence of uveitis in the sympathising eye are :—some fine punctate deposits on the posterior surface of the cornea, and these are often the first symptom ; slight pericorneal injection ; slight opacity of the aqueous humour ; some discoloration and indistinctness of the iris ; contraction of the pupil, but as yet no synechiæ ; some fine opacities in the vitreous humour ; and slight loss of sight owing to these changes.

Posterior synechiæ soon begin to form, and, in the most serious cases, the adhesions occur, not merely between the margin of the pupil and the anterior capsule of the lens, but, after a little while, between the whole of the posterior surface of the iris and the capsule —total posterior synechia. The exudation which causes this extensive adhesion soon pushes the iris forward—iris bombé—and renders the anterior chamber shallow ; but after a time, when the fibrinous exudation begins to shrink, the anterior chamber becomes deep at its periphery, owing to retraction of the iris. The iris gradually becomes more altered, its tissue more dull, discoloured, and indistinct, while large vessels form in it. Occasionally, in the anterior chamber a small pseudo-hypopyon is seen, formed by the fibrin which floats in the aqueous humour, some of which has gravitated.

The intra-ocular tension may become high, often very high, owing to blocking of the angle of the anterior chamber with inflammatory products, and this glaucomatous tension is apt to be attended by great pain. In consequence of the presence of such extensive adhesions, eserine and pilocarpine have no influence on this high tension, and the temptation to perform an iridectomy is very great.

Yet, it may be stated at once, that no graver mistake can be made in ophthalmic practice than to venture on any operative interference at this period. Far from doing good, an iridectomy is almost certain to do harm. It is impossible, owing to the disorganised state of the iris and its close adherence to the anterior capsule, to obtain anything like a satisfactory coloboma ; and even if the tension be reduced for a day or two after the operation, it soon becomes as high as before, in consequence of the rapid filling up of the coloboma by proliferation of the inflammatory products, while the traumatism of the operation only seems to lend additional violence to the inflammation.

In the further progress of the disease, the cornea gradually becomes more or less opaque, from derangement of its posterior epithelium by the punctate deposits of fibrin upon it, and the crystalline lens becomes cataractous. After a time the high tension disappears, and gradually, owing to shrinking of the vitreous humour, low tension comes on. Vision, already very bad, sinks further. The eyeball becomes smaller and very soft to the touch, and phthisis bulbi, with complete blindness, is presented. This entire process may occupy many months, and is often interrupted by short periods of slight improvement in the symptoms, which raise the hope of patient and surgeon.

In rare cases, the sympathetic uveitis comes on with violent pain, chemosis, and swelling of the eyelids, and ends rapidly in phthisis bulbi.

On the other hand, there is a less severe class of cases, in which total posterior synechia does not form, the pupillary margin alone becoming adherent, and these cases may run a comparatively favourable course.

A yet milder, and not uncommon, form of sympathetic uveitis is that in which the only signs are :—punctate deposits on the posterior surface of the cornea, and increased depth of the anterior chamber, without any iritis. The punctate deposits are often at first so fine as to be undiscoverable, unless by aid of a high convex lens behind the sight-hole of the ophthalmoscope, or with a corneal microscope. This form of sympathetic ophthalmitis is termed serous sympathetic uveitis, and its prognosis is favourable. Its one danger consists in the increased intra-ocular tension which is liable to come on, but which should not tempt the surgeon to employ

an iridectomy, whereby a mild process might be converted into a severe one.

More common than this typical serous uveitis are cases in which some fibrin is thrown out, with resulting posterior synechiæ at the pupillary margin, and where small round yellowish-white deposits may be found with the ophthalmoscope in the chorioid—called sympathetic disseminated chorioiditis—especially towards the periphery of the fundus. In some cases the iris is free from inflammation, the chorioid alone being affected in the manner mentioned. This form of sympathetic ophthalmitis is not attended by much irritation of the eye, nor need vision be much affected. The corneal deposits very gradually increase in number, and consequently, vision becomes affected to some extent, and then, if the tension do not increase, the signs and symptoms after a time very slowly abate, and a normal state is re-established. But relapses are liable to occur even after some months, and they may assume the very dangerous fibrinous type. So that, even in these mildest cases, the utmost care in treatment and prognosis is needed.

3. *The Interval that has elapsed between the Injury to the Exciting Eye, and the Onset of Uveitis in the Sympathising Eye.*—So far as our present knowledge based on reliable cases enables an opinion to be formed, the shortest interval which occurs between the injury to the first eye, and the onset of uveitis in the second eye, is fourteen days, and very few cases with this shortest interval have been reported. The period between the sixth and twelfth week after the injury seems to be the most dangerous. In 170 of the 200 cases collected by the Committee on Sympathetic Ophthalmitis of the Ophthalmological Society the second eye was attacked within the first year after the injury to the exciting eye. In only 12 of the 200 cases was the interval more than one year, and the longest interval was twenty years.

4. *The State of the General System.*—As the subjects of traumatic plastic uveitis in one eye are not immune against plastic uveitis in the other eye due to syphilis, rheumatism, tubercle, diabetes, etc., it is necessary in each case to consider, whether the attack in the second eye may not be a symptom of some systemic condition, rather than a sympathetic uveitis.

From the above it appears, then, that the diagnosis of sympathetic ophthalmitis depends on the following evidence :—(1) As

regards the exciting eye: an ectogenic infection; unless in those rare cases where a chorioidal sarcoma produces the infective substance. (2) As regards the sympathising eye: an inflammatory process of a plastic type, which attacks all three portions of the uveal tract, is very chronic in its course, often improves for a while, but relapses again. (3) As regards the interval between the perforating injury in the first eye, and the appearance of sympathetic ophthalmitis: an interval of at least fourteen days is required. The period between the sixth and twelfth week is the most dangerous, and very few cases occur after the first year. (4) As regards the general system: when careful examination of it does not reveal any condition, which might be the cause of uveitis in the second eye, the probability of this uveitis being sympathetic is increased.

Prognosis.—The prognosis of sympathetic uveitis is, in general, serious; yet it need not be quite hopeless, for even in severe cases very occasionally, and of course more frequently in the less severe cases, the sympathising eye does recover after prolonged treatment, with a useful amount of vision. But in these rare cases which undergo cure, the eyes are liable to occasional recurrences of the uveitis, and at least a year should elapse since the last recurrence, before a definite end to the diseased process can be said to have been reached.

The prognosis of sympathetic papillitis is quite favourable, when once the exciting eye has been removed.

Treatment.—Measures calculated to prevent the onset of sympathetic ophthalmitis are of the first importance. Where the injury is so extensive as to make all prospect of saving sight in the first eye hopeless, immediate excision of that globe is obviously indicated. Where some prospect of saving sight in the injured eye exists, attention is claimed in the first instance by the wound, which, in those cases that come for surgical aid sufficiently early, is to be protected from secondary infection by careful antiseptic cleansing, abscission of any prolapsed portions of the uvea, suturing of the wound in suitable cases, and dressing with bandage.

Should the wound be already infected, excision of the injured eyeball is called for. No temporising is admissible—even some useful vision being, for the time, retained by the injured eye is not a contra-indication to the operation.

Where sight in the injured eye is lost, it will not be difficult for the surgeon to recommend excision of the eyeball, and even to urge

it on the patient; but when some useful sight is still retained, it is not so easy to press this advice, although that should be done. We know, indeed, that in some cases of traumatic uveitis sympathetic uveitis does not supervene; and, provided the first eye be not too much disorganised by the injury, sight in it may ultimately be obtained. But, unfortunately, we are unable to foretell whether any given case will run so favourable a course; and to temporise, in the hope that it will do so, involves serious danger to the second eye, and, it may be, ultimate loss of all sight in each eye.

In short, it cannot be doubted that there are cases in which, in the present state of our knowledge, we recommend removal of the injured eye, and where, had we decided to run a fearful risk by allowing it to remain, not only would sight have been restored to it, but no sympathetic ophthalmitis would have come on.

It must be further stated, that we cannot feel sure that our removal of the first eye has averted sympathetic ophthalmitis from the second eye, until four weeks after the operation has elapsed.

Nearly every ophthalmic surgeon has seen cases in which sympathetic ophthalmitis has appeared subsequently to excision of the first eye, and in which, at the time of the operation, the second eye was perfectly sound. There are well-authenticated cases where sympathetic ophthalmitis appeared as long as four weeks after enucleation of the injured eye. The assumption is that, in these cases, the infective micro-organisms had already gone on their journey to the second eye. These cases are deplorable for the patient, and very trying for the surgeon, especially if the outbreak of sympathetic ophthalmitis should occur very soon after—perhaps the day after—the operation. Yet, where sympathetic ophthalmitis comes on after excision of the first eye, the operation need not be regarded as having been quite useless; for experience shows that the attack of uveitis in the second eye is then usually of a comparatively mild type, and fairly amenable to treatment.

In those cases in which the exciting eye has not yet been removed, and in which sympathetic ophthalmitis in the second eye has commenced, what are our duties? In the first instance, and at the earliest possible moment, the exciting eye should be removed, *always provided that it be quite and hopelessly blind.* The immediate result on the second eye of removal of the first eye under these conditions is not marked, for the inflammatory process in the former seems to

proceed as actively as before. But statistics show that more sympathising eyes are saved, or partially saved, when the injured eye has been removed soon after the outbreak of sympathetic ophthalmitis, than when the injured eye is removed a considerable time after the outbreak, or not at all. Presumably when the source of supply of the infection is withdrawn, the virulence of the sympathetic disease gradually subsides.

But *no exciting eye, which possesses even a slight degree of sight, should be removed when once sympathetic ophthalmitis has appeared.* For it may well happen, that the sympathising eye becomes entirely lost, while the exciting eye ultimately retains some degree of useful sight. Great caution is therefore required in deciding whether the exciting eye be capable of recovering to a certain extent, and this frequently is a matter of considerable difficulty. Even a partially phthisical eyeball may sometimes ultimately come round sufficiently to gain useful vision. Schirmer lays down the following rule:—When sympathetic ophthalmitis has broken out, the exciting eye should not be removed, unless it be absolutely blind ; or unless—if it still possess merely perception of light—it has been for several weeks very soft, and reduced in size ; or that, by reason of extensive corneal opacity, all hope of restoration of form-vision must be abandoned.

If sympathetic ophthalmitis have broken out, either before or after removal of the exciting eye, the treatment and care of the sympathising eye to promote its recovery must be considered. This consists in the use of atropine, warm fomentations, and sub-conjunctival saline injections (chap. x.), which latter are held by some to be very beneficial when high tension is present. With these local means is combined a general and prolonged course of mercurialisation—mercurial inunctions or calomel internally, or both, care being taken to avoid any severe stomatitis. Salicylate of soda is now used in large doses (as much as one hundred and fifty grains in the day) by some surgeons. The patient is to be confined in one warm but well-ventilated room, which should be kept almost dark. As this treatment must often be continued for many weeks or even months, it is trying for the patient ; but it is to be remembered that the issue at stake is a fateful one.

No operation on the iris is to be performed so long as there is the slightest inflammation, or tendency to inflammation ; and this rule holds good, even if the tension of the eye become glaucomatous.

Premature operative interference has only the effect of lighting up fresh inflammation; and, even if the tension be reduced by an iridectomy—which latter, owing to the diseased and degenerated state of the iris and the inflammatory exudation behind it, cannot be satisfactorily carried out—it will soon again become high. In six months or a year after every slight sign of inflammation, or tendency to inflammation—of which injection of the ciliary vessels on insertion of a spring speculum is not a bad criterion—has passed away, and a longer interval can only be of advantage, it may be allowable to perform an operation with the object of making an artificial pupil, always provided that there is good prospect of materially improving vision by this means. It must be remembered that, while every operation has its risks, the risks are unusually great in such disorganised eyes; and that any loss of sight is felt all the more in a case in which the eye operated on is probably the only one possessing even a little vision. On the other hand, when success crowns an operation in these sad and perplexing cases, the gain is great.

If it be decided not to remove the exciting eye, after sympathetic ophthalmitis has broken out, then the inflammatory process in it is treated on lines quite similar to those above recommended for the sympathising eye, and the advice as regards operations is the same.

Prophylactic Operations used for Sympathetic Ophthalmitis, performed on the exciting eye.

Enucleation (or Excision).—Of prophylactic operations for sympathetic ophthalmitis, enucleation of the first eye is the only one which is regarded by all ophthalmic surgeons as thoroughly reliable, when it is performed in time.

The speculum having been inserted, an incision is made in the conjunctiva all round the cornea, and about 6 mm. removed from the latter. The bulbar conjunctiva is separated from the globe freely in all directions with scissors. With a strabismus hook each orbital muscle is caught up, and its tendon divided close to the sclerotic. The eyeball is then made to start forward by pressure of the speculum backwards, or the eye is seized by the stump of the external rectus tendon and drawn forwards and inwards. The optic nerve is then divided with strong scissors passed into the orbit, either from the median or from the temporal side, as far back in the orbit as possible. Finally the edges of the conjunctiva are drawn together with a few points of suture.

Careful aseptic and antiseptic precautions are to be employed in connection with enucleation of the globe. Of these, next to thorough sterilisation of the instruments, irrigation of the cavity of the orbit as soon as the eyeball is removed, with a full stream of sublimate solution, 1 in 5000, or of sterilised normal salt solution is the most important. After the sutures have been applied, the interior of the orbit is well covered with xeroform, or other fine antiseptic powder, and an aseptic dressing is applied with a bandage. The orbit should be similarly dressed every twenty-four hours.

Some cases of meningitis following upon the operation, and which have proved fatal, are reported. There can be no reasonable doubt but that, in these instances, septic matter made its way along the lymphatics of the optic nerve to the meninges, and that this septic matter was introduced upon the instruments, or escaped, in purulent cases, from the interior of the eyeball. Hence the very great importance of the careful aseptic precautions above indicated.

An artificial eye (prothesis oculi) can usually be inserted after a fortnight, but should not be constantly worn for a month at least, because it is liable to cause irritation and conjunctivitis until that time has elapsed.

* *Evisceration.*—For mode of performing this operation *vide* p. 151. Evisceration is not held to be so good a safeguard against sympathetic ophthalmitis as excision, and is not employed for that purpose, unless quite soon after the injury. The advantage of evisceration over enucleation lies in the better stump provided by it for a prothesis, and the consequent better cosmetic effect.

* *Mules' Operation.*—For the description of this operation see p. 152. The objections to and advantages of this operation are the same as in evisceration, but it gives a better stump than the latter.

Therapeutic Operations used in Sympathetic Ophthalmitis.—The field for these operations, if it exist at all, is exceedingly limited. Practically the only indication for operative interference, in the active period of sympathetic ophthalmitis, is long-continued high tension; and in the foregoing pages the warning has been repeatedly uttered, that any operative meddling with the iris in this period is more apt to aggravate the process than to alleviate it; and that, even if tension be relieved by an iridectomy, it soon becomes high again, owing to fresh plastic exudation.

Should it seem imperatively necessary to endeavour to reduce

a long-continued high tension, sclerotomy is to be preferred to iridectomy. It may have a beneficial effect, and is not likely to do harm. It can be repeated more than once, should it be deemed necessary.

Paracentesis of the cornea is a measure which can be used as a temporary means of relief for high tension, and it, too, may be repeated.

* **Optical Operations used in Sympathetic Ophthalmitis.**—The object of these operations is to provide an artificial pupil in the sympathising eye after all inflammation, or tendency to it, has ceased, in order to improve, or to restore, vision which is interfered with by closure of the pupil. Similar operations may be indicated occasionally in the exciting eye, in cases where it has not been excised.

The cardinal point to be borne in mind, it may again be stated, is, that these operations must never be performed until six months at least have elapsed—and a longer period is preferable—after all and every tendency to inflammation, or irritation, has subsided. Inattention to this rule will result in a re-lighting of the inflammation, re-closure of the pupil which may have been made, or intra-ocular hæmorrhage, and a long period of waiting before any further operation can be undertaken ; or else the globes may become shrunken, and all hope may be at an end.

Moreover, as, even under the most favourable conditions, and with the most skilful operation, inflammation may return, or intra-ocular hæmorrhage may occur, or the eye may become phthisical, no operation should be done unless the advantage to be gained from it, if successful, promises to be considerable.

The three chief operations, one or other of which may be applicable, are :—Iridectomy, extraction of the clear or cataractous lens—for the lens is often cataractous from interference with its nutrition by reason of the irido-cyclitis—or, discission of the cataractous lens.

Iridectomy.—It is only exceptionally that iridectomy can be of use, in those eyes which have been the subjects of the severer plastic uveitis, resulting in total posterior synechia. In these cases, the tissue of the iris has undergone such extreme degeneration, that it is impossible to obtain more than mere shreds of the membrane with the forceps, so that a satisfactory coloboma can rarely be made. Or, if a fairly good coloboma be procured, it will probably be found that

the pigmentary layer of the iris is left behind ; and that this, with organised inflammatory products, lies on the anterior capsule, and obviates any gain that might have been derived from the coloboma.

Iridectomy is indicated in those cases rather, where a less severe form of iritis has existed, resulting in a complete ring synechia of the pupillary margin only. Here a wide coloboma may often be made satisfactorily. The iris should be seized with the forceps at about the lesser circle. If seized at the pupillary margin, the intimate adhesion between the latter and the lens capsule may cause injury to the capsule, and consequent traumatic cataract.

Extraction of the Lens.—This is indicated, if, on the formation of a coloboma, the lens be found to be cataractous, in those cases of ring synechia where iridectomy has been performed and the coloboma has closed again ; and in practically all cases of total posterior synechia, be the lens clear or opaque. In the former class of cases the ordinary combined method of cataract extraction answers the purpose, or a preliminary iridectomy may be made some weeks previously.

Cases of total posterior synechia require a procedure, such as one or other of the following :—

Wenzel's Method.—The puncture, counter puncture, and incision are the same as in an ordinary cataract extraction, but the knife on entering is passed through cornea, iris, lens, iris, cornea. The lens is thus delivered as completely as possible, and out of the membrane composed of degenerated iris, retro-iridic connective tissue, and capsule, a V-shaped piece is cut with the forceps-scissors. The traumatism of this operation is great, and not every globe will bear it, and phthisis bulbi may follow.

Hirschberg's Method.—An incision is made with a keratome in the lower margin of the cornea. With a fine capsule forceps, introduced into the pupil, the thickened anterior capsule is seized and drawn away and, by inserting a spatula, as much of the lens as possible is extracted. Some weeks later the pupillary membrane, composed of lenticular remains, posterior capsule, and inflammatory products, is divided with a cystotome. The advantage of this operation is that the iris is not interfered with.

Discission.—This operation was employed by the late Mr. George Critchett with success, in some cases where cataract was the main obstruction to sight. A discission needle is passed, by a boring

motion, through the lenticular capsule ; another needle is then passed in close to the first, and by separating one point from the other a rent is made. This is followed generally by the escape into the anterior chamber of a small quantity of cheesy lens matter, which becomes gradually absorbed, and in the course of some weeks the capsule closes again. The operation has to be repeated several times before a clear pupil is obtained, care being taken that all irritation from the previous operation has subsided before another be undertaken. The chief danger in this operation is irritation and high tension, from swelling of the lenticular masses in the disorganised eye. Ziegler's method too can be used in these cases with advantage (chap. ix.).

Pathogenesis.—The pathogenesis of sympathetic ophthalmitis is obscure. There are two theories, each depending on infection by a specific micro-organism introduced into the exciting eye at the time of the injury, and which passes from it to the sympathising eye ; but differing from each other in respect of the path by which they would make the micro-organism pass from the first to the second eye.

According to one theory the path is by the lymphatics of the optic nerve of the exciting eye, or its sheaths, then by the optic commissure, and optic nerve of the sympathising eye—in short, by direct continuity, as erysipelas extends over the skin. According to the other theory—which recent investigations seem to render the more probable of the two—micro-organisms enter the blood-vessels of the first eye, and are carried by the blood-stream through the body, but are pathogenetic only for the uveal tract of the second eye.

A third theory assumes the presence of the specific organism in the blood of some people. A perforating injury, or an intra-ocular sarcoma, in the eye of such a person gives rise to a state of the chorioid favourable to the development of the organism and in such a degree of virulence that, when it reaches the healthy chorioid of the second eye through the circulation, it sets up sympathetic ophthalmitis.

Pathology.—Hitherto the specific micro-organism of sympathetic ophthalmitis has evaded detection by every method. The inflammatory products, both in the exciting and in the sympathising eye, are of twofold nature :—1. A tough organised connective tissue containing few nuclei, which is developed on the surfaces of the iris,

ciliary body, and retina. 2. An infiltration of the stroma of the uveal tract with lymphocytes, epithelioid cells, and giant cells (Fuchs). This second product of inflammation is held by Fuchs to be the result of infection by the specific micro-organism which causes sympathetic ophthalmitis, while he regards the connective tissue development (endophthalmitis) as an accidental complication due to infection by simultaneous entrance into the injured eye of another micro-organism. The clinical appearances and symptoms are due as much to the one as to the other product, and it cannot be known clinically in any given case whether the essential product of the specific micro-organism be present in the first eye.

Injuries of the Uveal Tract.

Injuries of the Iris.—*Punctured Wounds* of the cornea, or of the corneo-scleral margin, frequently implicate the iris, but rarely do so without also injuring the crystalline lens or ciliary body, on which then the chief interest centres, as being the organs from which serious reaction is most likely to emanate. A small simple incised wound of the iris is not of great importance, for inflammatory reaction is not common, and any extravasation of blood at the seat of the iris wound, or into the anterior chamber (hyphæma) becomes absorbed, while, in most cases, the functions of the iris will probably not be affected, nor sight endangered. Nevertheless, as iritis does sometimes occur, it is desirable to use measures calculated to prevent it, such as atropine, a dressing, and rest of the eye and general system. Even extensive wounds of the iris are not often, as such, associated with serious danger to the eye, although the loss of continuity in the iris never closes up. Where, for instance, the iris is cut in its entire width from ciliary margin to pupillary margin, the permanent result is a wide coloboma, the margins of which may be adherent to the corneal wound. When the iris is prolapsed in the corneal wound, every effort should be made to reduce it completely; and, if this cannot be effected, it is necessary to abscise the prolapsed portion. Incarceration of the iris in the corneal cicatrix may lead to secondary glaucoma, cystoid cicatrix, secondary septic infection of the iris, etc.

Foreign Bodies of small size, such as bits of steel or iron, may perforate the cornea and fasten in the iris, the puncture in the cornea closing rapidly, and possibly no aqueous humour being lost.

It is necessary always to remove such a foreign body without delay, although for some time it may cause no reaction. An incision should be made with a Græfe's knife at the margin of the cornea corresponding with the position of the foreign body, and the portion of iris containing the foreign body is then removed with forceps and scissors.

Blows on the Eye are apt to cause, in addition to hæmorrhage into the anterior chamber from the iris or from the canal of Schlemm, one of several remarkable lesions of the iris, namely :—

1. *Iridodialysis*[1]—*i.e.* separation of the iris from its attachment to the ciliary body. This is usually accompanied by considerable hyphæma. As much as one-half of the circumference of the iris may be involved in the lesion ; or, the latter may be so small as to be diagnosed only by the presence of the resulting small fresh hæmorrhage near the ciliary margin of the iris ; or, after this has become absorbed, by aid of light transmitted to the eye by the ophthalmoscope, when not alone the physiological pupil, but also the minute marginal traumatic pupil will be illuminated. It is rarely that there is more than one dialysis. In certain degrees of the detachment, by reason of the sphincter of the iris having lost its fixed point, it becomes stretched in a straight line (Fig. 61) at the part corresponding with the dialysis, and assumes a D shape ; or, if the detachment be more extensive, the pupil becomes kidney-shaped ; or the detached portion may entirely cover the pupil. The detached portion, too, may be turned on itself (anteflexion of the iris), the uveal surface being to the front. The functions of the eye after such an injury, even when extensive, are sometimes but little disturbed, or there may be monocular diplopia.

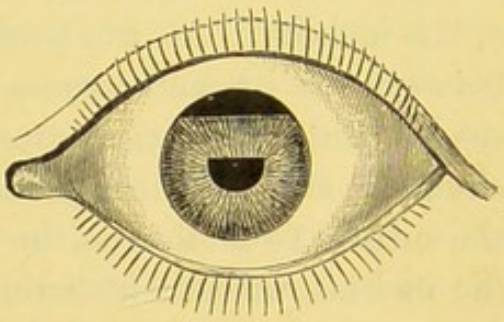


FIG. 61.

It is stated that iridodialysis does not become re-attached ; but a case has come under the notice of one of us in which a very minute iridodialysis was healed, and another such case is recorded. The lengthened use of atropine in the mass promotes such a result, but

[1] ἶρις, διάλυσις, *a separating*.

it can only be hoped for if the iridodialysis be not extensive, and if the case be seen early.

An operation for the remedy of iridodialysis has been proposed and successfully performed by Chalmers Jameson as follows :— If the dialysis be of some extent, two needles each carrying a suture of fine silk-worm gut are used. The first needle is passed through the corneo-scleral margin 2 mm. from the limbus, into the anterior chamber, under and through the torn iris-margin, of which less than 1 mm. is taken up, and through the cornea. The needle is liberated from the suture. The second needle is similarly introduced at a convenient distance from the first, according to the dimension of the dialysis. An incision is then made in the corneo-scleral margin in a straight line between the points of entrance of the sutures, leaving a short bridge of scleral tissue between those points, and the ends of the incision. An iris hook is passed into the anterior chamber between the iris and cornea, and the sutures are in turn carefully snared, the corneal ends drawn out of the cornea into the anterior chamber, and out through the corneo-scleral incision, thus enabling the sutures to be tied on the bridges of scleral tissue at each end of the incision without including the cornea. The sutures when tied bring the torn surface of the iris in contact with the inside of the linear incision, but not between its lips, and re-attachment of the iris by agglutination of the corneo-scleral wound is thus accomplished. Where the dialysis is of moderate dimension, one suture only is needed ; but where two are required, they should both be introduced into the iris before either is tied.

Iridodialysis does not increase in extent in the course of time, nor lead to further mischief in the eye.

* 2. *Retroflexion of the Iris.*—From a blow on the eye, the whole, or more commonly a portion, of the iris in its entire width can be folded back on the ciliary processes, giving the appearance of a very dilated pupil, or of a coloboma produced by a wide and peripheral iridectomy. In a true coloboma the ciliary processes would be easily seen, but not so in retroflexion, for the processes, being covered by the retroflexed iris, present a smooth surface. A slight dislocation of the lens in the direction away from the iris lesion is often observed. Retroflexion of the iris cannot be cured, but useful vision is retained, if the injury be uncomplicated.

* 3. *Rupture of the Sphincter Iridis.*—There are not many cases

of this lesion recorded. There may be but one rupture, or there may be a number of small ruptures distributed round the pupil. They show themselves as small triangular gaps in the pupillary margin, their bases directed towards the latter. This condition is also incurable, and some permanent disturbance of vision due to the mydriasis results.

* 4. *Dehiscence of the Iris* between the pupillary and ciliary margins. This is a slit-like rupture of the iris, which runs in a radial direction through the whole width of the iris, with the exception of the sphincter. The diagnosis sometimes cannot be made with certainty until, after a few days, the blood-clot covering the dehiscence is absorbed. The opening may be caused to close by the use of a myotic, which, by contracting the sphincter, brings the edges of the dehiscence together.

* 5. *Traumatic Aniridia.*—The whole iris is torn from its ciliary insertion, and may be found lying in the anterior chamber or under the conjunctiva, having in the latter case passed through a rent at the corneo-scleral margin. Not only does the anterior chamber contain blood, but the vitreous humour is often infiltrated with hæmorrhage. When the extravasated blood has become sufficiently absorbed, the absence of the iris will be noted, and in many instances the ciliary processes will be visible. If these latter are visible, the diagnosis 'aniridia' can be definitely made, but cases do occur in which, notwithstanding the absence of the iris, the ciliary processes are not visible, owing probably to changes in them which cause them to shrink. Such cases then are difficult to distinguish from retroflexion of the iris, but the importance of the diagnosis is not great.

6. *Traumatic Mydriasis, and Myosis.*—Of these, mydriasis is the more common. The dilatation is of medium degree, and the pupil is usually of irregular shape—oval, pear-shaped, or more dilated at one part than elsewhere—and contracts but slightly, or not at all, to light. Paralysis of accommodation usually accompanies traumatic paralysis of the sphincter iridis. The mydriasis is probably the result of concussion of the delicate nerve-endings in the sphincter of the iris. (See above, under Rupture of the Sphincter Iridis.) Traumatic mydriasis may recover after a long interval, but in most instances it remains as a permanent defect, with some derangement of vision due to it and to the paralysis of accommodation.

With traumatic myosis there is apt to be spasm of accommodation, which may produce apparent myopia. The prognosis is fairly good.

Treatment.—For mydriasis, protection spectacles, galvanism, and eserine. For myosis, atropine.

Injuries of the Ciliary Body.—*Punctured Wounds, and Foreign Bodies* perforating the sclerotic at a distance of about 5 mm. around the cornea, are almost certain to implicate the ciliary body. If there be no prolapse of the ciliary body, nor any foreign body in the interior of the eye, the sclerotic wound may heal by aid of a bandage without further ill results. If a prolapse of the ciliary body or iris be present, it is to be abscised, with careful antiseptic measures; and if the sclerotic wound be large, it may be thought desirable to unite its margins with sutures.

Wounds of the ciliary body are apt to cause cyclitis, especially if the former be incarcerated in the sclerotic wound in healing, for the incarcerated portion is liable to become infected.

* **Injuries of the Chorioid.** *Small Foreign Bodies* may pierce the sclerotic, or the cornea and lens, and may lodge in the chorioid, and, if favourably situated, can then be detected with the ophthalmoscope, and always by the Röntgen rays if of metal (chap. x.). These foreign bodies require operative removal by the magnet, if of steel or iron (chap. x.); or, if the foreign body cannot be extracted, the eyeball must be removed, to avert sympathetic ophthalmitis.

Incised Wounds of the sclerotic very frequently involve the chorioid (p. 174).

Rupture of the Chorioid near the posterior pole of the eye is often produced by blows on the eye, and is seen with the ophthalmoscope as a whitish-yellow (the colour of the sclerotic) crescent some two or three papilla-diameters in length, and about one papilla-diameter distant from the optic entrance, the concavity of the crescent being directed towards the latter. Immediately after the accident, extravasated blood sometimes prevents a view of the rupture. Some chorioiditis may result; but, when this passes away, good vision is frequently restored and maintained, provided detachment of the retina does not ultimately supervene from cicatricial contraction at the seat of the rupture. On the other hand, a scotoma in the field may be produced, and if the rupture be in the region of the macula lutea, serious loss of sight may be caused.

Treatment.—Careful protection of the eye, and abstinence from use of it, with dry cupping at the temple for three weeks, or until it may be assumed that all inflammatory tendency has subsided.

Blows upon the eye may cause *Extravasation of Blood in the Chorioid.* If small, these extravasations do not extend beyond the chorioid. But, in the case of copious extravasation, the hæmorrhage is poured out from the chorioidal vessels between that coat and the sclerotic, lifting and bulging forward the chorioid ; or between the chorioid and retina, giving rise to a detachment of the latter ; and if the retina give way, the blood is poured out into the vitreous humour. Should there be no vitreous humour opacity, the extravasations in the chorioid can be seen with the ophthalmoscope as somewhat indistinct (owing to resulting opacity in the overlying retina) small red spots, or large round red spots, darker in the centre than at the margin. That these hæmorrhages are in the chorioid can be recognised from the fact that they lie behind the retinal vessels. The hæmorrhages become slowly absorbed, and after a time, provided they have not ruptured the retina, useful vision may be restored.

Treatment.—Complete rest in bed. Atropine. Bandage.

New Growths of the Uveal Tract.

* **New Growths of the Iris.**—*Cysts of the Iris.* Also known as *Cysts of the Anterior Chamber.*—These vary from a very small size to that which would fill the anterior chamber. They may have either serous or solid contents. The serous form is occasionally congenital, but in the majority of cases the cyst originates in epithelial cells from the cornea, epidermis, etc., which are implanted in the iris on the occasion of a penetrating wound. The cysts with solid contents (epidermoid elements) usually have their origin in an eyelash which has entered the anterior chamber by occasion of a perforating corneal wound. All these cysts are sources of serious danger to the eye (irido-chorioiditis, glaucoma, etc.), and, it has been stated, may even be the cause of sympathetic ophthalmitis, and hence their removal is called for. This can be effected without much difficulty if the tumour be small, but if it have attained a large size, and become adherent to the posterior surface of the cornea, the attempt is often unsuccessful. A long incision should be made

in the corneo-scleral margin, and the cyst, along with the portion of iris to which it is attached, drawn out and cut off.

Granuloma is the name given to a benign neoplasm of the iris, of which the structure resembles granulation tissue. Clinically it is a small pale tumour, or there may be several such tumours, which gradually grow to fill the anterior chamber, rupture the cornea, and finally induce phthisis bulbi. It is held by some that these growths depend on a syphilitic taint, and by others that they are tubercular.

Solitary Tubercle.—Solitary tubercle may be accompanied by a few smaller growths, but it generally begins as a single yellowish-white tumour, often without iritis, which gradually increases in size until it may fill the anterior chamber. It finally involves the cornea, which it perforates, forming a fungating mass, and this subsequently breaks down, leaving only a small shrunken globe in the socket.

Treatment.—Tuberculin in the early stages; and, if perforation should take place, excision of the eyeball.

Sarcoma.—The iris is that portion of the uveal tract which is most rarely affected with primary sarcoma. It arises usually from a congenital pigmented nævus of the iris, and is commonly a melano-sarcoma; but leuco-sarcoma has also been recorded. As the tumour increases in size, it fills the anterior chamber, and grows backwards into the ciliary body and into the canal of Schlemm. It is not usual for the tumour to become extra-ocular by growing through at the corneo-scleral margin, as does tubercle of the iris. Irritation or inflammatory symptoms are not often present; and secondary glaucoma does not come on until a late stage, when the growth has filled the anterior chamber, or involved the ciliary body extensively.

Treatment.—Enucleation of the eye should be advised as soon as the diagnosis of sarcoma of the iris has been made. There is naturally a desire on the part of the surgeon, when the tumour is small, to save the eye, which probably has full vision, by excising the portion of iris in which the growth is seated, and there are some cases on record in which this was done, and where no recurrence of the tumour took place. But in adopting this conservative method there is serious danger; for it is not possible to determine clinically whether the sarcomatous growth is truly, or only apparently, confined to the limited region of the iris, where it can be seen. Even

in the early stages of many cases of sarcoma of the iris, the neoplasm invades the ligamentum pectinatum, the canal of Schlemm (Plate IV. Fig. 5), or the ciliary body; so that, although the iris tumour be thoroughly removed, the growth reappears in the eye before long, while in the meantime risk of infection of the general system has been run.

Carcinoma.—A few cases of metastatic carcinoma of the iris and ciliary body are on record, with the breast as the primary seat of disease.

Ophthalmia Nodosa.—See p. 84.

***New Growths of the Ciliary Body.**—*Sarcoma* of the ciliary body is generally pigmented, and often passes unobserved, until it attains considerable size as a brown mass, which was at first concealed from view by the iris. Occasionally it is first noticed when it makes its appearance at the angle of the anterior chamber. It usually also grows backwards into the chorioid, and runs the same course as sarcoma of the chorioid, but in rare cases extends round the whole ciliary region (ring sarcoma) (Plate IV. Fig. 5). Removal of the eyeball should be urged, but is often for a time declined by the patient, as sight is but slightly affected in the early stages.

Myosarcoma originating in the ciliary muscle has been observed a few times.

Carcinoma.—Secondary carcinoma may occur in the ciliary body as in the iris and the chorioid, but is very rare.

***New Growths of the Chorioid.**—*Sarcoma* is by far the most common neoplasm of the chorioid, and the chorioid is the most common seat of ocular sarcoma. It is seen at all times of life, but most frequently between the ages of forty and sixty. Both melano-sarcoma and leuco-sarcoma occur, and may originate in any part of the chorioid.

If seen in a very early stage, it is easily recognised from its projecting over the general surface of the fundus, the retina lying closely applied to it; but, unless it be in the region of the macula lutea, it may not cause any serious disturbance of vision, and hence may not at that period be brought under the notice of the surgeon. The diagnosis from detachment of the chorioid at this stage is made by the presence in the latter condition of the characteristic chorioidal vessels, and by the peculiar colour of the

chorioid. Detachment of the chorioid, too, is much rarer than sarcoma.

The new growth soon gives rise to detachment of the retina, by reason of serous exudation from the chorioid; and this may be accompanied by opacity in the vitreous humour, which contributes in rendering the diagnosis with the ophthalmoscope difficult or impossible. If the detachment be shallow and the retina translucent, the tumour may still sometimes be seen through the sub-retinal fluid by aid of strong illumination; and even direct sunlight may be employed in some such cases. Often the detachment commences at a part of the fundus not immediately over the tumour, but some distance removed from it. Owing to the great, and often sudden, defect of vision which comes on in this stage, we very commonly see these cases now for the first time. The history of the case may aid us; while the absence of the more usual causes of detachment of the retina should make us suspicious of an intra-ocular tumour, and the fundus should be carefully examined, with dilated pupil, in all such cases.

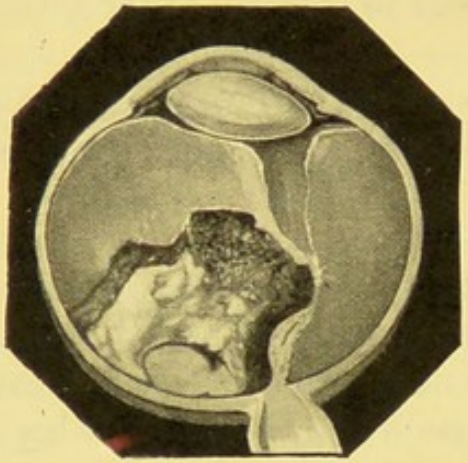


FIG. 62.—Chorioidal sarcoma springing from posterior pole of fundus. Complete detachment of retina. Lens pushed forwards. Iris pressed against posterior surface of cornea. As yet no cupping of the disc.

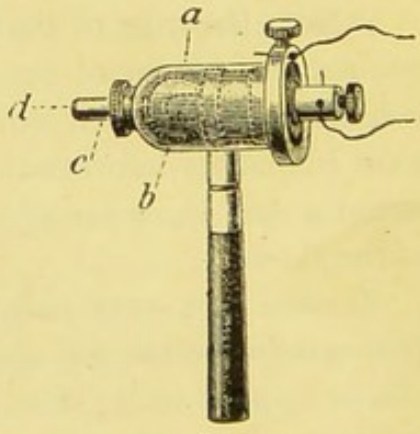


FIG. 63.

At this and at later stages, Leber's, or other, Sclerotic Trans-illuminator (Fig. 63, $\frac{1}{3}$ size) is a valuable diagnostic aid. It consists of a small electric lamp (*b*), which requires a current of eight to ten volts, enclosed in a metal jacket (*a*). The anterior end of the lamp is in contact with a short glass rod (*c*) covered with a hard rubber sheath. The light of the lamp is transmitted along the glass rod,

and the exposed end (*d*) of the latter is placed on the sclerotic of the cocainised eye, in a dark room. Then, if the eye be normal, or even if a ripe cataract be present, the pupil lights up with the familiar red glow from the chorioid. But if, internal to the spot at which the glass rod is applied, a new growth be present, the pupil does not light up—it remains dark. By slipping the rod over the whole of the suspected region, or as much of it as can be reached, or, indeed, over the whole exposed sclerotic, it can be ascertained whether an intra-ocular growth be present. The only limitation to the method is in those cases where the tumour is situated much behind the equator, a region in which the rod cannot be brought in contact with the sclerotic. The brightness of the red reflex in the pupil depends very much on the incidence of the rays passing through the sclerotic, and the brightest reflex is obtained in the normal eye when the glass rod is placed at about the equator of the eyeball. The observer should look at the pupil from the direction of the patient's gaze, whether this be straight forward or to one side. Non-pigmented tumours do not interfere with illumination of the pupil; nor do opacities in the cornea, or lens, nor even a ripe senile cataract. Inflammatory opacities in the vitreous humour do not interfere with the pupil-glow, but an intra-ocular hæmorrhage even of slight amount does so.

Soon the intra-ocular tension increases. This makes the diagnosis again more easy in many cases, for the combination of detached retina and increased tension exists only with intra-ocular tumours. The increased tension may come on very slowly, and without ciliary neuralgia; or more rapidly, and with all the signs and symptoms of acute glaucoma. Yet, if the case come under observation now for the first time, the diagnosis may be by no means easy, should the refracting media be opaque (as always in acute glaucoma), and consequently the detachment of the retina concealed from view. Here, again, the history of the case is all we have to depend on, especially the fact of the patient having noticed a defect at one side of his field of vision previous to the onset of glaucoma.

In the next stage of the growth it perforates the cornea or sclerotic, and, increasing rapidly in size, although still covered with conjunctiva, it pushes the eyeball to one side, the upper lid being stretched tightly over the whole. On raising the lid the tumour is seen as a bluish-grey mass with irregular surface. The conjunctiva

is now soon perforated, and the surface of the tumour becomes ulcerated, with a foul-smelling discharge and occasional hæmorrhages. The tumour gradually invades the surrounding skin and the bones of the orbit, and by extending through the sphenoidal fissure and optic foramen reaches the base of the brain.

Another, and less common, course of chorioidal sarcoma, is that in which, without first perforating the cornea or sclerotic, the tumour sets up irido-cyclitis, leading to phthisis bulbi. Cases in which sarcoma of the chorioid was found in shrunken eyeballs have given rise to the view that such eyeballs are prone to develop sarcoma. While it is possible that sarcoma may develop in a shrunken eyeball, it is tolerably certain that, in the majority of the cases in which both diseases are present, the sarcoma has been the primary disease, and has undergone regressive metamorphosis. An apparent cure is thus produced, but in cases in which the opportunity of sufficiently prolonged observation has been afforded, the growth has again become progressive. (See also glioma of the retina, chap. xi.)

Sarcoma of the chorioid occasionally gives rise to sympathetic ophthalmitis (pp. 204, 215).

It is usually upon the neighbouring tissues of the eyeball becoming involved that secondary growths begin to form in other organs, the one most prone to be affected being the liver. The lungs, stomach, peritoneum, spleen, and kidneys may all be attacked.

Chorioidal sarcoma is almost always primary, but it has been seen a few times as a metastatic disease.

Carcinoma.—This is extremely rare, and the cases of it on record, as in the iris and ciliary body (p. 223), were all of metastatic origin, the primary disease being in the breast. It is not possible to distinguish chorioidal sarcoma from chorioidal carcinoma by the ophthalmoscope.

Tubercle is sometimes seen in cases of acute miliary tuberculosis as round, slightly prominent, pale yellowish spots, of sizes varying from 0·5 to 2·5 mm. in diameter, situated always in the neighbourhood of the optic papilla and macula lutea, and unaccompanied by pigmentary or other chorioidal changes. There may be but one of these foci, or there may be many of them. When they occur, it is, as a rule, in a late stage of the general disease, but they have occasionally been noted long before its appearance. In obscure cases of the general disease, the ophthalmoscope has sometimes

rendered valuable diagnostic aid by revealing these minute growths in the chorioid.

Very rarely does a tubercular tumour grow in the chorioid in cases of general chronic tuberculosis, attaining to a large size, and destroying the eye similarly as does sarcoma or carcinoma.

In young children it may be impossible to diagnose between a tubercular tumour of the chorioid and a glioma of the retina (chap. xi.). Yet, as in either case enucleation is indicated, the diagnosis is not of great clinical importance.

Other, but rare, forms of tumour of the chorioid are :—

Sarcoma Carcinomatosum, *Osteo-Sarcoma*, and *Lymphoma*.

Treatment.—So long as, in cases of sarcoma and carcinoma, the tumour is wholly intra-ocular, enucleation of the eyeball should be performed, and may be done with fair hopes of saving the patient's life, if the disease be primary. When the orbital tissues have become involved, extirpation of all the contents of the orbit, and even, if necessary, removal of portions of its bony walls, ought to be undertaken, should the general health permit, in order to rid the patient of his loathsome disease ; although the probable presence of secondary growths elsewhere renders but slight the prospect of saving the patient's life.

Cases of miliary chorioidal tubercle do not call for direct treatment.

In cases of tubercular tumour, the question of removal of the eyeball must depend upon the general state of the patient ; but, if it seem probable that life will be prolonged until after the ocular growth would have become extra-ocular, removal of the eye should be recommended.

* **Other Diseases of the Chorioid.**—*Posterior Sclero-Chorioiditis, or Posterior Staphyloma.*—This condition will be described in connection with myopia (chap. xv.), which is its almost constant cause.

Detachment of the Chorioid.—As the result of copious loss of vitreous, during operations, or from injury, detachment of the chorioid is not uncommon, but it does not require to be specially diagnosed in these instances, and therefore it is not important to consider it further here.

Idiopathic detachment of the chorioid is extremely rare. Its ophthalmoscopic appearances are apt to be taken at first sight for

a simple detachment of the retina, or for leuco-sarcoma ; but, on closer inspection, the chorioidal stroma is observed to lie immediately behind the detached retina, and its vessels, etc., are seen in the upright image by aid of the same lens as are the retinal vessels. The chorioid is not everywhere detached, but is separated from the sclerotic in several different places, and these detachments are seen in the form of apparently solid hemispherical protuberances rising abruptly from the fundus into the vitreous humour. In other places the chorioid is in contact with the sclerotic, although in some of these positions there may be detachment of the retina alone. The vitreous humour is more or less opaque. Vision is greatly lowered or quite destroyed.

It is probable that a chronic chorioido-retinitis has been an antecedent condition in all of these cases. Indeed, signs of old retinitis are often present, such as perivasculitis and connective tissue striation ; and in one case retinitis was actually observed long before the detachment of the chorioid came on. Adhesions between the chorioid and sclerotic are formed in consequence of this inflammation ; and then inflammatory exudation takes place behind the chorioid, and separates it from the sclerotic, where it is not adherent to the latter.

The process ends either in phthisis bulbi, in consequence of vascular changes and disturbances of nutrition, or in cure to a certain degree, in so far as by absorption of some of the exudation, and by alteration of the remainder of it into connective tissue, a return of the chorioid and retina to their normal position is rendered possible ; but even then restoration of sight, with tissues so disorganised, cannot be looked for.

Treatment hitherto seems to have been of no avail. Probably active mercurialisation might afford the best chance of doing good, should a case come under notice.

Fuchs has pointed out that detachment of the chorioid occurs in a good many cases of cataract extraction some days after the operation, although there has been no loss of vitreous, and also in some cases of iridectomy. It can often be found with the ophthalmoscope, and even sometimes with the oblique illumination, in those cases of cataract extraction in which the anterior chamber has not formed, or in which, having formed, it has become empty again. It is mainly after iridectomy for chronic simple glaucoma

that chorioidal detachment has been noticed. The probable explanation is, that a slight aperture of communication has been made between the anterior chamber and the sub-chorioidal space, through which the aqueous humour passes behind the chorioid. With the re-establishment of the anterior chamber, the chorioidal detachment goes back, and the prognosis is in all cases good as regards vision.

* *Central Senile Areolar Atrophy of the Chorioid.*—This is not a very rare disease and presents the appearance of a white patch, often of considerable extent, at and around the macular region. In some cases a hæmorrhage in the chorioid and posterior layers of the retina forms the starting-point of the disease. The retinal functions always suffer much; for an absolute central scotoma is produced, which renders reading and writing impossible, although orientation is not greatly impeded, as the periphery of the field remains intact.

The discovery of the presence of this disease, after a cataract has been successfully removed, is sometimes a source of intense disappointment both to patient and surgeon, which cannot be guarded against, unless the condition of the fundus oculi have been noted while the cataract was still incipient.

Treatment is of no avail, but absolute rest of the eyes from all attempts at near work, and the use of dark protection spectacles are important, so that, at the least, the advance of the disease may not be promoted.

Malformations of the Uveal Tract.

* **Malformations of the Iris.**—*Heterophthalmos* (ἕτερος, *different*; ὀφθαλμός).—This term indicates that the colour of the iris in one eye is different from that in the other.

Corectopia (κόρη, *the pupil*; ἔκτοπος, *out of position*), or malposition of the pupil. The pupil sometimes occupies a position farther from the centre of the iris than normally.

Polycoria (πολύς, *many*; κόρη, *the pupil*).—Where there is more than one pupil. The supernumerary pupil may be separated by only a small bridge from the normal pupil, or it may be situated very near the periphery of the iris. In neither case has it a special sphincter.

Persistent Pupillary Membrane.—This appears in the form of very fine threads stretched across the pupil. They cannot be mis-

taken for posterior synechiæ, as they spring from the anterior surface of the iris at the corona, some distance, that is, from the margin of the pupil. They do not interfere with the motions of the pupil, nor with vision.

Coloboma (*κολοβός, maimed*) and *Irideremia* (*ἶρις*, the iris; *ἐρημία, want of*).—These two defects have been shown by Treacher Collins to be due to a similar cause—in short, that they are different degrees of one and the same condition.

Before the iris is formed in the fœtus there exists—between the posterior surface of the cornea and the anterior capsule of the lens—the anterior portion of the fibro-vascular sheath. This receives its blood-supply partly from the ciliary arteries, and partly from the vessels in the posterior fibro-vascular sheath, which are prolonged round the sides of the lens to join it. The cornea, anterior fibro-vascular sheath, and lens lie in close contact with each other.

The iris is developed by growing forwards from the margin of the anterior chamber, and in so doing has to insinuate itself between the cornea and anterior fibro-vascular sheath on the one hand, and the lens on the other, pushing the prolongation from the posterior fibro-vascular sheath in front of it. The anterior fibro-vascular sheath subsequently becomes the pupillary membrane, of which portions sometimes persist (p. 229).

If we suppose some abnormal adhesion to occur between the cornea, anterior fibro-vascular sheath, and lens-capsule, or some delay in their separation at the whole circumference of the future anterior chamber, we can understand how a mechanical obstruction to any growth of the iris forwards would be introduced, resulting in complete absence of the iris, or irideremia. Irideremia may be complete or partial. In the latter case it may be the inner circle only which is wanting, giving the pupil the appearance of dilatation with atropine. Where the entire iris is absent the ciliary processes can be seen all round. The condition may be binocular. If the obstruction be confined to a portion only of the anterior chamber, the corresponding portion only of the iris will be prevented from growing forwards, and the result will be one or more congenital colobomata.

The patients suffer chiefly from dazzling by light, from which either protection or stenopæic spectacles afford some relief.

* **Malformations of the Chorioid.**—*Coloboma.*—This is a solution

of continuity occurring always in the lower part of the chorioid, and usually associated with a similar defect in the iris. It may commence at the optic papilla, and involve the ciliary body also, and sometimes the sclerotic (p. 177), and even the crystalline lens may have a corresponding notch ; or it may not extend so far in either direction. The condition is recognised ophthalmoscopically by the white patch, due to exposure of the sclerotic where the chorioid is deficient. Sometimes the retina is absent over the defect in the chorioid, a circumstance which may be ascertained by the arrangement of the retinal vessels ; but, even if it be present, its functions at that place are wanting, and a defect in the field of vision exists. Central vision is often normal.

Albinismus, or defective pigmentation of the chorioid and iris. This is usually accompanied by defective pigmentation of the hair of the body. The iris has a pink appearance, due to reflection of light from its blood-vessels, and from those of the chorioid, and with the ophthalmoscope the latter vessels can be seen down to their finest branchings. The pupil to the observer is red, not black. The light which enters the eye, not being partially absorbed by pigment, causes the patient much dazzling, and high degrees of the condition are usually accompanied by nystagmus. In childhood the albinismus and attendant symptoms are more marked than later in life, when some degree of pigmentation usually takes place.

Much advantage may be derived in many of these cases by the use of stenopæic spectacles, at least for near work. Any defect of refraction should be carefully corrected, in order to give the patients the best possible use of their eyes.

Operations on the Iris.

* **Iridectomy.**—This is performed for optical purposes, in zonular cataract, corneal opacities, or closed pupil ; to reduce abnormally high intra-ocular tension, in primary and secondary glaucoma ; and for the removal of tumours or foreign bodies in the iris.

The instruments required are a spring speculum ; a fixation forceps, with spring catch (Fig. 68) ; a lance-shaped iridectomy knife (keratome) (Fig. 64), or a Græfe's cataract knife ; a bent iris forceps (Fig. 65), or a Tyrrell's hook (Fig. 66) ; a pair of iris

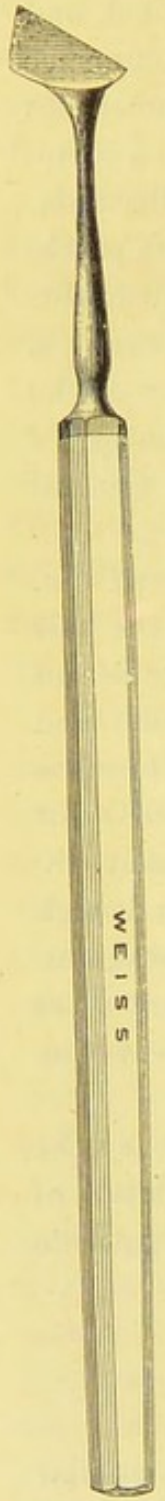


FIG. 64.



FIG. 65.



FIG. 66.

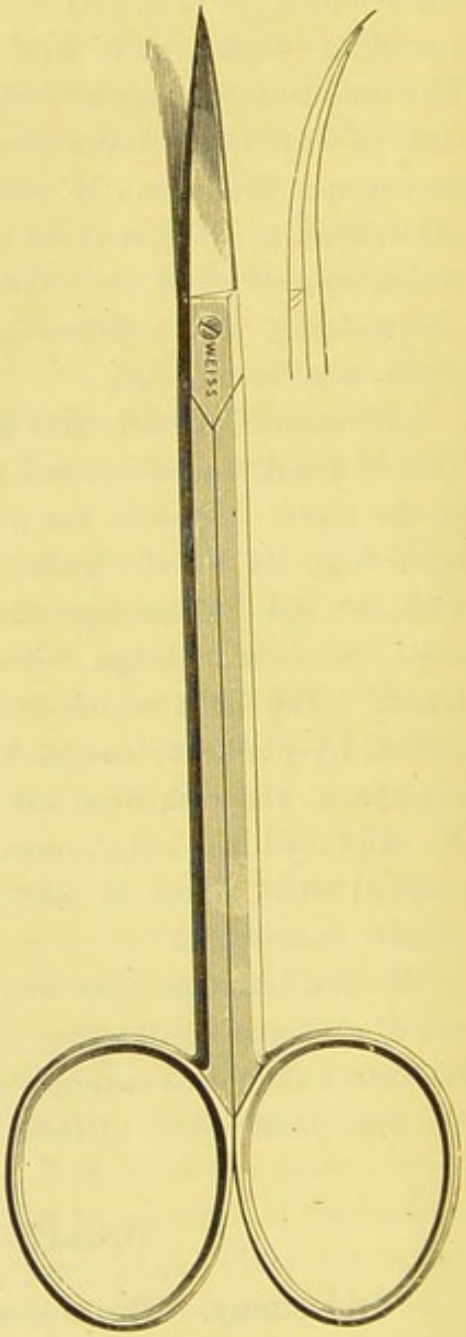


FIG. 67.

scissors curved on the flat (Fig. 67), or de Wecker's forceps-scissors; and a small spatula.

The width of the coloboma depends a good deal on the length of the corneal incision, for it cannot be wider than the incision is long. *Its depth* depends on the proximity of this incision to the corneo-

scleral margin. If a wide and very peripheral coloboma be desired, the incision must be long, and must lie actually in the corneo-scleral margin ; the iris forceps being then introduced, a portion of the iris

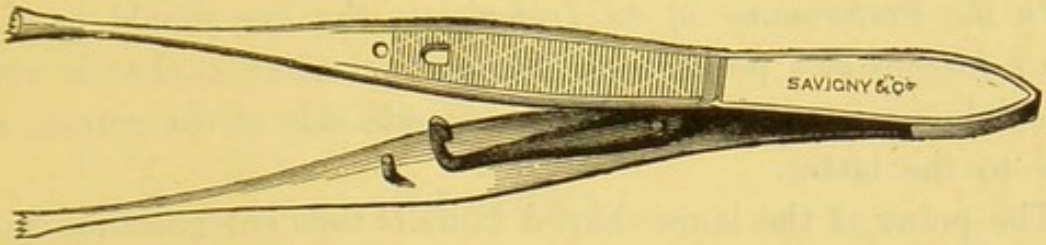


FIG. 68.

corresponding with the length of the incision may be seized, drawn out, and cut off, the blades of the scissors being applied parallel and close to the incision, and by this means a coloboma, as at Fig. 69, is produced. An incision somewhat inside the corneal margin will give a pupil, as in Fig. 70. A narrow coloboma (Fig. 71) is obtained by making a short corneal incision, which may be more or less peripheral as circumstances require ; by taking up as little as possible of the iris in the forceps, or by using a Tyrrell's hook, instead of an iris forceps, for catching and drawing out the iris ; and by applying the blades of the scissors at right angles to the incision in the corneal margin.

In glaucoma a wide and very peripheral coloboma is required. For optical purposes a narrow iridectomy is required, because with a wide coloboma the diffusion of light may be very troublesome to the patient.

The best position for an iridectomy for glaucoma is in the upper



FIG. 69.



FIG. 70.



FIG. 71.

quadrant of the iris, as when made there the subsequent dazzling by light and the disfigurement are least. But the position, by preference, for an optical pupil is below and to the inside, being that most nearly in the direction of the axis of vision. If, however, this position be occupied by a corneal opacity, the coloboma should be made directly downwards ; or, if that place be ineligible, then

downwards and outwards, or directly outwards, or directly inwards. The upward positions are of little use for optical pupils, owing to the overhanging of the upper lid; yet it often happens that we have no other choice.

In the Performance of an Iridectomy, the eye should be fixed with a forceps at a position on the same meridian as that in which the coloboma is to lie, but at the opposite side of the cornea, and close to the latter.

The point of the lance-shaped knife is then entered almost perpendicularly to the surface of the cornea, and made to penetrate the latter. As soon as the point of the blade has entered the anterior chamber, the handle of the knife is lowered, and the blade is passed on into the anterior chamber in a plane parallel to the surface of the iris, until the incision has attained the required length. The handle of the knife is now lowered yet more, so as to bring the point of the blade almost in contact with the posterior surface of the cornea, in order to prevent any injury to the lens in the next motion. The knife is then very slowly withdrawn from the anterior chamber. At the same time the aqueous humour flows off slowly, and the crystalline lens and iris come forwards.

The fixation forceps is now taken over by the assistant, and the bent iris forceps is passed closed into the anterior chamber, its points directed towards the posterior surface of the cornea, so as to avoid engaging them in the iris. When the pupillary margin has been reached, the forceps is opened as widely as the corneal incision will permit, and the corresponding portion of the iris is seized and drawn out to its full extent through the corneal incision.

With the scissors held in the other hand the exposed bit of iris is snipped off quite close to the corneal incision. Care should now be taken that the angles of the coloboma do not remain in the wound; and, if they are seen to do so, they must be reposed by pushing them into their places gently with the spatula.

Iridotomy.—For description and uses of this operation see chap. ix.

CHAPTER VIII.

GLAUCOMA.[1]

As the primary cause of Glaucoma remains, to a great extent, obscure, it cannot well be included under the heading of the diseases of some definite part or tissue of the eye, and therefore it becomes necessary to assign to it a special chapter. It probably has its origin in some vascular derangement of the uveal tract.

The chief and essential symptom of this disease is Increased Intra-ocular Tension—increased hardness of the eyeball—due to over-fullness of the globe. All the other symptoms of the disease result from this one.

There is Primary Glaucoma and Secondary Glaucoma.

In primary glaucoma, the increased tension comes on without any previous recognisable disease of the eye ; and it is with it we have mainly to do in this chapter.

In secondary glaucoma, the increased tension is caused by obvious antecedent disease in the eye.

Primary Glaucoma.

Primary glaucoma is almost invariably a binocular disease. Yet it does not always attack each eye simultaneously, indeed it is more common for the disease to appear in the eyes with an interval of months, or longer.

Of primary glaucoma there are, clinically, two great kinds—Chronic Simple Glaucoma ; and Congestive, or more or less Acute Glaucoma. There is also Chronic Congestive Glaucoma. But these different clinical varieties of glaucoma are liable to run into

[1] From γλαῦκος, *sea-green*. The name was given to the disease by the old writers, on account of the greenish reflection obtained from the pupil in some cases. But this greenish reflection is seen in other diseased conditions, and is not characteristic of glaucoma.

each other—chronic simple glaucoma may become congestive, and congestive glaucoma may after a time take on the chronic simple form.

Increased intra-ocular tension, as stated, is the chief and essential symptom of glaucoma, whatever form of it may come before us; although this increased tension may not always be present in the same degree, nor at every hour of the twenty-four.

If the tips of the index fingers be placed close together on a normal eyeball (Fig. 72), and gentle pressure be made with them alternately, the eyeball will be felt to pit slightly, and a sensation of fluctuation is given to the fingers. The amount of this pitting, or fluctuation, varies according to the degree to which the eyeball is filled with its humours, and also, to some extent, according to the thickness of the sclerotic coat. The glaucomatous eyeball is more resistant, is harder than the normal globe, because it is too full.



FIG. 72.

But there are normal eyes which have a tension below the average normal tension, and others which have a tension somewhat above the average normal tension; and, in eyes of the latter class, it is occasionally difficult to decide whether or not the tension be abnormally high. If it be a question of one eye only, then a comparison of its tension with that of its fellow decides the question, for the physiological tension is always the same in each eye.

While marked variations from the normal are easily observed, some clinical experience is necessary in order to appreciate by palpation those degrees of tension which are just above or just below the normal. A tenometer recently devised by Schiotz is proving of practical use.

For the purposes of clinical notation certain signs have been adopted. Normal tension is indicated by the letter T, or Tn, slight increase of tension by T + 1, still higher tension by T + 2, while T + 3 denotes stony hardness of the eyeball. In the same way diminished tension is T − 1, T − 2, and T − 3. T + ? and T − ? indicate that it is doubtful whether the tension be slightly above or below the normal.



FIG. 1. Glaucomatous Cup.

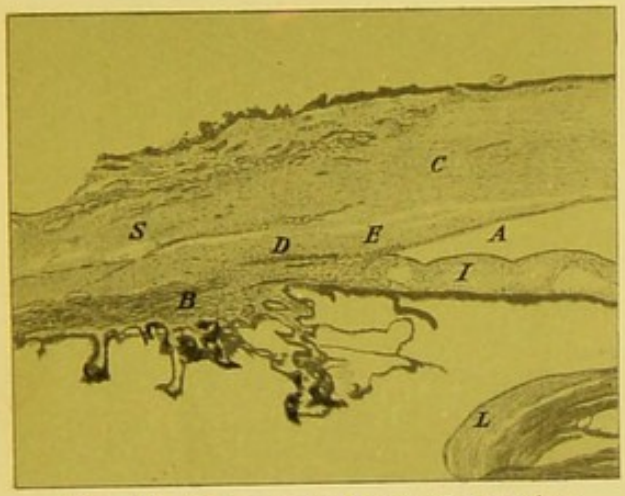


FIG. 2. Closure of Angle of Anterior Chamber (Glaucoma).

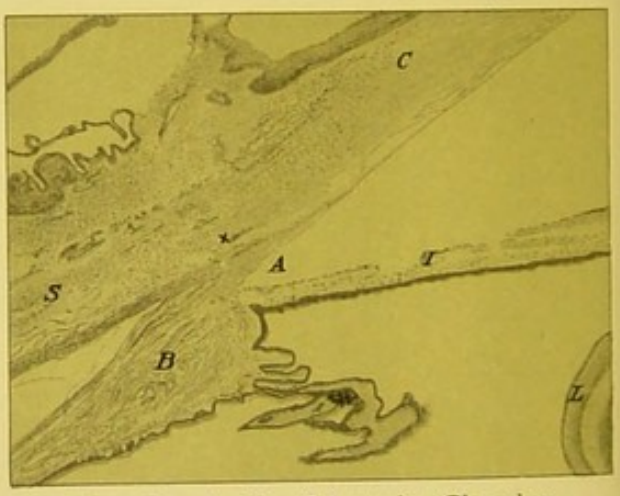


FIG. 3. Angle of Anterior Chamber in a Normal Eye.

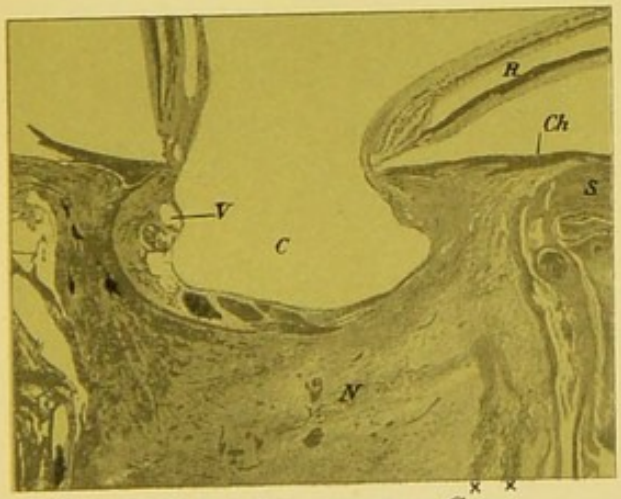


FIG. 4. Glaucomatous Cup.



FIG. 5. Secondary Glaucoma with open Angle, but obstructed Canal of Schlemm, etc.

PLATE IV

(*To face page* 237)

FIG. 1.—The optic disc is atrophied and greyish white, and is surrounded by a pale ring, the glaucomatous halo. The cupping is recognised by the curving of the vessels, where they dip over the edge of the cup, and seem to end abruptly, as well as by the paler appearance, and displacement of the trunks of the vessels in the centre of the cup.

FIG. 2.—C, cornea; S, sclerotic; B, ciliary body, atrophied; I, iris; A, anterior chamber; L, lens. The iris is adherent to the cornea from D to E.

FIG. 3.—Letters as in Fig. 2. The x is just above the canal of Schlemm.

FIG. 4.—N, optic nerve, atrophied, xx pointing to the only remaining bundles of nerve fibres. S, Sclerotic; Ch, chorioid; R, retina, which was partly separated in making the section; C, deep cup; V, a vessel, with some others containing blood, below it.

FIG. 5.—From a case of ring-sarcoma of the ciliary body. Letters as in Fig. 2. The cornea (C) has been partly cut away. x points to canal of Schlemm and tributary vessels, all filled with pigment cells. I, extension of growth into iris.

(For the micro-photos of sections represented by Figs. 2 and 3 we are indebted to the kindness of Professor O'Sullivan and Dr. Wigham of the pathological department of Trinity College, Dublin.)

PLATE IV

(To face page 237)

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(For the micro-photos of sections represented by Figs. 2 and 3 we are indebted to the kindness of Professor O'Sullivan and Dr. Higgins of the pathological department of Trinity College, Dublin.)

Other symptoms of glaucoma, as already stated, are due to the increased tension ; but in chronic glaucoma there are fewer symptoms than in acute glaucoma. Let us now describe these two great forms of primary glaucoma separately.

And first as to **Chronic Simple Glaucoma** (also known as Simple Glaucoma, and as Chronic Non-Congestive Glaucoma).

Symptoms.—Dimness of vision, gradually increasing, in the affected eye, is the only symptom of which the patient with chronic simple glaucoma usually complains. But some patients complain of a permanent 'fog,' which yet does not reduce the acuity of vision as measured with the test types ; while others have short attacks of 'fog' associated with the appearance of rainbow colours around the flames of lamps or candles.

The tension is raised. Sometimes the eye is very hard (T + 2, or more), and again it may be but slightly raised (T + 1). Even in one and the same eye the tension usually varies, and may be at one time too high, and at another almost, or quite, normal. Hence it may be necessary to test the tension at different times before a decision can be arrived at.

The external appearance of the eye is usually normal, and the pupil reacts well to light. The anterior chamber is sometimes a little too shallow.

On examination with the ophthalmoscope, the optic papilla is found to be cupped ; because the optic disc, or, more correctly, the lamina cribrosa, being the weakest part of the sclerotic, is the first place to give way to high intra-ocular tension. Consequently, the lamina cribrosa being pushed back, the optic disc becomes depressed, or cupped, and the cup becomes sometimes even deeper than the outer surface of the sclerotic.

This cupping of the papilla (Plate IV.) is a most important sign of glaucoma, and differs essentially in appearance from the physiological cupping (p. 35), inasmuch as it occupies the entire area of the papilla, and has steep, not shelving, sides. As shown in Plate IV. Fig. 4, the walls of the excavation are often hollowed out, and the ophthalmoscopic effect of this is to give to the retinal vessels the appearance of being broken off at the margin of the papilla (Plate IV. Fig. 1), where they pass round the overhanging edge of the excavation, and become hidden by it, while on the floor of the excavation they reappear.

The presence of an excavation may be recognised ophthalmoscopically, in the examination by the indirect method, by means of lateral motions of the convex lens. It will then be seen that, while the whole fundus seems to move along with the motion of the lens, the floor of the excavation apparently moves in the same direction, but at a slower rate. This parallax is the more marked the deeper the excavation, and is best seen by observing the margin of the excavation. The phenomenon is explained by the accompanying figure (Fig. 73). If *o* be the optical centre of the lens being used in the examination, and *b* and *a* two points lying one behind the other, the inverted images of these points will be situated at b^1 and a^1. The line $a^1\ b^1$ lies in the visual line of the observer;

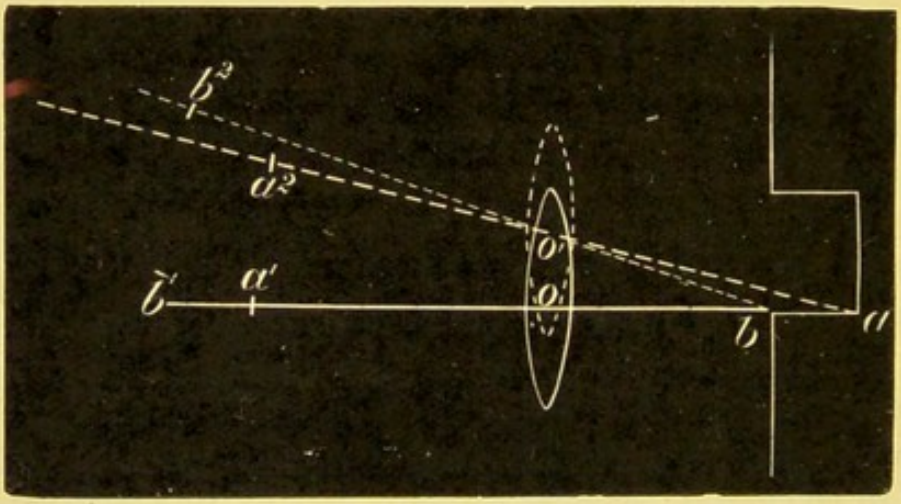


FIG. 73.

and if the lens be moved upward a very little, so that the optical centre comes to o^1, the inverted images of *b* and *a* will be removed to b^2 and a^2. If the observer have not altered his point of view, it will seem to him that the point *b* has made a more extensive motion than the point *a*; or that it has moved more rapidly than *a*, and has glided between *a* and the observer. Short and rapid motions of the lens from side to side, or from above downwards, will best show the parallax.

In examination by the direct ophthalmoscopic method, the existence of an excavation may be ascertained, by observing that a lens of a different power is required in order to obtain a clear image of the margin of the papilla and of its floor. The depth of the excavation may be estimated by noting the difference between these two lenses—*e.g.* if the general fundus of the patient be emmetropic,

and the emmetropic observer require — 3 D to see the floor of the excavation, the depth of the latter is about 1 mm., and in the same proportion up to 10 D.

Besides being cupped, the optic papilla in glaucoma becomes atrophied, and its consequent pallor serves to aid the diagnosis between this and a physiological excavation.

If primary atrophy should attack an optic nerve in the disc of which there is a physiological cup, the appearance presented may be identical with that of a glaucomatous cup, and the diagnosis would then depend upon other symptoms of each disease.

Spontaneous pulsation of the arteries on the optic papilla may be often noted in glaucoma, or can be produced by slight pressure on the eyeball with the finger; because blood can only be forced into these vessels by a pressure greater than that opposed to it. Now, in an eye with normal tension there is no arterial pulsation—and slight pressure with the tip of the finger does not bring it on—for the arterial tension is greater than the intra-ocular tension; and therefore the blood flows in a continuous stream. But, in the decidedly glaucomatous eye, the intra-ocular tension opposes so great an obstacle to the arterial flow, that at the systole alone can it make its way through.

Arterial pulsation also occurs, although rarely, in exophthalmic goitre (chap. xix.); and it occurs where the pressure in the arteries themselves is low (weak heart action, aortic regurgitation, etc.), even though that in the vitreous chamber be normal.

Around the margin of the glaucomatous excavation, especially in chronic glaucoma, one usually sees the whitish appearance, termed the glaucomatous ring (Plate IV. Fig. 1), which is held to be due to atrophy of the chorioid from pressure.

While increasing dimness of sight is the symptom of which the patient chiefly complains in a case of chronic simple glaucoma; an examination of the field of vision will show it to be contracted—the contraction of the colour-fields preceding that for white—(Fig. 12) in consequence of interruption to the conduction in the retinal nerve-fibres from pressure on them at the margin of the depressed optic papilla. This contraction of the field must always be carefully looked for with the perimeter in eight or ten meridians, as it is most important for diagnosis and prognosis. The contraction commences

at the nasal side as a rule, while at the same time central vision is lowered, and at a later stage the temporal portion of the field becomes contracted, and gradually complete blindness is brought about.

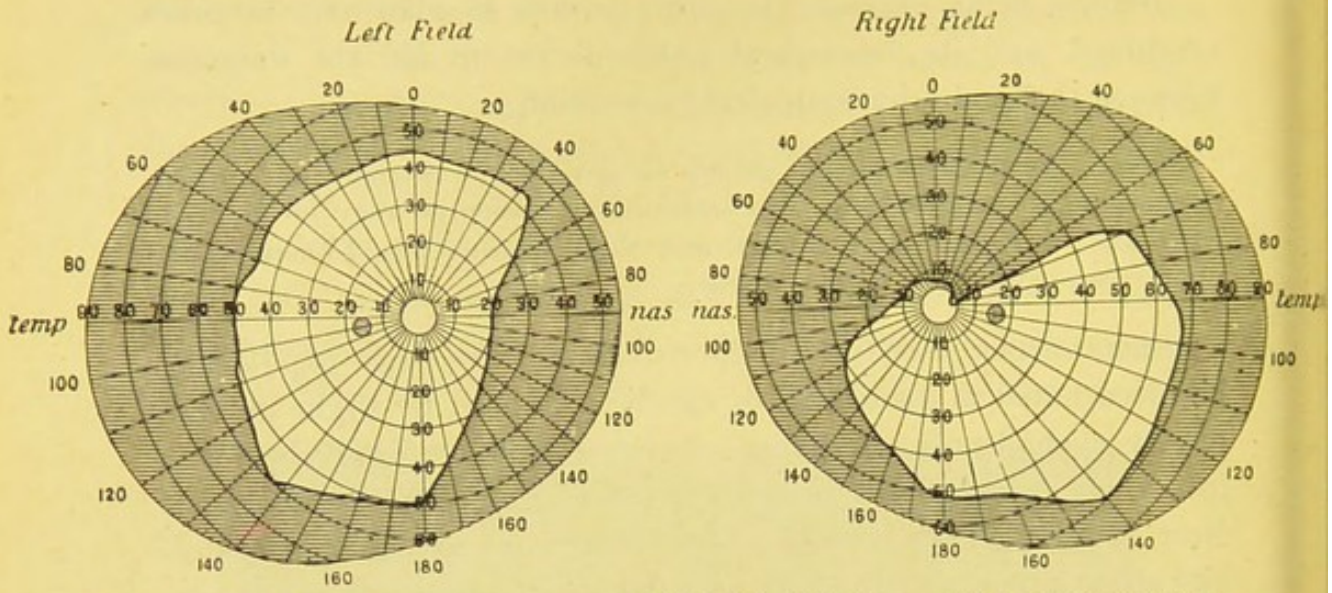


FIG. 74.—*Case of Glaucoma.* Right Field (taken with perimeter) contracted, especially at nasal side, so close up to fixation point that operation was contra-indicated. V = 6/36. Left Field, as taken 3½ years after iridectomy, contracted, especially at nasal side. V = 6/18. No further contraction of field or loss of vision took place in this eye.

In addition to the examination of the field with the perimeter, Bjerrum recommends that, when glaucoma is suspected, the field should be further investigated by aid of a black velvet screen two metres square and a test object about 2 mm. square. By this means the state of relative vision within the field is examined. He has pointed out that in glaucoma the area of relative defect in the field can always be traced to the blind spot, if a sufficiently small test-object be used; or, in other words, that the area of most acute vision, and that of relative defect, meet at the blind spot. In some cases a crescentic para-central scotoma which includes the blind spot may be found.

Bjerrum claims that the diagnosis between glaucoma and primary atrophy of the optic disc, which is sometimes difficult, may be made by this method of examination of the field of vision. The examination of the field of vision by the ordinary method does not always assist, for in each of these diseases the field is liable to be contracted. If the contraction occur with re-entering angles, it points to primary atrophy, for this form of field is not found with glaucoma, but

Bjerrum's symptom occurs with glaucoma, and not with primary atrophy.

The effect of a myotic on the intra-ocular pressure may aid the diagnosis; for while it would not materially influence the normal tension in primary atrophy, it would reduce the high tension in glaucoma.

The central colour sense usually remains normal in glaucoma until a late stage, but in primary optic atrophy it is defective at an early stage.

Again, if slight pressure with the tip of the surgeon's finger during the ophthalmoscopic examination produce arterial pulsation at the optic papilla, it is suggestive of glaucoma; for in an eye with normal tension, as already stated, considerable pressure is needed to produce this effect.

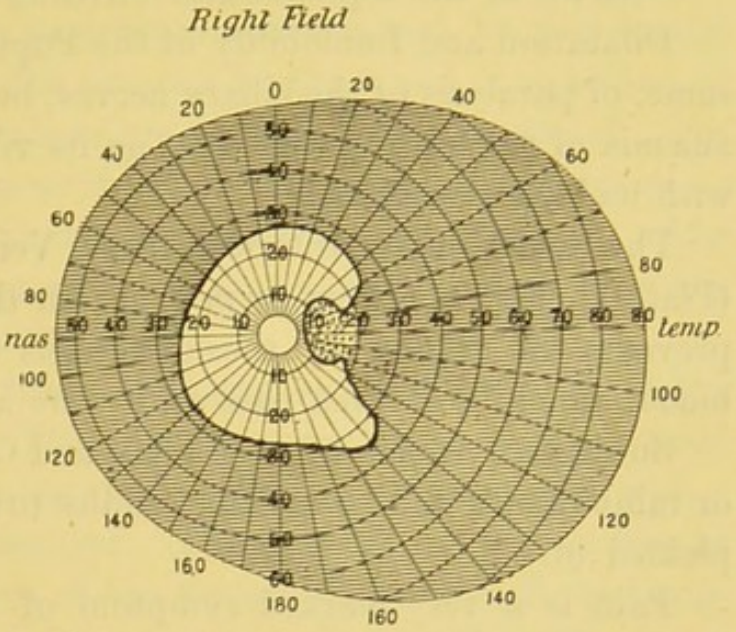


FIG. 75.—*Case of Glaucoma.* Right Field, taken by Bjerrum's method. The contraction of the field extends to the blind spot, which is situated in the dotted portion of the figure.

The progress of chronic simple glaucoma is extremely slow and insidious, extending often over several years, and ending in total blindness, if untreated.

Acute Glaucoma. (Also called Acute Congestive Glaucoma.)—In this form the Increase of Tension is always very marked. The following symptoms are also found :—

Diminished Depth of the Anterior Chamber, from pushing forwards of the lens and iris.

Diminution of the Refracting Power of the Eye, by reason of the nearer approach of the latter to a globular shape.

Diminution of the Amplitude of Accommodation, and Anæsthesia of the Cornea, owing to pressure on the ciliary nerves as they pass along the inner surface of the sclerotic.

Opacity of the Cornea, giving its surface a steamy or breathed-

on appearance, due to œdema of the corneal tissue and epithelium.

A similar appearance is seen in interstitial keratitis.

Indistinctness of the Pattern of the Iris, similarly due to œdema.

Opacity of the Aqueous and Vitreous Humours.

Dilatation and Immobility of the Pupil, the result, according to some, of paralysis of the ciliary nerves, but, according to others, of anæmia of the iris from pressure on its vessels. The pupil is oval, with its long axis vertical.

The Episcleral, or Anterior Ciliary, Veins are large and tortuous (Plate II. Fig. 4), owing to pressure on the venæ vorticosæ, which prevents the outflow by those channels of the chorioidal venous blood, which must then pass off by the anterior ciliary veins.

Subjective Appearances of Light and Colour, and coloured halos or rainbows around lamps and candles (iridescent vision), are complained of.

Pain is a very marked symptom of acute glaucoma, both in the eye and radiating over the corresponding side of the head, and is often very violent; and, in consequence of the pain and of the injection of the eyeball, the term 'inflammatory' is sometimes applied to congestive glaucoma, although there is no inflammation in the true sense.

Vision is greatly affected, and in cases of some standing the field of vision, when it can be examined, will be found contracted.

The Optic Papilla, when the media are sufficiently clear to admit of its being examined, is seen to be cupped, if the disease have continued sufficiently long to bring about this change.

The pain, the injection, and the indistinctness of the iris stroma may render a diagnosis from iritis not quite plain to a beginner; and an error would be serious, because the treatment is very different. In iritis the pupil is contracted; in acute glaucoma it is dilated and oval from above downwards. In iritis there are usually posterior synechiæ; in acute glaucoma there are none. In iritis the tension is nearly always normal, and never high, while in acute glaucoma it is always markedly raised. In iritis the anterior chamber is of normal depth; in acute glaucoma it is too shallow.

In acute glaucoma we recognise certain *Premonitory Symptoms*—viz. sudden diminution of the amplitude of accommodation, evidenced by the rapid onset or increase of presbyopia, and the

consequent necessity for higher + glasses for near work; and the occasional appearance of coloured halos around the flames of lamps or candles, with attacks of fogginess of the general vision. The duration of one of these foggy attacks may be from a few minutes to several hours. Such attacks are apt to occur after a sleepless night, or after a meal, and are sometimes accompanied by peri-orbital pains. Slight opacity of the aqueous humour, and sluggishness of the pupil, with some dilatation, are present during an attack; but the eye afterwards returns to its normal condition, and remains so for weeks or months, until another similar attack comes on. The premonitory stage may last a year or longer, but cases also occur in which there is no premonitory stage.

The most favourable time for operative interference is during this premonitory stage. The operation can then be performed with technical accuracy in an eye free from congestion, and with a normally deep anterior chamber. There is, too, as yet no loss of sight, nor any degeneration of the tissues of the eyeball, and consequently the operation can preserve full vision. The difficulty is to induce patients to consent to operation at this period.

The onset of the *True Glaucomatous Attack* is usually at night. It is accompanied by violent pain radiating through the head from the eye, and by pericorneal injection, chemosis, and lacrimation. The aqueous humour becomes cloudy, the anterior chamber shallow, the iris discoloured, and the pupil dilated to medium size and of oval shape, while the cornea becomes steamy and anæsthetic. The patient frequently complains of subjective sensations of light, and vision is very defective, or may be quite wanting. Vomiting very frequently accompanies acute glaucoma.

The latter fact leads to errors of diagnosis, the patient's ailment having been taken to be a gastric derangement, while the ocular symptoms were regarded as mere coincidences, such as a cold in the eye, neuralgia, etc.

An attack such as that just described may, to a great extent, pass away in the course of a few days, but a complete remission of all the symptoms does not again take place. Some defect of central vision is left, or, it may be, some slight peripheral defect in the field of vision; the tension does not become quite normal again, and the pupillary motions remain slightly sluggish. Another acute attack of glaucoma comes on in the course of some weeks or months,

and it, too, may pass away, leaving the eye in a worse condition than it found it. The attacks gradually become more frequent; and if in the intervals the eye be examined, the cornea and vitreous humour will be found more or less opaque, the optic papilla cupped, and pulsation of the central artery of the retina may be discovered. Finally, there is no remission from the attack, the violent glaucomatous symptoms become permanent, and all vision is for ever destroyed.

Even when vision has been destroyed, the high tension continues, and gradually produces that disorganisation of the tissues of the eyeball known as glaucomatous degeneration. The iris becomes atrophied, the lens becomes opaque, and the cornea frequently ulcerates, while hæmorrhages are apt to occur in the anterior chamber. In time the excessive intra-ocular tension causes staphylomatous bulging of the sclerotic in the ciliary region, or farther back; and finally, these eyes may become the subjects of acute purulent chorioiditis, ending in phthisis bulbi.

Acute glaucoma almost always comes on in both eyes, either at the same time, or with an interval, it may be of weeks, or of months.

The reason for the marked difference between the symptoms and course of chronic and of acute glaucoma is, probably, that in the former the increase of tension is very gradual, and therefore the eye gradually becomes accustomed to it; while in acute glaucoma the increase is rapid or sudden, and the circulation of the eye has not time to accommodate itself to the new state of things.

Glaucoma Fulminans is the term given to a form of the disease, which is more acute than the ordinary acute glaucoma just described. It has no premonitory stage, and, coming on with all the symptoms of acute glaucoma greatly intensified, does not remit, and causes complete permanent destruction of vision in the course of a few hours. It is very rare.

Subacute Glaucoma.—This form differs from acute glaucoma, in that its premonitory stage merges gradually into the actual disease, without the occurrence of an acute attack. The eye gradually becomes hard, the pupil dilated, the anterior chamber shallow, the aqueous humour opaque; while the cornea is 'steamy' and anæsthetic, and the episcleral veins are distended. With the ophthalmoscope the cupped disc and pulsating arteries may be seen,

when the opacities of the media permit. Vision sinks, and the field is contracted towards its nasal side. The progress of the disease is very slow; and in its course attacks of ciliary neuralgia, with greater increase of the tension, greater opacity of the aqueous humour, increase of the corneal opacity and anæsthesia, and increased dimness of vision, are experienced. These attacks pass off in the course of a few days or hours, leaving the eye harder and blinder than before. The subacute glaucoma sometimes takes on the acute form. It is liable to bring about the same glaucomatous degeneration of the eye as does the latter.

Etiology of Glaucoma.—Glaucoma is a disease of advanced life, occurring most usually after fifty years of age, and rarely under the thirtieth year. Myopic eyes are less liable to it than hypermetropic, or emmetropic eyes.

Anxiety, sorrow, and influences in general which depress the spirits have often been noticed to precede the onset of acute glaucoma, but no other immediate causes have been recognised.

Pathology of Glaucoma.—The theory of this disease which obtains very general acceptation is known as the Retention Theory.

In the normal eye the intra-ocular fluids are being constantly renewed, and they must as constantly escape from the eyeball. Their exit is mainly by way of the sinus venosus, or canal of Schlemm, situated in the angle of the anterior chamber (anterior way of exit). The spaces of fontana are separated from the sinus venosus by a delicate wall which consists of a layer of endothelium only. Again, the intimate union of the distal aspect of the blood-vessel with the tissue of the sclerotic keeps it patent, and in this way the constant outflow of the fluids is assured. Hence the most favourable anatomical conditions for filtration are present at the angle of the anterior chamber. Moreover, physiological experiment has shown that the intra-ocular fluids do escape by this path. It is true that the aqueous humour and other intra-ocular fluids escape, also, through the veins on the anterior surface of the iris, and through the veins of the ciliary body, into the venæ vorticosæ (posterior ways of exit); but it is tolerably certain that the main exit is through the canal of Schlemm, at the angle of the anterior chamber.

Now, it has been ascertained that, in glaucomatous eyes, the root of the iris is pushed forwards, and lies in close contact with the periphery of the cornea; thus effectually sealing the angle of the

anterior chamber (Plate IV. Fig. 2), so that no fluid can escape through the spaces of fontana and canal of Schlemm. The intra-ocular fluids must then be retained in the eye, and its tension must be increased; or, in other words, it must become harder than it is normally. But what the factor is which brings about the peripheral adhesion of the iris is an obscure question on which opinions are divided.

Priestley Smith is of opinion that the chief predisposing cause of primary glaucoma is an insufficient space—the circumlental space—between the margin of the lens and the structures which surround it, and to the progressive increase in the size of the lens, which he has shown to occur as life advances, he attributes the greater liability of elderly people to glaucoma.

In eyes in which the circumlental space is insufficient, by reason either of the original structure of the eye (and small eyeballs are specially liable to primary glaucoma, a fact often demonstrated by the small size of the cornea in the eyes attacked) or of the enlargement of the lens, any condition which tends to overfill the veins of the head and uveal tract may initiate an attack of acute glaucoma, as follows :—

An increase in the amount of blood in the uveal tract must be compensated by the expulsion of some other fluid from the eye; consequently, the aqueous humour filters out more rapidly than is normal at the angle of the anterior chamber. As the contents of the chamber diminish, the lens and iris move forwards towards the cornea. Now, in the normal eye, and especially in the youthful eye, this compensation is effected without danger to the angle of the anterior chamber, because the lens is comparatively small, the circumlental space large, and the anterior chamber deep. But, when the lens and ciliary processes are already in close relation to each other, and the anterior chamber is already shallow, then any increased fullness of the uveal tract involves danger to the angle of the chamber. The turgid ciliary processes find insufficient space for their expansion; they are carried forwards together with the lens, and, pressing upon the base of the iris, lock up the angle of the anterior chamber. Thereupon, the further escape of fluid being impossible, high tension of the eyeball is established.

According to this explanation, then, the high tension is due to impeded escape of the intra-ocular fluid (the retention theory), and

depends, primarily, upon an increase in the amount of blood in the eye. Priestley Smith considers that, in chronic simple glaucoma, the predisposing causes are the same as in acute glaucoma; but that in the former, the vascular disturbance being gradual and slight, the vessels adapt themselves to the slowly increasing pressure, and the angle of the anterior chamber is more or less compressed, but not tightly closed.

Thomson Henderson, by his investigations of normal and glaucomatous eyes, has arrived at a theory of glaucoma very different from that generally held. It is briefly as follows:—The eyeball is a closed and unyielding capsule, and the total volume of its contents a fixed quantity. In such a system the intra-ocular tension must be the same as the lowest intra-venous tension—viz. that in the canal of Schlemm. In the healthy eye the free contact between aqueous and veins—mainly the venous canal of Schlemm—causes the intra-ocular pressure to be maintained at the normal intra-venous level. If the contact of the aqueous with the veins in the iris, or more especially in the canal of Schlemm, becomes diminished, the intra-ocular circulation is converted into a system of rigid, instead of elastic, tubes, and in such a system the venous pressure is raised. In glaucoma, Henderson holds, owing to sclerosis of the ligamentum pectinatum, the contact between veins and aqueous is reduced, and the intra-ocular fluids act as a rigid volume, which, operating through the tissues, converts the intra-ocular circulation into a system of rigid tubes, and consequently the intra-ocular tension is raised. There are, he believes, two factors in glaucoma:—A constant predisposing one—namely, sclerosis of the ligamentum pectinatum, preventing access of the aqueous to the canal of Schlemm, the chief normal outflow of the aqueous—and an immediate exciting one, which is vascular. If the aqueous have sufficient access to the iris veins by way of the iris crypts—which in the normal eye are only accessory passages for the aqueous—sclerosis of the ligamentum pectinatum alone will not cause glaucoma. But if, in addition to sclerosis of the ligamentum pectinatum, the minimum circulatory pressure in the eye be raised, in response to an increase from any cause in the vascular pressure of the general circulation of the body, contact between the aqueous and veins is rendered insufficient. The raised pressure of the intra-ocular fluid contents acts then no longer directly on the venous walls, but indirectly through the uveal

tissues, so that the intra-ocular circulation is forced into rigid lines' and abnormally high intra-ocular tension results.

Treatment.—The performance of an iridectomy is the means discovered by von Græfe, in the year 1857, for the cure of glaucoma, a disease which had hitherto been incurable.

To ensure the success of an iridectomy for glaucoma, so far as is possible, it is necessary (1) that the incision should be peripheral—*i.e.* as far back in the corneo-sclerotic margin as is compatible with the introduction of the knife into the anterior chamber, and with the avoidance of injury to the ciliary body; (2) that the portion of iris removed should be wide—*i.e.* involving about one-fifth of the circumference of the iris (Fig. 69); and (3) that it should be abscised as peripherally—*i.e.* as close to the root of the iris, as possible.

It is, moreover, important to withdraw the knife very slowly from the anterior chamber, when the corneo-scleral section is complete, in order that the aqueous humour may flow off gradually, lest an intra-ocular hæmorrhage from the sudden reduction of tension should occur.

The portion of iris should be most carefully abscised, so that no tag of it may remain in the wound, and become caught in the cicatrix in the course of healing. Such an occurrence is apt to produce a cystoid cicatrix, which may at a later period become the starting-point of irritation, and even of serious inflammation. Some operators prefer von Græfe's cataract knife for the performance of the operation, but the lance-shaped keratome is the instrument usually employed.

For the purpose of reducing the intra-ocular tension, it matters nothing what region of the iris be abscised; but, as a rule, the upper quadrant is to be preferred, for there the resulting coloboma, being covered to a great extent by the upper lid, will give rise to less diffusion of light than in any other position.

Immediately after the operation, palpation of the eyeball should show a marked diminution of tension. When this is not so the prognosis is unfavourable. Should an increase of tension occur on the day after the operation, it is of no consequence, as it passes off again in the course of the next few days. Until then, the anterior chamber will not be restored, and we see cases where the anterior chamber does not appear for a week or more. The bandage should

be worn until the anterior chamber is completely restored. It is desirable to perform the operation with general anæsthesia, to secure technical accuracy. The pain for some time after the operation is considerable, and should be relieved by a hypodermic injection of morphia in the corresponding temple.

Malignant glaucoma is the term applied to certain rare cases, in which immediately after iridectomy, although the operation may have been faultlessly performed, the lens is violently pushed forwards, blocking the wound, obliterating the angle of the anterior chamber, and preventing any fluid from escaping from the eye, so that it is soon as hard as, or harder than, before ; and the condition is accompanied by cloudiness of the cornea, injection of the blood vessels, chemosis, violent pain, and great loss of sight. This complication seems to be caused by the retention of fluid behind the lens, and is more likely to occur in cases of chronic simple glaucoma, than in the acute forms of the disease. The only prospect of saving eyes which take this malignant course is by the operation of posterior sclerotomy. A broad needle, or a Græfe's knife, is entered through the sclerotic, 8 or 10 mm. behind the outer margin of the cornea, and the blade is given a quarter turn on its axis, so as to make the wound gape, or the latter may even be somewhat enlarged in a meridianal direction. At the same time gentle pressure is applied, by means of the upper lid, on the centre of the cornea. This causes fluid to escape through the scleral wound by the side of the knife, and it also causes the lens to go back into its place, with restoration of the anterior chamber. The pressure on the cornea may be maintained with advantage for a minute or somewhat longer.

The therapeutic value of a correctly performed iridectomy for glaucoma depends mainly on the form of the glaucoma—congestive, or chronic simple—for which the operation is performed. The more congestive or acute the case, the more favourable is the prognosis in respect of the result which may be expected from the operation ; and hence the congestive forms are more favourable for operation than the simple chronic form.

In the congestive forms, the operation may be expected with great certainty to preserve permanently whatever vision remains, and it can restore the great loss of sight dependent on an attack of acute congestive glaucoma, if performed without delay. It will not, in these acute cases, restore vision which has been lost for a few days.

But in chronic simple glaucoma, when the disease has advanced so far that the contraction of the field has approached close to the fixation-point, although central vision may still be fairly good, the prognosis must be very guarded. Because in such cases, while the iridectomy may prove successful in so far as reduction of tension is concerned, yet the contraction of the field—*i.e.* the progress of the atrophy of the optic nerve—is often hastened, and shortly afterwards may be found to engulf the centre of vision, and rapid complete blindness may be precipitated. Indeed, where the contraction is near the fixation-point at one side (Fig. 74), and is advanced in other directions, operation is contra-indicated in chronic simple glaucoma.

Yet, in the early stages of chronic simple glaucoma, while central vision is as yet unaffected; the field of vision, not at all, or only slightly contracted; and the optic disc although somewhat cupped, yet not advanced in atrophy, an iridectomy may save the sight permanently. Even at a later stage, with some contraction of the field and a certain amount of atrophy, some vision is often saved, or blindness is retarded.

A falling away in vision must be expected in almost all cases of chronic simple glaucoma after the iridectomy; but in the favourable cases this is only temporary, and the sight gradually returns to its previous state in the course of some weeks.

In cases of acute or subacute glaucoma, it has frequently been observed that shortly, even within a few hours, after the performance of the iridectomy, the other eye, previously healthy, or, at most, affected with but slight premonitory symptoms, is attacked with glaucoma. It is probable that this is due to dilatation of the pupil, with pressing of the iris into the angle of the anterior chamber, in consequence of confinement in the dark room, and eserine should be put into the sound eye as a precaution.

The Mode of Action of the Operation is not clearly understood. The view is held that the cure depends, not on the removal of the portion of iris, but on the incision in the corneo-sclerotic margin, or, rather, on the nature of the cicatrix (filtering cicatrix) produced by that incision. It is believed that this cicatrix is formed of tissue, which admits of a certain amount of filtration through it of the intra-ocular fluids, and that in this way the intra-ocular tension is kept down to the normal standard.

Thomson Henderson's view is that wounds of the healthy iris never cicatrise, and hence an iridectomy by facilitating the direct contact of aqueous with iris veins, prevents the intra-ocular vessels from acting as rigid tubes.

Priestley Smith has satisfied himself that, in a large number of successful iridectomies, the success is due to the formation of a permanent corneo-scleral fistula—not merely a filtering cicatrix. The same view is held by Treacher Collins, who finds that this permanent gap is maintained by prolapse of a fold of iris into the wound. The latter author, indeed, discards the filtering-cicatrix theory, for which he considers there is no evidence. In those cases where a fistula, as described, is not formed by the operation, Collins considers that the obstruction to the outflow of lymph becomes freed, either by the iris being torn away at its thinnest part—that is, its extreme root—thus leaving a large portion of the filtration angle open for drainage ; or, by the escape of the aqueous and the drag on the iris, incidental to the iridectomy, being sufficient to dislodge the periphery of an iris, which has only recently come into apposition with the cornea.

In view of the theory that it is not the removal of a portion of the iris which is the tension-reducing element in the operation of iridectomy, but rather the nature of the corneo-scleral cicatrix, a number of operations have been devised for the cure of chronic simple glaucoma, with the object of providing a filtering cicatrix either without an iridectomy, or combined with an iridectomy. They are not intended for the congestive forms of glaucoma, for which iridectomy is quite satisfactory. Of these operations the principal ones are as follows :—

1. *Sclerotomy* (De Wecker).—Before the operation the pupil is to be contracted to pinhole size, to obviate prolapse of iris. If eserine does not produce a sufficient myosis, sclerotomy should not be performed.

The instrument used is von Græfe's cataract knife. The point of the knife is entered into the anterior chamber, through the corneo-sclerotic margin, at a point corresponding with that selected for the puncture in cataract extraction, but 1 mm. removed from the corneal margin, as represented at *a* in Fig. 76. The counter-puncture is made at a point (*b*) corresponding with this, at the opposite side of the anterior chamber. With a slow sawing motion the section is en-

larged upwards, until only a bridge of tissue, about 3 mm. broad, remains (at *c*), and this is left undivided, the better to guard against prolapse of the iris. The knife is now slowly withdrawn from the eye, care having been first taken that the aqueous humour is thoroughly evacuated. This can be effected by tilting the edge of the knife slightly forwards, so as to make the lips of the wound gape somewhat. If the pupil be quite round at the conclusion of the operation, the dressing may be applied, a drop of solution of eserine having been first instilled; but if the pupil be oval, or of other irregular shape, a tendency to prolapse of the iris is indicated, and a spatula must be introduced into the anterior chamber, to restore the pupil to its normal shape by gentle pushing of the iris. If there be an actual prolapse of the iris, an attempt may be made to repose it with the spatula; but should this not prove satisfactory the prolapse is to be abscised with scissors, thus turning the sclerotomy into an iridectomy.

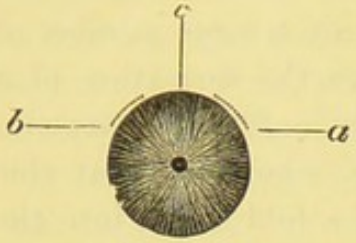
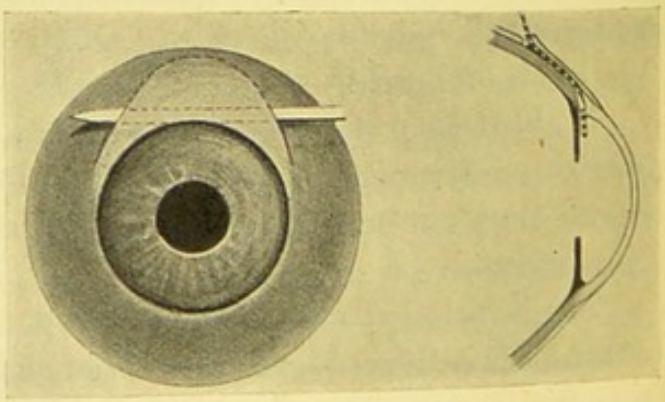


FIG. 76.

2. *Combined Iridectomy and Sclerectomy* (Lagrange's Operation).—Before the operation the pupil is contracted with a myotic. A Græfe's knife is entered about 1 mm. from the corneal margin, and the counter puncture is made at a corresponding point at the opposite side; but the incision should not be so long as that for a cataract extraction. The incision is then carried upwards into the irido-corneal angle; and, when it is about to be completed, the edge of the knife is directed somewhat backwards, so as to bevel the centre of the sclerotic incision in cutting out, and finally a large conjunctival flap is formed (Fig. 77). The conjunctival flap is then lifted with a forceps, and drawn downwards (Fig. 78); and, with suitably curved and very sharp scissors, a sufficiently large morsel of the


FIG. 77.

sclerotic is resected from the lower, or corneal, edge of the wound. Iridectomy is now performed in the usual way, and the conjunctival flap is spread over the incision.

Some operators prefer to remove the piece of sclerotic with a medium-sized Bowman's trephine.

3. *Elliott's Operation.*—Above the cornea a large triangular flap of conjunctiva is dissected up, its base lying quite at the corneo-sclerotic margin. The flap is turned over the cornea. A space close to the cornea is carefully freed from all sub-conjunctival tissue by means of scissors, to allow the easy working of a Bowman's trephine. A trephine of 2·0 mm. or 2·5 mm. diameter is applied on the corneo-sclerotic margin, and with quick light movements a piece is cut out. As soon as the anterior chamber has been reached, the aqueous humour wells up alongside the trephine, showing that the instrument has perforated. If the iris now lie in its normal position, the conjunctival flap is restored to its place, and the operation is concluded. Should the iris bulge into the opening, it is snipped with scissors to enable the aqueous humour to escape, when it usually goes back of itself; but, if it does not do so, an iridectomy is performed.

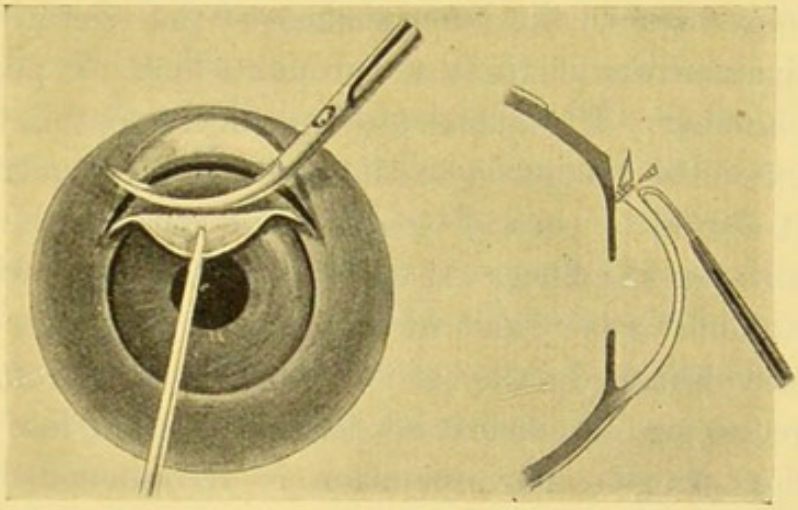


FIG. 78.

4. *Iridencleisis* (*Holth's Operation*).—About 10 mm. from the margin of the cornea an incision, parallel to the corneal margin, is made in the conjunctiva with scissors. A lance-shaped knife is passed through this incision and under the conjunctiva, and an opening 8 mm. long is made into the anterior chamber at the corneo-scleral margin. A small iridectomy is made, and then one of the pillars of the coloboma is drawn into the wound and allowed to remain there to become incarcerated when healing takes place. In this way a cystoid cicatrix is formed which admits of a considerable filtering of the intra-ocular fluids.

5. *Cyclodialysis (Heine's Operation).*—The object of this operation is to make a communication between the supra-chorioidal lymph space and the anterior chamber, by separating the ciliary body and the root of the iris from the ligamentum pectinatum, whereby freer drainage for the intra-ocular fluids may be provided, by way of the posterior exits which are not occluded.

The pupil having been contracted with eserine, the operation is performed as follows :—About 5 mm. from the corneal margin the conjunctiva is separated from the sclerotic ; then, with a straight lance-shaped knife, which is held vertically like a pencil, an incision 2 mm. long is made, through the sclerotic, as deep as the ciliary muscle, but without injury to the latter. A thin spatula, or stiletto, is now introduced through the opening and passed forwards, being kept close to the inner surface of the sclerotic, until it reaches the ligamentum pectinatum through which it is pushed into the anterior chamber. By lateral motions of the spatula the dehiscence can be extended according to the operator's judgment, and it is desirable it should be carried to about one-third of the circumference of the anterior chamber. If the spatula be slowly withdrawn, no aqueous humour is lost, and in that case a reduction of tension is not observable until a day or two after the operation. If some immediate reduction of tension be desired, more or less aqueous is caused to flow away. The operation is recommended for chronic simple glaucoma, hæmorrhagic glaucoma, and hydrophthalmos (p. 257). It is more painful than iridectomy.

The Treatment of Glaucoma by Myotics.—Eserine and pilocarpine as eye-drops in 1 per cent. solutions often have the power of reducing glaucomatous tension. This power depends on the contraction of the pupil, and consequent drawing away of the base of the iris from the angle of the anterior chamber ; and, if the myotic does not contract the pupil greatly, it will not reduce the tension. Cases of acute glaucoma, brought on by the injudicious use of atropine (pp. 187, 225), may frequently be completely and permanently relieved by a myotic instilled a few times.

In acute congestive glaucoma the use of a myotic in the premonitory stage will often postpone the true glaucomatous attack, and even sometimes relieve the latter for the time ; but the myotic treatment cannot produce a radical cure, and it should only be used to preserve the health of the eye, until the operation is performed.

In chronic simple glaucoma, too, myotics bring down the tension when they contract the pupil, and may be used in those cases where the patient positively declines an operation, or where an operation in the fellow eye has not resulted satisfactorily, or where an operation is contra-indicated by a very contracted field. The anti-glaucomatous action of the myotic only lasts so long as the pupil is contracted, and it must consequently be applied once or twice in twenty-four hours. The myotic treatment can only be regarded as palliative. It may keep glaucoma to some extent in abeyance for a time, but it is not a cure for the disease.

It may be here once more stated that, while myotics possess the power of reducing glaucomatous tension, atropine, and all mydriatics, bring on glaucoma, where there is already a tendency to it. In all old people, therefore, before atropine is used, it is well to ascertain that the tension is not too high.

Treatment of Painful Blind Glaucomatous Eyes.—Eyes blind of acute glaucoma may, as has been stated, continue to be painful, and to render the patient's life very miserable. Iridectomy is very commonly performed to relieve the pain, although all hope of restoration of sight is lost; but the operation sometimes fails in its object, and excision, or evisceration, must be resorted to. Mules's operation should not be performed here.

Secondary Glaucoma.

In addition to the different forms of primary glaucoma above described, we find, as already stated, that high tension occurs as a sequel of diseased conditions previously existing in the eye. There are several diseased states which are liable to become complicated with glaucomatous tension; but it should be clearly understood that, in almost every instance, the immediate cause of the high tension is the same as in primary glaucoma—namely, a closure of the angle of the anterior chamber.

The following are the chief conditions which are liable to lead to secondary glaucoma :—

a. Complete Posterior, or Ring Synechia (p. 180). The iris, being pushed forwards by the aqueous humour pent up in the posterior part of the aqueous chamber, is pressed tightly against the

cornea, and obliterates the angle of the anterior chamber and the ways of exit. An iridectomy relieves the high tension here.

b. Perforating Wounds or Ulcers of the Cornea, followed by incarceration of the iris in the resulting cicatrix. The iris, being drawn tautly towards the cornea, a large portion, or the whole, of the filtration angle may be closed by it. An iridectomy is indicated.

c. Dislocation of the Crystalline Lens into the Anterior Chamber. Here the normal flow of the intra-ocular fluids through the pupil, towards the filtration angle, is arrested by reason of the presence of the lens in the anterior chamber. The onward current then presses the iris against the posterior surface of the lens, and the root of the iris, which is unsupported by the lens, against the periphery of the cornea, and in this way the angle of the anterior chamber is closed. In these cases the lens must be removed from the eye.

d. Lateral (traumatic) Displacement of the Crystalline Lens. The lens, being pushed in between the ciliary processes and the vitreous humour, drives the root of the iris forwards against the cornea at that place, while in other parts of the circumference the displaced vitreous acts in the same way. In these cases, too, the lens must be removed.

e. Traumatic Cataract (pp. 270, 291). The swelling lens pushes the iris forwards against the angle of the anterior chamber. Evacuation of the lens should be performed.

f. After Cataract Extraction. For explanation of this see p. 288.

g. Intra-ocular Tumours (p. 225). The growth of the tumour gives rise to a transudation of serum from the chorioid which detaches the retina, and after a time pushes the lens, the ciliary processes, and the iris forwards, and thus closes the filtration angle.

h. Serous-Cyclitis, or Iritis. Here the filtration angle is not closed. Priestley Smith thinks that the increased tension is due to diminished filtration-power of the eye, and perhaps to tissue changes around the filtration angle, and to deposit of exudation in the angle of the anterior chamber.

Another, and peculiar, form of secondary glaucoma is Hæmorrhagic Glaucoma. Retinal hæmorrhages of the ordinary type are sometimes followed, a few weeks later, by increased intra-ocular tension, which generally assumes the symptoms of acute or sub-

acute glaucoma, and, more rarely, those of chronic simple glaucoma. A satisfactory explanation for these cases has not been offered. When such a glaucoma becomes pronounced, it is not usually possible to distinguish it from a primary form of the disease. This disease is practically hopeless. Iridectomy is more likely to do harm than good, the operation being almost invariably followed by fresh intra-ocular hæmorrhages, and by a further increase of tension. Sclerotomy is said by some to act with fairly good results; but the myotic treatment is ineffectual.

* Congenital Hydrophthalmos.

This disease, also known as Buphthalmos, and as Cornea Globosa, is glaucoma of early childhood, the incipient stages of which are intra-uterine. The eyeball is enormously enlarged, the cornea very much wider than normal in its diameter, the anterior chamber deep, the iris trembling, and the sclerotic thinned. Increase of tension and cupping of the optic papilla are usually present, and there is severe pain if the tension become high.

The Pathology of the disease is obscure. Treacher Collins holds that it is caused by a failure in the separation of the iris from the back of the cornea at its extreme periphery, in course of the development of the eye; E. von Hippel believes it to be the result of an intra-uterine inflammation; while Seefelder's investigations lead him to regard it as due to mal-development of the ways of exit of the intra-ocular fluids.

Treatment.—In the early stages, an iridectomy often arrests the progress of the disease and preserves sight. When the disease is very advanced, treatment is of no avail; although, if there be much pain, an iridectomy or sclerotomy may relieve it.

CHAPTER IX.

DISEASES OF THE CRYSTALLINE LENS.

Cataract, by which is meant an opacity of the lens, may be said to be the only disease of this part of the eye. Cataract may be complete—occupying, in its final stage, the whole, or nearly the whole, of the lens ; or partial—occupying only part of the lens, and with little or no tendency to extend to other parts of it.

Complete Cataracts.

Of these, the most common is **Senile Cataract**. It occurs in persons of over fifty years of age, rarely in those under forty-five years of age.

Progress, Pathogenesis, and Etiology of Senile Cataract.—In incipient senile cataract, the opacity is found :—*a*. In the cortical layers of the lens, especially at its equator, and in the latter position can often be detected only with transmitted light from the ophthalmoscope mirror, or with focal illumination, even if the pupil be dilated with atropine. This opacity takes the form of lines, or of triangular sectors, of which the bases are towards the equator of the lens, while the apices are towards its centre. These lines or sectors look black with transmitted light, but grey with focal illumination, and between them clear lens-substance is present. Or, *b*. Incipient cataract may appear as a diffuse opacity in the layers surrounding the nucleus of the lens. Or, *c*. The opacity may commence both near the equator and around the nucleus at about the same time. Or, *d*. The opacity may in the beginning be disseminated through the cortex, in the form of flocculi, dots, and lines. *e*. In some cataracts, in a very incipient stage, there are no absolute opacities ; but with weak transmitted light—*i.e.* from a plane ophthalmoscope mirror—numbers of fine dark lines will be seen in the lens, which

vanish and reappear according as the incidence of the light is altered ; while not until later do true opacities make their appearance. Gradually the cataract extends to other parts of the lens, until the whole cortical portion is opaque.

In senile cataract, the very nucleus itself does not become cataractous, although it is usually sclerosed (harder and drier).

Sclerosis of the nucleus of the lens is a physiological condition of advanced life, and will be found in many an eye where there is no cataract. It gives to the senile non-cataractous lens, as seen with a dilated pupil or with focal illumination, a peculiar smoky appearance, which is often mistaken by inexperienced persons for cataract ; but examination with transmitted light will show that there is no true opacity. When a senile cataract has become complete, the sclerosed nucleus imparts to its centre a brownish or yellowish hue, while the other parts of the lens are of a greyish white. As a rule, the most peripheral layers of the cortex are the last to become opaque. Accordingly as the lens becomes opaque, it often swells slightly ; and when this occurs the anterior chamber becomes a little shallower.

Until the whole cortex is opaque, a clear interval will be present between the iris and the cataractous part ; and, on examination with the oblique light, a shadow of the iris will be thrown on the cataractous part at the side from which the light comes ; and the cataract, in this way, is proved to be immature in the strict sense. If the whole cortical substance be opaque, the thickness of the capsule alone will intervene between the pupillary margin and the opacity, and no shadow of the iris can be thrown on the latter.

In addition to this examination with focal light, the pupil should be dilated, and the lens examined by transmitted light from the ophthalmoscope mirror, when a completely opaque cataract should permit of no red reflection being obtained, in any direction, from the fundus oculi.

As soon as the whole of the cortical substance has become opaque, any swelling of the lens which there may be subsides, and the anterior chamber finally regains its normal depth. If there be no glittering sectors in the cortex, the cataract is now ‘ mature,’ or ‘ ripe ’ for operation—that is to say, if an extraction operation be now undertaken, the lens will be with great certainty delivered in its entirety ; whereas, prior to this stage, cortical substance would

have been more liable to adhere to the capsule, and to be left behind.

But a cataract is immature, notwithstanding the absence of iris-shadow and of the illuminable pupil, and even though the anterior chamber be of normal depth, if the cortex present well-marked glittering sectors. The glitter of the different sectors varies with the angle of illumination, so that the surface appears facetted. In such a lens there are thin transparent flakes, as well as opaque flakes, close beneath the capsule ; and, if an extraction operation be undertaken, the transparent portions are very apt to remain within the eye, in spite of every attempt to remove them. A few months later the sectors lose their sharp contour, break down, and finally disappear. We can then depend upon the exit of the whole cataract.

Yet in persons over sixty years of age, in whom the nucleus is usually large, many a cataract can be completely removed which does not come up to the strict standard of maturity just laid down ; and, at that time of life, the surgeon need not hesitate to operate, without waiting for absolute maturity, if the patient be materially incommoded for want of sight.

The foregoing is the most common course of events in the progress of a senile cataract ; but there is a less common form of it, in which total opacity of the cortical layers never does come about. In this form the lens is occupied by radiating linear opacities up to the very capsule ; while between these opaque lines there are clear intervals, which may even admit of the fundus oculi being examined, although dimly, and which allow of a certain amount of sight. These cataracts usually occur in myopic eyes, and they can be successfully removed.

After the stage of maturity a cataract gradually goes on to be hypermature. Here one of two changes takes place : either the cortical substance breaks down, and becomes fluid, the nucleus retaining its consistency, and gravitating to the lowest part of the capsule (Morgagnian cataract) ; or, more commonly, the cortical substance dries up, as it were, and finally comes to form, with the nucleus, a hard flat disc. Accompanying these changes in the lens-substance are changes in the epithelium lining the inner surface of the anterior capsule, which result in a thickening of the capsule. In a Morgagnian cataract the fluid cortex finally undergoes absorption, and the anterior and posterior capsules come in contact (cataracta membranacea). In some cases the capsule remains more or

less transparent, and the sight may greatly improve ; and cases are on record of spontaneous cure of cataract, due to intracapsular absorption.

The dimensions of the nucleus vary a good deal. In some cataracts it is small, and these are called soft cataracts, as they consist chiefly of the soft cortical substance. In others—and as a rule in patients over sixty years of age—the nucleus is large, and these are called hard cataracts, although they are not hard throughout. The size of the nucleus can be estimated pretty accurately by the extent and intensity of the yellowish or brownish reflection, which is obtainable by focal illumination from the centre of the cataract.

In some senile cataracts, the sclerosis is not confined to the nucleus, but extends to the cortical layers as well. This causes much disturbance of sight, and the term cataracta nigra is given to these lenses, from their very dark hue, although they are not cataracts in the true sense of the term. They require operation, and, as they are always of large size, wide openings have to be made to deliver them.

In the lenses of young people there is no nucleus : consequently, in the complete cataracts of children and of young adults, there is no nucleus ; the whole lens becomes opaque, and the cataract is always soft.

Pathogenesis of Senile Cataract.—According to Priestley Smith's investigations a diminished rate of growth of the lens precedes the formation of cataract ; and it is held by some that the cataractous process in the senile lens is the result, in the first instance, of a rapid sclerosis and shrinking of the nucleus. If the process of sclerosis and shrinking be very gradual, cataract does not appear, because the cortical layers of the lens have time to accommodate themselves to the altered state of things ; but, if the shrinkage be rapid, the cortical layers cannot so rapidly accommodate themselves, and consequently the fibrillæ of these layers become separated somewhat from each other, fluid collects in the interspaces, and causes disintegration of the lens-substance, gradually leading to opacity of the whole lens. As the opacity increases, more fluid is present in the lens, and this causes swelling of the lens. When the whole cortex has become opaque, the fluid contents begin to diminish, and the lens returns to its normal size. Senile cataract, according to this

view, is entirely a local process. But it has not been proved that the nucleus of these cataractous lenses does undergo a process of shrinkage.

Römer, Hess, and others incline to the view, for which they advance fairly well-founded reasons, that senile cataract is the result of certain specific toxines which enter the lens and damage the epithelial cells lining its capsule, and that this leads on to derangement of all the lenticular fibres.

Senile cataract has not been associated with any recognisable disturbance of the general health.

The Symptoms to which senile cataract, in the earliest stages, gives rise, are : more or less dimness of vision, as if looking through a mist, or a net, and sometimes polyopia. The polyopia annoys the patient especially in the evening, when they look at gas or candle flames, the moon, etc. It is caused by the irregular astigmatism produced by the slight changes which sometimes precede actual opacities (p. 258), or by the points of early peripheral opacities extending into the pupillary area.

In some cases of incipient cataract there is an increase in the refracting power of the lens, with the result that the patient becomes slightly myopic, if, previously, he have been emmetropic.

Gradually, as the opacity extends to other parts of the lens, the acuteness of vision becomes decidedly affected ; and this is the more marked, the more the cortex at the anterior and posterior poles of the lens is involved. In those cases where the equatorial parts of the lens are but little affected, while the polar regions are a good deal affected, the patients see better in the dusk, or with their backs to the light, than when their eyes are exposed to a strong light ; the reason being that in the dusk the pupil is dilated, and light can pass through the clearer periphery of the lens, while in a strong light the pupil is contracted. On the other hand, when the opacity is confined rather to the equator of the lens, a strong light is not disturbing to sight ; or, if the centre of the lens be quite clear, a strong light may even be agreeable to the patient.

According as the lens becomes more opaque, the acuteness of vision is proportionately reduced, until, finally, even large objects cannot be discerned, and only quantitative perception of light remains. Some cataracts, however, when quite ripe, still admit of finger-counting at a few feet.

In advanced stages of the disease, when the opacities occupy a great portion of, or the entire cortex, they are easily recognised even by ordinary daylight, often giving a greyish appearance to the pupil.

Inflammatory exudation of some standing in the area of the pupil would afford a somewhat similar appearance, but would be attended by other signs of the previous inflammatory process, such as synechiæ, disorganisation of the iris, etc., and the opacity would be seen to lie more in the plane of the iris than does any lental opacity.

The length of time occupied by the ripening of a cataract varies in different cases from a few months to many years. In very old persons the progress is, in general, more rapid than at an earlier time of life. That form which commences at the equator as fine lines is slower than that with flocculent opacities, or than that in which the cortex around the nucleus is likewise implicated at an early period.

All examinations as to the condition of the lens are rendered easier and more conclusive if the pupil be previously dilated; but the tension of the eye should be ascertained before a mydriatic is instilled, lest glaucoma, or a tendency to it, be present.

Treatment.—No external local applications, nor internal medicines, are of any avail in the treatment of cataract at any stage. Removal of the cataract from the eye by operation is the only cure for blindness caused by it.

In cases of incipient cataract, or in those, rather, which have advanced somewhat beyond this stage, we often find that vision is improved, or made more pleasant, by the wearing of tinted glasses to moderate the light. With commencing cataract, where slight myopia has come on, low concave glasses for distant vision will, for a time, be found of service; while, for reading, stenopæic glasses sometimes give good results. Yet, as a rule, patients are unwilling to avail themselves of any of these aids.

Dilatation of the pupil is in many cases of great benefit, especially where the nucleus is much more opaque than the cortical portion; but sometimes the resulting diffusion of light is distressing to the patient, and greater impairment and confusion of vision are produced.

Patients with incipient or advancing cataract may, with impunity, be allowed to make every use they can of the sight they possess;

and the surgeon should give them hints as to the arrangement of light in their rooms, and for their work, etc., so as to enable them to employ their sight to the best advantage.

The truly distressing period in the progress of cataract, when both eyes are affected, lies between the advent of that degree of blindness which incapacitates the patient for reading or writing, or for making his way about alone, and the occurrence of maturity, or of that degree of maturity which is deemed requisite for successful removal. This is often a lengthened time. Fortunately, in many instances the cataract in one eye is much more advanced than that in the other; and then no such trial need be passed through.

The question is often asked by patients, whether the cataract in one eye should be extracted until both eyes are blind. The answer is:—A patient with one mature cataract, and the other progressing towards maturity, should have the ripe cataract removed. Hypermaturity is thus avoided, and also the stage of blindness above referred to. Again, if there be a ripe cataract in one eye, and not even incipient cataract in the other, it is often advisable to operate for the purpose of increasing the binocular field of vision.

* *Artificial Ripening.*—For the purpose of hastening the maturity of a cataract, when the patient has become incapacitated, the following method is sometimes used. The anterior chamber is paracentesed, and, when the aqueous humour has flowed off, the lens is massaged with gentle circular motions, with the angle of a strabismus hook, or other suitable instrument, applied to the anterior surface of the cornea. The circular massage must be applied, through the cornea, to the entire surface of the lens as far as its very periphery. Within forty-eight hours the cortex becomes opaque. The proceeding acts by deranging the epithelium of the anterior capsule, after which the aqueous humour can pass through the intact capsule, and produce disorganisation of the lens fibres, as occurs after the operation of discission. Care must be taken that the pressure be not too great, or the capsule may be ruptured, or severe iritis may be caused. This measure is employed less frequently, since it has become the practice to extract cataract in many cases before maturity is reached.

Complete Congenital Cataract.—Children are sometimes born with crystalline lenses opaque in all their layers, while the other tissues of the eye are healthy. With congenital cataract defects

of the chorioid or retina, or congenital amblyopia without ophthalmoscopic appearances, are also sometimes present, and are usually indicated by nystagmus.

Treatment.—Discission.

Complete Cataract of Young People.—The spontaneous occurrence of total acquired cataract in the youthful lens is of rare occurrence, and its pathogenesis is unknown.

Treatment.—Discission.

Diabetic Cataract.—This is a complete opacity of the crystalline lens occurring in diabetes, but the immediate cause of the cataract is not known. The cataract does not differ in appearance or consistency from other cataracts, according to the time of life of the patient.

Treatment and Prognosis of Diabetic Cataract.—A few cases have been recorded in which upon reduction of the sugar in the urine, by suitable anti-diabetic treatment, the central opacity disappeared; but, as a rule, extraction of the cataract is the method which must be relied on to restore sight, and contrary to a very general opinion, these cases are not very unfavourable for extraction operations. We have operated on cases of this kind, and always with success, save once, when the eye was lost by intra-ocular hæmorrhage; and we have seen such cases operated on successfully by others. Occasionally patients operated on for diabetic cataract die of coma within a fortnight or so after the operation, and hence, when operation is contemplated, it is necessary to submit the possibility of this occurrence to the patient.

Glass-Blower's Cataract.—Glass-blowers are very liable to cataract. Whether this is due to the great heat to which their eyes are exposed, or to the congestion in the blood-supply of the uvea caused by the repeated act of blowing, or to some other cause, is unknown.

Treatment.—Extraction.

* **Black Cataract.**—This name, as above stated, is sometimes given to cases of extreme sclerosis of the lens, in which it assumes a dark brown colour; but in other cases the lens is really black, the pigment being derived from the blood (hæmin, and hæmatin). The prognosis for an operation in these latter cases is not good, as they are often complicated with disease of the chorioid, or with hæmorrhage in the vitreous humour.

Partial Cataracts.

These are nearly all congenital.

* **Central Cataract.**—This is a congenital and usually non-progressive form. It is an opacity of the central, or oldest, lens-fibres, while the peripheral layers remain clear.

Treatment.—Discission, or iridectomy.

Zonular, or **Lamellar, Cataract.**—This is congenital, or forms in early infancy, and is the most common kind of cataract in children. It usually is present in both eyes, but it has been seen in one eye only. In it the very centre of the lens is clear (Fig. 79, diagrammatic), while around this is a cataractous layer or zone, and outside that again the peripheral layers are transparent. The majority of these cases are not progressive, but occasionally the whole lens does become opaque, and usually then there have been previously some slight opacities in the otherwise clear cortical layers.



Fig. 79.

With oblique illumination, the cortical layers of the lens are seen to be clear, while towards the centre of the lens a uniform grey circular opacity will be observed. The diameter of this opacity may be small, perhaps not more than 3 mm. or 4 mm., or it may extend very nearly to the equator of the lens. If the pupil be dilated, and the lens examined with transmitted light, the cataractous portion will appear as a more or less dark disc in the centre of the lens, while all around it is seen the red light reflected from the fundus oculi. The centre of this disc is either of the same degree of darkness as its margin, or but very little darker; and this fact serves to distinguish this form of cataract from one in which the whole centre of the lens is opaque. In the latter case it is evident that the centre of the opacity must be darker than its margin. In many cases small radial opacities are seen round the equator of the lens, passing from the anterior to the posterior surface, their concavity embracing the circumference of the central opacity. They are called riders (Fig. 79).

It has been held that lamellar cataract is due to some transient disturbance of nutrition in utero, occurring at the time the affected layers of the lens are being laid down. But against this view is the fact that one half of the lens only may present the appearance of zonular cataract. The subjects of it are usually rachitic, as shown

by the irregular and imperfect development of the teeth (Fig. 80), and by rachitic alterations in the bones of the skull. Convulsions during infancy in these patients are common.

The Treatment of central lental cataract and of zonular cataract is similar, and consists either in elimination of the lens by discission, or in the formation of a narrow coloboma downwards and inwards by means of iridectomy. The latter is very decidedly to be preferred in those cases in which the central opacity is so small that, on dilatation of the pupil, the acuteness of vision, with the aid of a stenopæic slit, is increased in a satisfactory degree. When the improvement so produced is but slight, the operation of discission is indicated. The advantage of iridectomy over discission, when the former can be adopted, is that no spectacles are afterwards required, and that the power of accommodation is retained.

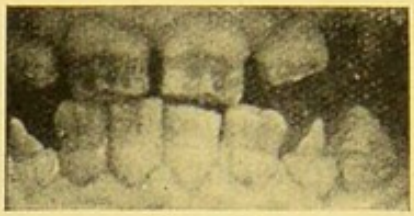


FIG. 80.

Congenital cataracts may be needled any time after dentition is completed.

Anterior Polar, or **Pyramidal, Cataract** may be either congenital or acquired. In the former case it must be referred to some inflammatory disturbance occurring about the third period of development of the lens. In both cases the mode of origin of the opacity is the same, whether it be punctiform, flakelike, or pyramidal—namely, by contact of the lens with an inflamed cornea. In fœtal life this may occur without any perforation of the cornea, as there is then no anterior chamber. Fig. 81 shows a case, in which in the left eye a filament connects the disc-like anterior polar cataract with an opacity of the cornea. In the right eye there is a pyramid-shaped cataract. After birth a perforating ulcer of the cornea is a necessary precursor of this form of lental opacity, but the ulcer need not be central (p. 62). This contact with an inflamed and ulcerating cornea leads to subcapsular cell-proliferation, at that portion of the capsule which is exposed in the pupillary area, and to consequent subcapsular opacity in this small area.

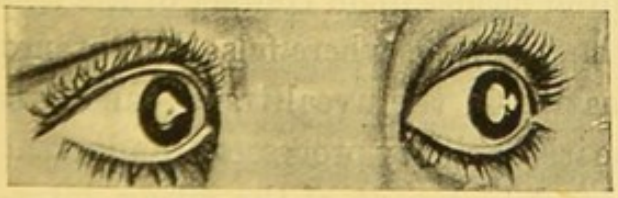


FIG. 81.

No *Treatment* is required, as vision is not affected.

* **Fusiform,** or **Spindle-Shaped, Cataract** is also congenital, and is rare. It consists in an axial opacity extending from pole to pole, and may be combined with central or lamellar opacity.

The foregoing forms of cataract, with the exception, perhaps, of the anterior polar and genuine black cataract, are primary; that is to say, they are not dependent on, nor are they the results of, disease in other parts of the eye.

Posterior Polar Cataract.—An opacity at the posterior pole of the lens may occur congenitally.

Secondary, or Complicated, Cataract.

Some diseased states of the eye give rise to cataract.

Of this a partial kind is

* **Posterior Polar Cataract.**—Besides the congenital variety, posterior polar cataract may be acquired. This form is seen, with transmitted light, as a star-shaped or rose-shaped opacity in the most posterior layers of the posterior cortical substance, its centre corresponding with the posterior pole of the eye.

Posterior polar cataract is usually found in eyes which are the subjects of disseminated chorioiditis, retinitis pigmentosa (p. 319), or diseased vitreous humour. It sometimes progresses, and becomes a complete cataract; and then the prognosis for sight after extraction is not very good, owing to the disease which is present in the deep parts of the eye.

The additional disturbance of sight caused by the presence of posterior polar cataract depends a good deal upon its density.

Total Secondary Cataract often ensues upon contact of the lens with inflammatory products in the eye—*e.g.* where false membranes have been produced by inflammation in the uveal tract; and it is called *Cataracta Accreta*, when the iris or ciliary processes are adherent to it. Cataract is also caused by detachment of the retina, intra-ocular tumour, absolute glaucoma, dislocation of the lens, etc. The reason of this is that the lens, in these cases, imbibes abnormal fluids from the diseased tissues with which it is in contact.

Such cataracts often undergo a further degeneration, and become calcareous. Calcareous cataracts are easily recognised by their densely white or yellowish-white appearance; and almost always

indicate deep-seated disease in the eye, even when the functions, so far as they can be tested, are fairly good.

These secondary cataracts rarely come within the range of *Treatment*, as the diseases which give rise to them are usually destructive of sight. When, occasionally, they can be dealt with they should be extracted.

The term secondary cataract is also used in cases in which, after a cataract extraction, the capsule of the crystalline lens, which is left behind, presents an obstacle to good sight, but here it is not a suitable term. This will be referred to again, and does not come within the scope of this paragraph.

Capsular Cataract.

By this term is meant an opacity of the anterior capsule, or of the capsular epithelium. It is usually confined to the centre or anterior pole, and is most frequently seen in over-ripe senile cataracts, and in secondary cataracts

Traumatic Cataract.

Every perforating injury of the eye which opens the capsule of the lens is liable to cause cataract, by reason of the admission to the lenticular substance of some of the surrounding fluids.

Perforating injuries with sharp instruments, or the entrance of small foreign bodies—in both cases, as a rule, through the cornea—are the most common injuries that produce traumatic cataract. Blows upon the eye, without any perforating wound, also, although more rarely, produce cataract. In these latter cases there is a rupture of the capsule, either at the equator of the lens, or on its posterior or anterior surface.

Within a few hours after a perforating injury of the anterior capsule, the lens-substance in the immediate neighbourhood of the opening becomes opaque, swells, and protrudes, as a grey fluffy-looking mass, through the opening in the capsule into the anterior chamber, where it gradually breaks up, dissolves, and becomes absorbed. It is immediately followed by other portions of the lens which have become cataractous, until, after some weeks, the whole lens will have disappeared, and the pupil will again become

black; and the eye may now see well, if a suitable convex lens be put before it. The swelling and absorption of the lens is all the more rapid, the larger the opening in the capsule and the younger the patient.

But the course of events just sketched is the most favourable one, and is hardly likely to take place in a case which is wholly untreated. In the first place the swelling of the lens—especially if, in consequence of a wide opening in the capsule, it be rapid—is liable to irritate the iris, and to cause iritis; or to push the periphery of the iris forwards against the periphery of the cornea, block the angle of the anterior chamber, and cause secondary glaucoma (p. 256).

Moreover, violent plastic or purulent uveitis may come on, as the consequence of the introduction of infective matter on the perforating object, or foreign body, which causes the cataract. Where this occurs, the case enters the category of diseases of the uveal tract; and the cataract, as such, becomes a minor consideration.

Again, we sometimes meet with traumatic cataracts which do not undergo absorption, but simply remain stationary; or, in the course of years, they may undergo secondary changes, similar to those which occur in senile cataract. In these instances, the trauma is usually a blow on the eye, not a perforating injury: and it is believed that the rupture of the capsule closes soon after the blow, and hence no lens matter can escape into the anterior chamber; also, the rupture in many of these cases is probably at the equator of the lens, where the aqueous would not readily gain access to the lenticular substance.

Occasionally, cataracts caused by blows on the eye (concussion cataracts) take the form of posterior polar cataracts, very similar to those seen sometimes with chorioiditis and retinitis pigmentosa (chap. xi.), the rest of the lens remaining transparent. These traumatic posterior polar cataracts sometimes clear up spontaneously.

Where the cataract is produced by a small foreign body, which has passed through the cornea and into the lens, it is a matter of importance, for the prognosis, to decide whether the foreign body be in the lens, or have passed through it into the deeper parts of the eye. In the former case we may hope to extract it with the cataractous lens; while in the latter case we must fear that it will set up dangerous inflammatory reaction. In such cases the lens should be

well searched with focal illumination, and the transmitted light may also be of use; but in these traumatic cataracts there are often glittering sectors in their deep parts, which may readily be mistaken for a metallic foreign body. If the foreign body be of steel or iron, the sideroscope may be employed for its detection, or the Röntgen rays can be utilised (chap. x.).

Very rarely the capsule has been opened, and yet the lens has not become opaque; and, also, very rarely, after a perforating injury, the opacity which formed has cleared away again. The latter event is more frequently seen in cases of traumatic posterior polar cataract than in other cases.

Treatment.—The pupil should be kept dilated with atropine, in order to draw the iris out of the way of the swelling lens matter; and nothing more is necessary if complications do not arise. But should iritis, or high tension, come on—and the surgeon must constantly test the tension—it is important, without further delay, to extract as much as possible of the cataract. This may be done either without an iridectomy, through a linear incision some 10 mm. long in the upper third of the cornea, or with an iridectomy, through an incision in the upper margin of the cornea.

If a foreign body be present in the lens, extraction of the latter with the foreign body should invariably be undertaken.

Where violent purulent or plastic uveitis is set up by the trauma, the treatment resolves itself into that required for these inflammations (chap. vii.).

* Operations for Cataract.

With regard to the *State of Health of the Patient* about to be operated on for senile cataract it is desirable, as in every operation, that it should be good. Yet, we have so often in these cases to deal with very old people, that we cannot in every instance require sound organs and a robust constitution; and, as a matter of experience, serious disease of the heart, lungs, and liver, even when they all existed in the same individual, have not proved any impediment to a successful operation. Diabetes is no absolute contra-indication, although, as already stated, coma does sometimes ensue, and even in the presence of Bright's disease a successful operation may be performed. Very advanced years, even up to one hundred, form no obstacle.

The State of the Eye itself should be carefully investigated prior to proposing, or undertaking, an operation for cataract, and is a more important matter than the patient's general health. Above all things, it is to be determined whether there be intra-ocular complications, which would neutralise the result of a successful operation, such as detachment of the retina, disseminated chorioiditis, atrophy of the optic nerve, etc. The examination of the eye before the lens has become opaque, if the surgeon have had that opportunity, will provide the most reliable data ; and, for this reason, a careful note should be taken of the condition of the fundus in each case of incipient cataract. The examination of the fundus of the fellow eye, if its lens be clear, may help in determining the point, in so far as those intra-ocular diseases are concerned which are apt to be binocular ; but retinitis pigmentosa, which is usually binocular, is no contra-indication to operation (Doyne). Again, the condition of the anterior capsule of the lens should be observed, for a defined glistening white square patch, about 2 mm. broad, situated in the centre of the capsule, tells the tale of intra-ocular mischief. It cannot be confounded with the more diffused striated and punctated capsular alterations due to over-ripeness.

Finally, the functions of the eye should be examined. With an uncomplicated cataract of the most opaque kind, good perception of light should be present, so that the light, say, of a candle some two metres distant may be distinguished. In less dense cataracts, fingers may be counted at 1 m. or 1·5 m., even when full maturity has been attained. The field of vision must be examined by means of the 'projection' of light—*i.e.* the position of a lighted candle held in different parts of the field should be recognised by the patient, who is required to point his finger in the direction of the light, as it is moved rapidly from one part of the field to another. This examination is usually made by means of the light reflected from the ophthalmoscope mirror. If the patient fail to project the light in any direction, a diseased condition in the corresponding part of the retina may be suspected. Yet, in cases of very old uncomplicated cataract, the patients often project the light in some one direction, no matter where it may come from. A certain degree of intelligence on the part of the patient is required for this test.

By the foregoing means, most of the intra-ocular complications of a serious nature can be detected ; but there is at least one against

which there is no safeguard, namely, a small circumscribed spot of chorioido-retinal degeneration at the macula lutea (central senile chorioiditis, p. 196). After removal of a cataract from an eye affected in this way, the patient's vision is so much improved as to enable him to go about alone; but reading will still remain an impossibility for him, and to that extent the result of the operation will be a disappointment to patient and surgeon.

The Cornea should be Examined.—Such corneal opacities as would seriously compromise vision may contra-indicate the operation; but slighter opacities, discernible only with oblique illumination, would merely diminish the future acuteness of vision, and would require a corresponding prognosis to be given before operation.

The Condition of the Appendages of the Eye, too, must be examined. Should there be any conjunctivitis, or blepharitis, it ought to be cured or alleviated before the operation is undertaken.

In cases of dacryocystitis, extirpation of the lacrimal sac is imperative, prior to a cataract extraction. Should the precaution be neglected, infection of the wound with disastrous results is very likely to ensue.

Extraction of Cataract.

* **Linear Extraction.**—The extraction through a linear incision in the cornea is applicable only to soft, or fluid, cataracts, in persons under the age of twenty-five. The instruments required are:—A spring lid speculum, a fixation forceps, a broad keratome or a Græfe's cataract knife, a cystotome, and a spatula. The pupil is contracted with eserine.

The eye having been cocainised, and the speculum applied, a fold of conjunctiva close to the margin of the cornea, and at the inner end of the horizontal meridian of the latter, is seized (Fig. 82) with the fixation forceps, and the eye fixed by it throughout the operation. The point of the keratome is now entered into the cornea in its horizontal meridian, about 4 mm. from its outer margin, and is passed into the anterior chamber; or, the incision may be made in the upper part of the cornea. The blade of the knife is then laid in a plane parallel to that of the iris, and pushed on until the corneal incision has attained a length of 6 or 7 mm. The point of the knife being now laid close to the posterior surface of the cornea—in order

that no injury may be done to the iris or lens when the aqueous humour commences to flow off—the instrument is very slowly withdrawn, so that the aqueous humour may come away gradually, without causing prolapse of the iris. In withdrawing the knife it is well to enlarge the inner aspect of one or other end of the wound, by a suitable motion of the instrument in that direction.

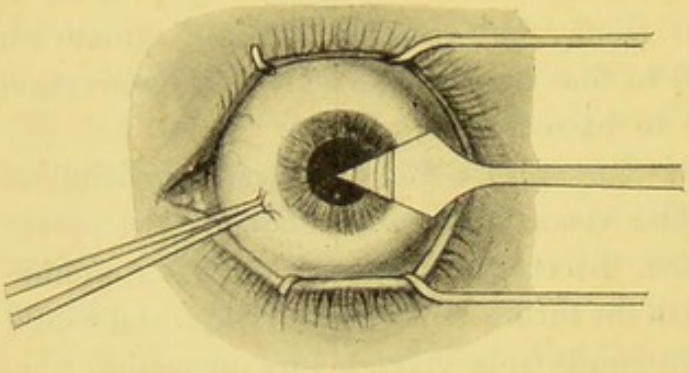


FIG. 82.

The keratome being now laid aside, the cystotome is passed into the anterior chamber (Fig. 83) as far as the opposite pupillary margin, care being taken, by keeping the sharp point of the instrument directed either up or down, not to entangle it in the wound or in the iris. The point is now turned directly on to the anterior capsule, and, by withdrawing the cystotome towards the corneal incision, an opening in the capsule of the width of the pupil is produced. The cystotome is then removed from the anterior chamber, with the same precautions as on its introduction.

The spatula is then placed on the outer lip of the wound, and the latter is made to gape somewhat, gentle pressure being at the same time applied to the inner aspect of the eye by the fixation forceps, and in this way the lens is evacuated. When the pupil has become quite black the operation is concluded. If pressure do not at first clear the pupil completely, the speculum should be removed, the eyelids closed, a compress applied, and a few minutes allowed to elapse, in order that some aqueous humour may be secreted. A renewal of the efforts to

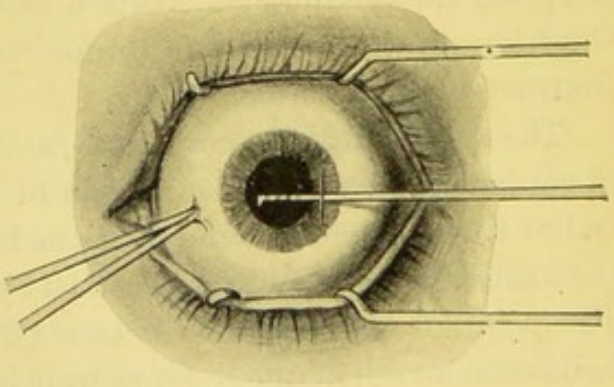


FIG. 83.

clear the pupil will probably now be successful, or, if not, another pause may be made, and then fresh attempts employed until the pupil is quite clear. Fragments may be fetched out of the anterior chamber with the spatula, or they may be washed out of it with a suitable syringe or irrigator. Should some fragments be left, no ill results need necessarily follow, although iritis is more apt to supervene than if the lens be thoroughly evacuated. Fragments left behind become absorbed. If there be a prolapse of the iris which cannot be reposed, it must be abscised.

***The Three Millimetre Flap Operation,** or, as it is more commonly called, **The Combined Operation** (*i.e.* combined with an iridectomy). For success in the cataract operation, it is necessary, not only to select a rational method, but also to devote the utmost attention to a series of minute details in its performance. We shall describe the operation as we are in the habit of performing it.

Preparation of the Patient.—A gentle purgative is given the day before the operation, so that the bowels need not be disturbed for two days after the operation. The face is washed with hot water and soap, shortly before the operation.

Preparation of the Eye.—Half an hour before the operation, a drop of a sterilised 2 per cent. solution of sulphate of eserine is instilled. Just before the operation, at intervals of two minutes, three drops of a sterilised solution of adrenaline (1 in 1000) containing 3 per cent. of cocaine are dropped into the eye. Finally, the lids having been everted, the conjunctival sac is thoroughly washed out with sterilised physiological solution of common salt, particular attention being paid to the fornix of each lid, and to the inner and outer canthus. Then the skin of the eyelids and immediate surroundings of the eye are freely washed with the same solution.

Preparation of the Instruments.—Immediately before the operation the instruments are sterilised by boiling, and are then plunged for a moment into absolute alcohol, laid on a sterilised porcelain tray, and covered with a sterilised cloth, until required for use.

During the Progress of the Operation, small pledgets of sterilised lint, wet with the sterilised salt solution, are employed to wipe away coagula, cortical masses, etc., and are not used a second time. An assistant should place the instruments in the surgeon's hand in their turn, and take out of his hand those he has used, in such a

manner as to render it unnecessary for the operator to look away, even for a moment, from the field of operation.

The Operation.—A spring wire lid-speculum is applied. The eye is fixed with a catch fixation forceps by a fold of conjunctiva and sub-conjunctival tissue, below the vertical meridian of the cornea, or a little to one side of this line (Fig. 84).

The point of the knife is entered just outside the margin of the clear cornea, at the outer extremity of an imaginary horizontal line which would pass 3 mm. below the summit of the cornea. This line is easily found by placing the knife, which is about 2 mm. broad, horizontally across the cornea, so that a margin of clear corneal tissue 1 mm. broad may remain exposed between the knife and the summit of the cornea. The knife is then passed cautiously through the anterior chamber, and the counter-puncture is made just beyond the corneal margin at the inner extremity of the horizontal line described (Fig. 84), and the incision is then finished in the sclero-corneal margin by a few slow to-and-fro motions of the knife. The blade will then be found to be under the conjunctiva, of which a flap is formed in cutting out.

While the incision is being made, the aqueous humour flows off, but, owing to the action of the eserine instilled before the operation, the iris does not prolapse.

The Second Stage of the Operation consists in an Iridectomy. The fixation of the eye having been given over to the assistant, the iridectomy is performed by passing a curved iris forceps into the anterior chamber, seizing the smallest possible portion of the sphincter of the iris at a point corresponding with the centre of the incision, drawing it out, and with the forceps-scissors excising a very small central bit of iris. This should be done by approaching the forceps-scissors from over the cornea—*i.e.* at right angles to the wound—the iridectomy being thus made with one snip of the instrument, and, if care be taken to keep the blades close to the forceps, a narrow, neat coloboma will be obtained. A Tyrrell's hook, instead of a forceps, may be used to draw out the iris, and this stage of the operation is thereby rendered less painful, as the pinching of the iris with the forceps causes pain. A small coloboma, say of 2 mm. to 3 mm. in width, as in Fig. 71, is sufficient to allow of an easy delivery of the lens by doing away with the resistance of the sphincter iridis, and to prevent secondary prolapse of the iris (*vide*

infra); and its advantages over a wide iridectomy, from an æsthetic point of view, are obvious. It should be the object of the surgeon to obtain the smallest possible coloboma. The procuring of a neat coloboma is much facilitated if, prior to the operation, the pupil has been contracted (Fig. 84) by the instillation of one or two drops of solution of sulphate of eserine, as above recommended.

The Third Stage of the Operation is the Capsulotomy. The operator takes the fixation forceps from his assistant, who then raises the speculum and eyelids slightly off the globe, in order that no pressure may be exerted on the latter during the remainder of the operation. The surgeon, passing the cystotome into the anterior chamber, divides the anterior capsule of the lens by two incisions, one passing from the lower pupillary margin upwards and outwards, the other upwards and inwards, as far as the anterior surface of the lens can be seen, while a third incision is made along the upper periphery of the lens. An extensive opening in the capsule is of importance, because otherwise difficulty in delivery of the lens may be experienced, and because a small opening renders the occurrence of secondary cataract more likely. In dividing the capsule it is important not to dig into the lens, as this, in the case of a hard cataract, is apt to dislocate it. A rather oblique application of the cystotome to the capsule is, for this reason, the best.

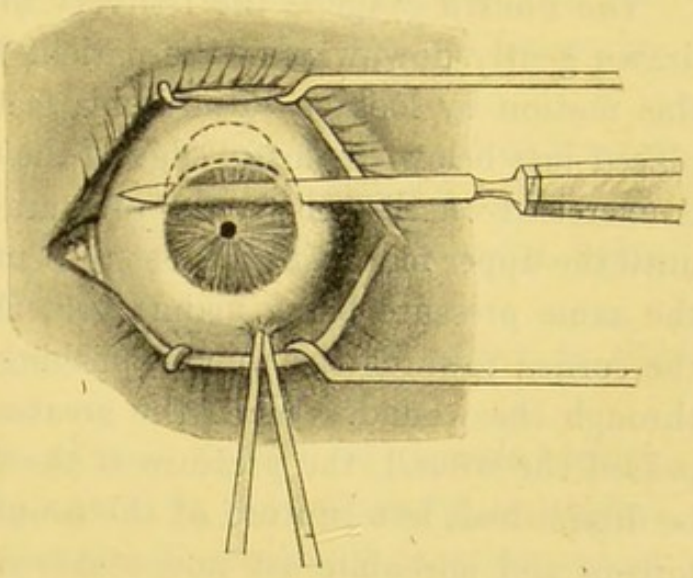


FIG. 84.—Cataract extraction. Position of the knife after the counter-puncture has been made. Lower dotted line indicates where the sclero-corneal incision will be, and the upper dotted line is the outline of the conjunctival flap to be.

The cystotome as it is withdrawn may pull a tag of the capsule into the corneal wound, where it lies until the end of the operation, and where, owing to its transparency, it may easily pass unnoticed.

Such a tag acts as a foreign body, and may subsequently form the starting-point of troublesome complications.

Capsule forceps have been devised for the purpose of taking away a large portion of the anterior capsule, instead of merely dividing it; but this does not altogether obviate the danger of capsule in the wound, nor does it do away with the likelihood of secondary cataract. The method has no advantages over that just described, in cases where the capsule is not thickened. But, when the anterior capsule is thickened, and is therefore almost certain to cause an obstruction to vision, it is always desirable to tear away a central portion of it with forceps.

The Fourth Stage is the Delivery of the Cataract. The eye is drawn gently downwards—the patient being called on to assist in this motion by looking towards his feet; the spoon or spatula is placed just below the lower edge of the cornea, and gentle pressure is exercised on this place, the pressure being gradually increased, until the upper margin of the lens presents itself in the wound, when, the same pressure being maintained, the spoon is advanced over the cornea towards the wound, pushing the lens before it and out through the wound. When the greatest diameter of the lens has passed the wound, the pressure of the spatula should immediately be diminished, lest rupture of the zonula be caused. The fixation forceps and speculum are now removed from the eye, and a cold sterilised compress is laid on the closed lids.

It may be noted that the fixation forceps and the speculum are used until this late stage in the operation. Some operators employ neither fixation forceps nor speculum from beginning to end of the operation; while others discard the fixation forceps when the corneal section is completed, but retain the speculum until after the iridectomy only, delivering the lens with the finger placed on the lower lid. The use of the fixation forceps and speculum until after the lens is delivered gives more security and stability to the operator than the other methods, while it has no counter disadvantages.

The Fifth Stage consists in Freeing the Pupil of any Cortical Masses which may have been rubbed off in the passage of the lens through the wound, and is what is called the Toilette of the Wound. The presence of cortical remains is recognised by the pupil not having become quite black, or by the vision not being such as it ought to be (fingers counted at several feet), or by inspection of the

cataract just removed showing that some portions of it are left behind. The use also of focal electric illumination for the detection of cortical fragments is very advantageous. If any fragments be present, the cold sterilised compress having lain on the eye for a few minutes to enable some aqueous humour to collect, the operator, facing the patient, raises the upper lid with the thumb of the left hand, and then, with the first and second fingers of the right hand laid on the lower lid, he makes light rotatory motions with this lid over the cornea so as to collect the masses towards the pupil, and then with a few rapid light motions upwards, with the margin of the lid, these masses are driven towards, and out of, the wound. Care and delicacy of touch are required in order to perform this lid-manœuvre successfully, without rupturing the hyaloid by undue pressure.

Another useful method for clearing the pupil of cortical masses consists in washing them out by means of a syringe or undine and warm normal saline solution, the point of the instrument being inserted into the anterior chamber.

With an iris forceps the blood-clots which may adhere to the wound are now removed.

To prevent the possibility of any portion of capsule—which may have been drawn into the wound by the cystotome, or pushed into it during delivery of the cataract—becoming incarcerated in the wound during healing, a bent iris forceps is now passed open between the lips of the wound, closed, and drawn gently out again. Frequently a tag of capsule will be captured by the forceps, and is snipped off with the scissors, or it may be that no capsule is caught. The forceps is then similarly inserted at an adjacent part of the wound ; and in this manner the wound is searched from end to end for capsule.

The coloboma has now to be seen to. The peripheral portions of the iris corresponding with the ends of the wound are apt to have become prolapsed in the course of the operation, and to have displaced the angles of the coloboma upwards. If this be not corrected, the prolapsed portions of the iris heal in the wound, and cause bulgings there later on, the pupil in the course of some months becoming drawn up towards the cicatrix. Hence, in every case, even where everything seems to be in order, it is important to pass the narrow spatula into the anterior chamber, and gently to stroke

down each pillar of the coloboma as far as it can be brought. The instillation of eserine, which has been made before the commencement of the operation, will cause the sphincter iridis to assist in producing the desired result. Finally, the conjunctival flap is spread out smoothly into its place, so that it covers the incision in the corneo-scleral wound. All this is aptly termed the toilette of the wound.

The sight of the eye should then be tested by finger counting, as this affords the patient satisfaction, and lends him courage for the next few days of strict quiet. Patients, especially those for whom cataracts with yellowish or orange-coloured nucleus have been extracted, often state now that all objects seem to them to be of a deep blue colour. This is a contrast effect, due to the elimination of the yellow medium through which light had reached the retina. A drop of eserine solution is instilled, to provide further security against prolapse of iris. Finally, the conjunctival sac is flooded with the sterilised saline solution.

The dressing is now applied. A piece of dry sterilised lint, sufficiently large to extend $\frac{1}{4}$ inch beyond the orbital margin in every direction, is laid on the closed eyelids. Pieces of sterilised absorbent cotton-wool are laid on this, the hollows at the inner canthus, etc., being carefully filled up ; so that, when the bandage is applied, it may exert equal and gentle pressure on every part of the eye. Three turns of a narrow roller bandage over the dressing and round the head are applied ; but various other, and doubtless equally good, forms of bandage are in use. The pressure of the bandage need only be sufficient to maintain the dressing firmly in its place. The other eye is closed by a light bandage.

We do not recommend the after-treatment of cataract operations without bandages, as advocated by some surgeons.

Accidents liable to occur during the Operation.—The Incision may be made Too Short, and the delivery of the lens, consequently, may be so difficult that the margins of the wound become contused, and consequently suppuration may be promoted. The zonula, too, may be ruptured by the excessive pressure used to force the lens out through the narrow aperture, and prolapse of the vitreous may ensue. If the directions above given be carefully attended to, the vast majority of both hard and soft cataracts may be extracted without difficulty ; but should the wound be made too small, it can best be

enlarged by the forceps-scissors, or a blunt-pointed knife made for the purpose. Where the presence of an unusually large hard cataract is diagnosed, it is important to make the incision larger *ab initio*, by placing puncture and counter-puncture nearer to the horizontal meridian of the cornea than above directed.

Hæmorrhage into the Anterior Chamber may take place. It may be from the iris, from the corneo-sclerotic margin, or from the conjunctiva. Pressure with the spatula on the cornea, which causes the wound to gape, is often successful in clearing the chamber of blood, which might interfere with accurate division of the capsule. Yet, when this cannot be completely got rid of, the capsulotomy can be performed by the exercise of greater care. Adrenaline dropped into the eye aids in arresting the bleeding.

Prolapse of the Vitreous Humour. This accident may be caused by undue pressure made on the eyeball by the speculum, fixation forceps, or spatula, or by the lower lid during the lid-manœuvre. It may be due to defective zonula with fluid vitreous humour. When the vitreous prolapses prior to delivery of the lens, the latter falls back into the eye, and can only be delivered by at once drawing it out with a vectis ; and the accident is one of the most serious which can occur in the course of the operation, for it is often impossible to reach the lens with the vectis without doing such damage to the eye that sight is lost. Loss of vitreous after delivery of the lens is less serious ; indeed, a considerable portion of the vitreous may then escape without ill result to the eye ; yet it increases the traumatism, and renders inflammatory reaction more liable to occur. Opacities in the posterior chamber of the eye are frequently an ultimate result of loss of vitreous ; but a much more serious consequence is sometimes seen in detachment of the retina.

Normal After-Progress.—Soon after the completion of a normal operation, the effect of the cocaine having passed off, some smarting commences, and continues for four or five hours. After that time, the patient has no unpleasant sensation in the eye, unless it be some itching, or a slight momentary pain, or sensation of a foreign body, especially when the eye is moved under the bandage. The first dressing is made in forty-eight hours, in a manner similar to that immediately after the operation, a drop of atropine being instilled, as also at each successive dressing ; and the sterilised salt solution is used for freely washing the margins of the eyelids, some of it

being allowed to trickle into the conjunctival sac. At this first dressing, it is well to abstain from a very minute or lengthened examination of the eye ; but, if the lid be gently raised, the wound will be found closed, the cornea clear, the anterior chamber completely restored, and the pupil semi-dilated and black. The subsequent dressings are made night and morning, for the purpose of instilling atropine. On the third day after the operation the patient may be allowed to sit up, the room being kept moderately dark ; and on the fifth or sixth day the bandage may be left aside permanently, and dark glasses worn in its stead. In the course of a few more days the patient, having been gradually accustomed to more light, may be allowed out of doors. It is desirable to continue the use of atropine for about a fortnight longer, or until all abnormal vascular injection of the white of the eye has disappeared, as until then there is danger of iritis. (For selection of glasses in aphakia see end of this chapter.)

* *Irregularities in the Process of Healing.*—The pain may continue longer than four or five hours, and it is then well to give a hypodermic injection of morphia in the corresponding temple, so that the patient may not be restless. Should severe pain come on some hours later, it is apt to be due to an accumulation of tears under the eyelids, and it immediately subsides on the bandage being removed, and exit given to the tears by slightly opening the eye.

Late Appearance of the Anterior Chamber. At the first dressing it will sometimes be found that there is no anterior chamber, although the appearance of the wound is satisfactory ; but this need occasion no alarm, as the anterior chamber is sometimes not restored for three or four days. Should a more lengthened absence of the anterior chamber be noticed, it may be due to the presence of a small tag of capsule, or a small portion of iris, in the wound, and it is then desirable to search the latter with a forceps, and to cut off any capsule or iris which may be found there.

Striped Keratitis. At the first dressing, also, it may sometimes be observed that there is a more or less well-marked striated cloudiness of the cornea, extending over nearly the whole of it, or occupying only a part in the immediate neighbourhood of the wound. This opacity is held by some to be the result of injury to the endothelium of the posterior surface of the cornea during the operation. It is this endothelium which protects the cornea from being infiltrated

by the aqueous humour, and the appearance we call striped keratitis is caused by œdema of the cornea. According to another explanation, striped keratitis is due to folding of the posterior layers of the cornea, on account of the difference in tension in the vertical and horizontal directions. Striped keratitis is, for the most part, of no serious import, as it usually passes away in a few days, and leaves the cornea perfectly clear.

Expulsive Hæmorrhage. Soon after the operation—it may be before the patient is removed from the couch—great pain sets in. On removal of the dressings they are found to be saturated with blood, while the corneal flap is turned downwards, the wound is gaping, and through it blood-clot, vitreous, and iris protrude. The hæmorrhage is from the retinal or chorioidal blood-vessels which are atheromatous. The accident, which is rare, cannot be foreseen, and the eye is always lost.

Septic Infection. With careful aseptic measures this is a rare event. When it occurs, it usually does so between the twelfth and thirty-sixth hour after the operation, rarely earlier or later, and is very serious; for, in the vast majority of cases, do the surgeon what he may, it leads to loss of the eye. Its onset is usually made known by severe pain of a continuous aching kind in and about the eye; and it is thus easily distinguished from the slight, short, stabbing pain, with long intermissions, and gradually diminishing intensity, which some patients complain of, and which has no evil import. On removing the bandage the margin of the upper lid will be found œdematous, the eye full of tears, and the wound covered with a layer of muco-pus, which can be removed with the forceps in one mass, while the aqueous humour and cornea may already present some opacity. In some hours more, the corneal opacity increases considerably, the iris becomes distinctly inflamed, and the pupil filled with a mass of inflammatory exudation. In many instances the attack commences as septic iritis. The inflammatory process may remain confined to the wound and iris, and when, in the course of some weeks, it entirely subsides, it leaves the pupil drawn up towards the wound, so that an appearance as in Fig. 85 is presented. Or, the inflammation may strike into the ciliary body and chorioid, and produce purulent panophthalmitis, with total destruction of the eye.



FIG. 85.

To combat Septic Infection the best method is the immediate cauterisation of the corneal wound, if it be the seat of the process, in its whole extent with the galvano-cautery. Also, the wound may be opened up from end to end with a spatula, the aqueous humour evacuated, and the anterior chamber washed out with injections of sublimate solution 1 in 10,000, while the conjunctival sac is irrigated with the same solution. If necessary these measures are to be repeated at intervals of eight or ten hours. Good results have been obtained from use of the staphylococcus vaccine. Sub-conjunctival injections of solution of sublimate 1 in 2,000, or of oxycyanide of mercury 1 in 5,000, are often of use in these cases, if they be commenced very soon after the onset of the attack. Half a c.cm. is to be injected as far back as possible under the conjunctiva once, or even twice, in twenty-four hours ; and from four to eight injections are usually needed according to the severity of the case. Intense chemosis and much pain are caused. To prevent the painfulness of the injection, five drops of a 1 per cent. solution of acoine may be added to the quantity of oxycyanide of mercury solution injected, or to the sublimate injection a few drops of 2 per cent. cocaine solution. Nevertheless very severe radiating pain usually comes on a quarter of an hour later, and continues for several hours. Hot fomentations afford some relief from this pain. The patient should be confined to bed, and a dressing should be applied to the eye.

Plastic Iritis. A few days after the operation plastic iritis, sometimes of a severe type, may come on. It, too, must be reckoned as due to infection during the operation, especially if some lens-substance have remained, for the latter is a favourable nidus for the cultivation of infective material. The iritis is ushered in with the usual symptoms of pain. General plastic uveitis may ensue, and sympathetic uveitis may result. *Treatment* consists in strict confinement to a dark room, with atropine, and sub-conjunctival mercurial injections, and quinine or salicylate of soda internally.

Detachment of the Chorioid. Fuchs has pointed out that detachment of the chorioid occurs some days after cataract extraction, in some of those cases in which the anterior chamber does not form ; or in which, having formed, it becomes empty again. Detachment of the chorioid occurs occasionally after iridectomy unconnected with cataract extraction. It can be seen with the

ophthalmoscope, and sometimes even with focal illumination. Vision while the lesion is at its height is seriously affected, but the prognosis is good, for the detached portion always becomes reposed.

Cystoid Cicatrix. After convalescence, the cicatrix in the corneal margin sometimes becomes prominent and semi-transparent, presenting the appearance of a vesicle, and may attain a large size. The extremities of the incision are the most common positions for this condition, but it may occupy the entire length of the cicatrix. It does not generally appear for some weeks, or more, after the operation. In some cases it is caused by a tag of iris which is incarcerated in the wound; but in other cases by a small piece of capsule, which has similarly healed in the wound. Irregularity in curvature of the cornea, and consequent irregular astigmatism, are the least of its evil consequences. If the condition be caused by incarceration of iris, the pupil will be gradually drawn close to the upper corneo-sclerotic margin; while, if it be caused by a portion of capsule, irido-cyclitis may be produced. Whether the iris or the capsule be the cause, these eyes are always exposed to the danger of a sudden onset of purulent irido-chorioiditis (p. 197). All this demonstrates the immense importance of attention to those details of the operation, which are calculated to obviate incarceration of iris, or of capsule, in the cicatrix.

* **Cataract Extraction without Iridectomy,** or, as it is more commonly termed, **The Simple Operation.**—This method differs from the Combined Operation, in that the incision occupies a greater extent (about one-third) of the circumference of the cornea, and that no iridectomy is made. The round pupil, and consequent prettier appearance of the eye, and the diminished tendency to loss of vitreous, and to incarceration of the capsule, are the advantages this procedure has over the Combined Operation as above described; for vision with a circular pupil is not better than where a narrow coloboma has been made.

On the other hand, the extraction without iridectomy exposes the eye to the serious danger of prolapse of the iris into the wound some hours, or days, after the operation. An iridectomy must be made in all cases in which the iris cannot be satisfactorily reposed after delivery of the lens. These cases are, however, few in number. But, even when the iris can be well reposed, security against the occurrence of a prolapse within the first two or three days after the

operation is not obtained ; nor does eserine, nor any other means, provide the desired safeguard. Prolapse of the iris does take place after a number of these operations, and there is no means of foretelling in what eyes it will occur. The prolapsed portion of iris heals in the wound, which then, in a few weeks, becomes more or less cystoid and bulging, causing displacement of the pupil and irregular curvature of the cornea, with resulting deterioration of vision. Nor is this all ; for such eyes are liable—weeks, months, or even years after the operation—to take on severe irido-cyclitis, ending in total loss of sight. Another disadvantage of the operation is that removal of cortical remains cannot be so effectually performed as where a coloboma has been made.

Why it is that in the simple extraction prolapse of the iris with subsequent incarceration is more liable to occur, even some days after the operation, than in the combined operation, and why it is difficult to devise a sure means for preventing the accident, as, also, how even a very narrow coloboma is almost always sufficient to protect the eye from this accident, can be explained as follows :— Within a few hours after the operation the wound in the corneal margin commonly closes, the aqueous humour collects, and the anterior chamber is restored. But it takes many hours more for the delicate union of the lips of the wound to become quite consolidated, and during this time it requires but a slight thing—a cough, a sneeze, a motion of the head, the necessary efforts in the use of a urinal or bed-pan, no matter how careful the nursing—to rupture the newly formed union ; and, as a matter of fact, this often does take place. The aqueous humour then flows away through the wound with a sudden gush, and, where the simple extraction has been employed, carries with it the iris. It is that portion of the aqueous humour which is situated behind the iris, which is chiefly concerned in the iris-prolapse ; the aqueous humour in the anterior part of the anterior chamber probably flows off without influencing the position of the iris.

The formation of even a narrow coloboma prevents prolapse of the iris when the wound is ruptured, but this is not because the portion of iris which is liable to prolapse has been taken away, for that would be nothing less than the whole of that part of the iris which corresponds with the length of the wound. The coloboma averts secondary iris-prolapse, by providing a way for the aqueous

humour contained in the posterior part of the anterior chamber to escape directly through the wound, without carrying with it the iris in its rush ; and the narrowest coloboma which can be formed is sufficient for the purpose.

There is practically no disfigurement of the eye from the coloboma, when the latter is narrow, and is situated in the upper part of the iris. The pupil, too, is almost, if not quite, as movable as in most cases of simple extraction ; for a narrow coloboma does not render the pupil immovable. Where there are no adhesions between the pupillary margin and the capsule, as frequently happens, the reaction to light is active, a drop of atropine will dilate the pupil widely, and a drop of eserine will contract it.

* **Extraction in the Capsule.**—The ideal cataract extraction is that in which the opaque lens in its capsule is removed, thereby obviating all subsequent troubles due to the capsule. The objection which has prevented the method from coming into general use is the great danger of prolapse of vitreous which must attend it, owing to the liability of the hyaloid membrane to be ruptured during delivery of the cataract. The operation has been performed by ophthalmic surgeons from time to time, and has recently been cultivated in India by Major Henry Smith. His incision lies in the cornea about 3 mm. below its upper margin, the puncture and counter-puncture being in the corneo-scleral margin, as peripherally as possible. The speculum is then removed, and the assistant raises the upper lid with a strabismus hook, and draws the under lid down with his finger. The curve of a strabismus hook is placed on the cornea in its lower third, and a Daviel's spoon just above the upper edge of the wound. With these instruments gentle pressure and counter-pressure is made, until the lens is more than half delivered ; it is then tilted with the hook, and the delivery is completed. The operation may be done with or without iridectomy, but must be performed slowly and cautiously, else the lens capsule may be ruptured, and the object of the method frustrated. Major Smith, in a large number of cases, had loss of vitreous in only 6·6 per cent.

* *Mental Derangements after Cataract Extractions.*—After cataract extractions, during the period of confinement to bed, passing mental disturbances are sometimes seen in old people. This usually takes the form of confusion of ideas, hallucinations, and terror. It is hard

to assign a cause for it, but probably it is mainly due to the quiet, and to the exclusion of light if a binocular bandage have been applied, following on a period of some anxiety and excitement. A few doses of sulphonal, and permission to sit up—at least in bed—with removal of the bandage from the unoperated eye, will be the best measures to adopt in such a case; and speedy restoration of mental equilibrium may be looked for with confidence. Care should be taken not to mistake the symptoms of atropine poisoning for this form of mental disturbance.

* *Secondary Glaucoma after Cataract Extraction* occurs now and then, by whatever method the extraction may have been performed. This, perhaps, is contrary to what would be expected, in view of the diminished contents of the globe, and especially where an iridectomy has been made. High tension in these instances may come on soon after recovery from the cataract operation, or after a good result has existed for a considerable time. It is due to the corneal epithelium growing into the wound and into the anterior chamber where it spreads over the angle of the latter, and occludes the ways of exit. This is liable to take place in cases in which, for one reason or another, the healing of the wound has been delayed. A wide and peripheral iridectomy, or a sclerotomy, should be made as soon as possible after the high tension shows itself, and by this means many of these eyes may be saved.

* *Erythropsia after Cataract Operations.* For an account of this see chap. xiii.

* *Secondary Cataract.*—The term secondary cataract, as here employed (compare p. 268), usually means a closure of the opening which is present in the anterior capsule after the removal of a cataractous lens, combined with a thickening of the capsule in some cases, whereby an impediment is offered to the rays of light in passing through the pupil. The thickening may have pre-existed in the capsule, or it may be due to subsequent proliferation of the epithelial cells on the inner surface of the capsule. Or, without becoming thickened, the capsule may become wrinkled, and cause irregular refraction of the rays entering the eye and consequent lowering of the vision. The term is also applied to those cases in which, after cataract extraction, an exudation in the pupil, following upon iritis, has occurred. Finally, and very incorrectly, it is applied to the cases which Fig. 85 represents, in which, after suppuration

of the wound with irido-cyclitis, the iris is dragged upwards, and the pupil is consequently obliterated.

The most simple form of secondary cataract occurs as a very fine cobweb-like membrane—the capsule of the lens—extending over the whole area of the pupil, which can often only be discovered by careful examination with oblique illumination. It may not cause any trouble of vision until some months after the extraction, when a little thickening or wrinkling of it may have taken place.

Capsulotomy, as the operation for making a clear opening in this membrane is called, is performed with a Knapp's needle-knife. This instrument has a blade 4½ mm. in length. It cuts on one side only, and the blade andt he evenly rounded shaft are so proportioned that the shaft fills exactly the opening made by the blade, and consequently the needle can be moved within the anterior chamber in every direction, without escape of aqueous or bruising of the cornea. The instrument must be of the utmost sharpness in point and edge, so that it may cut, and not tear. The point of the needle-knife is entered through a thin part of the capsule, and with one sweeping motion of the blade an opening is cut in it, hard and inelastic bands being avoided. Ziegler's knife is also a useful instrument, and for tough membranes a better one. With it a sawing motion is used.

Iridotomy is the operation used for cases (as in Fig. 85) where the iris forms a complete and tightly stretched curtain across the pupil. A vertical incision having been made in the cornea, about 3 mm. long, and the same distance removed from its inner margin, the closed blades—one of which has a sharp point—of de Wecker's forceps-scissors are passed into the anterior chamber. The blades are then opened, and the sharp point of one of them is forced through the stretched iris, and some 3 or 4 mm. behind it. By closing the blades the tightened iris fibres are cut across, and on their retraction a central clear pupil is formed in the iris and retro-iridic tissue.

Ziegler's Operation is performed with his knife, which has a straight, narrow blade 7 mm. long, the shank just fitting the puncture that is made. It is introduced at the upper margin of the cornea, carried to a point 3 mm. from the opposite periphery of the iris, and 3 mm. from the lower end of the vertical meridian. The membrane is then pierced and cut upwards, with a very slight sawing motion. The point of the blade is then carried an equal distance to the

other side of the vertical meridian, the membrane again pierced and cut upwards to the termination of the first incision. The flap of iridic tissue thus formed retracts downwards, leaving a wide triangular pupil.

* **Discission** means the tearing of the anterior capsule of the lens with a needle, so as to give the aqueous humour access to the lenticular fibres, which causes them to swell, and gradually to become disintegrated and absorbed. The larger the capsular opening, the more freely is the aqueous brought in contact with the lens, and the more rapid is its swelling. The rapidity of the swelling. disintegration, and absorption depend, also, on the original consistence of the lens. The softer it is the more rapid is the process, the completion of which may require from a few weeks to many months. It is wise to make the first discission of moderate extent, especially in adults.

The instruments required are a spring speculum, a fixation forceps, and a discission needle. The pupil is to be dilated with atropine.

The eye having been cocainised, the speculum applied, and the eye fixed close to the inner margin of the cornea, the needle is passed perpendicularly through the cornea in its lower and outer quadrant, at a point corresponding with the margin of the dilated pupil ; or, many operators now introduce the needle under the conjunctiva a few millimetres outside the margin of the cornea, and enter the anterior chamber sub-conjunctivally at the sclero-corneal margin. It is then advanced upwards to the upper margin of the pupil (Fig. 86), where it is passed into the capsule, but not deeply into the lens, and a vertical incision is effected by withdrawing the instrument slightly. If an extensive opening in the capsule be wished for, a horizontal incision can be added to the vertical one by a corresponding motion of the needle. During these manœuvres the cornea, at the point of punc-

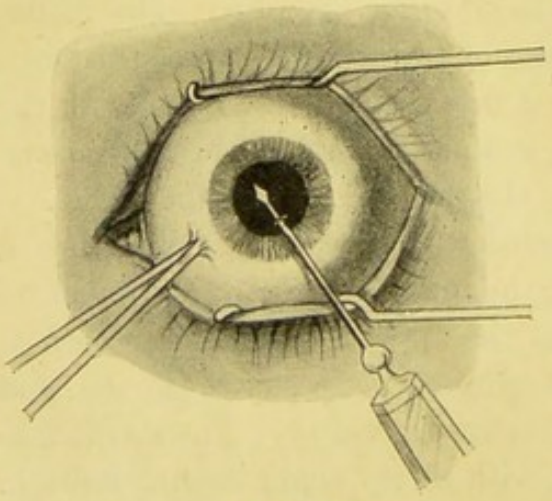


FIG. 86.

ture, must form the fulcrum for the motions of the instrument. The instrument is then withdrawn from the eye, and some aqueous humour escapes through the opening. Atropine is instilled, and the dressing applied. The patient is kept in bed for a day, and then the dressing may be dispensed with, and dark spectacles worn. The iris is to be kept well under the influence of atropine, until the absorption of the lens is completed. Repetition of the operation is called for, if the opening be so small as to admit of but a very slow absorption of the lens, or if, as sometimes happens, the opening should close.

This method is applicable to all complete cataracts up to the twenty-fifth year of age, and to those lamellar cataracts up to the same age in which the opacity approaches so close to the periphery of the lens, that nothing can be gained by an iridectomy (p. 266). After the above age, the increasing hardness of the nucleus, and the increasing irritability of the iris, render the method unsuitable.

Discission is a safe procedure, when used with the above indications and precautions. The danger chiefly to be feared is iritis, from pressure on the iris of the swelling lens masses. When this occurs, or is threatened, removal of the cataract by a linear incision in the cornea should be at once performed.

Another danger consists in glaucomatous increase of tension (secondary glaucoma), which may come on without any subjective symptoms—although severe pain usually attends it—while the absorption of the lens is still running its proper course. It may happen, consequently, that, when absorption of the cataract is completed, the eye will be found blind from glaucoma. Frequent testings of the tension of the eye during the cure are therefore a most important precaution. Should the tension rise, removal of the lens through a linear incision in the cornea is at once indicated.

Dislocation of the Crystalline Lens.—This may be congenital (p. 292), or it may be the result of disease, such, for example, as anterior sclero-chorioiditis; or it may be caused by a blow on the eye.

The dislocation due to disease or trauma may be partial or complete. Partial dislocation is often so slight as to be discoverable only when the pupil is widely dilated, the margin of the lens becoming then visible, by aid of the ophthalmoscope mirror, as a curved black line in some one direction; or, the displacement may be so great

as to bring the margin of the lens across the centre of the undilated pupil, in which case one part of the eye will be highly hypermetropic, while in another part it will be myopic. Complete dislocation may take place into the anterior chamber, into the vitreous humour, or even under the conjunctiva, if the sclerotic have been ruptured.

The symptoms in partial dislocation are those of loss of power of accommodation, and monocular double vision. Iridodonesis (*i.e.* trembling of the iris when the eye moves) is present, as a rule, in consequence of the loss of support provided for the iris by the lens. The anterior chamber is caused to be shallow at one part by pressure of the dislocated lens against it, while at any part where the lens does not press against the iris it is deep. In complete dislocation the symptoms are those of aphakia—*i.e.* extreme hypermetropia, and want of power of accommodation.

Treatment.—In partial dislocation it is rarely that any treatment can be of service. The prescribing of spectacles suited, so far as it is practicable, to the faulty refraction is indicated. In complete dislocation of the lens into the anterior chamber, its extraction is usually required, especially if it cause symptoms of irritation. Dislocation into the vitreous humour is generally unattended by irritation; but when the latter does arise, removal of the lens by aid of a spoon, through a peripheral corneal incision, has to be attempted.

* **Congenital Defects of the Lens.** *Congenital Cataract* (pp. 264, 266, 267).

Ectopia of the Lens (Congenital Dislocation).—This is often hereditary, and often present in more than one member of a family. The displacement is more frequently in an upward direction than in any other. It is usually in both eyes of the patient. It is due to a mal-development of the zonula of Zinn, which in these cases is shorter in the direction towards which the lens is luxated. Discission or extraction is not indicated here. Occasionally some advantage is gained for vision by the correction with glasses of one or other portion of the doubly refracting eye.

Coloboma of the Lens.—Coloboma of the lens often co-exists with coloboma of the iris (p. 233), but may be present alone. It is generally in the lower periphery of the lens.

Lenticonus.—This is a rare congenital anomaly of the lens, in which its anterior surface, or, still more rarely, its posterior surface

is cone-shaped. The derangements of vision are very similar to those caused by conical cornea.

Aphakia (*ἀ, priv.*; *φακός, a lentil, lens*), or **Absence of the Crystalline Lens.**—The emmetropic eye after the removal of a cataract becomes highly hypermetropic, and its power of accommodation is lost. Consequently, in order that the eye may have the best possible sight for distant objects, a high convex glass has to be experimentally found to suit it, and yet stronger lenses must be prescribed for shorter distances.

The degree of vision obtained varies considerably in different cases; frequently $V = \frac{6}{6}$ is obtained, but $V = \frac{6}{18}$ may be regarded as a satisfactory result; and even lower degrees, which enable the patients to find their way about with comfort, are classed as successful operations. The vision often improves for some months after the operation, patients who at first obtained only $\frac{6}{18}$, or so, advancing up to $\frac{6}{9}$ or $\frac{6}{6}$. For reading, writing, etc., at about 25 cm., a still higher convex glass must be provided. If the correcting lens for distant vision be + 10 D, its power, for the purposes of vision at 25 cm., must be increased by the lens which would represent the amplitude of accommodation from infinite distance up to 25 cm. This lens is 4 D (because $\frac{100}{25} = 4$); therefore + 14 D is the lens required for reading, etc. With these two lenses the majority of cataract patients are satisfied. For distinct vision at middle distances, they learn to vary the power of the lenses by moving them a little closer to, or farther from, the eye; but, if necessary, a lens can be prescribed for distinct vision at any desired distance.

In the case of hospital patients, one is often obliged to select the + glasses a fortnight or three weeks after the operation, but the result is more satisfactory when the selection can be postponed for six weeks or two months. Permanent wearing of the + glasses should not be permitted until all redness of the eye has passed off, and this varies in different cases. Until then, also, dark protection spectacles should be worn.

In the majority of cases, after cataract operations, the best vision is not obtained unless a certain degree of astigmatism is corrected. This astigmatism is caused by a flattening of the vertical meridian of the cornea, due to the cicatrix at its upper margin, and hence it is against the rule (chap. xv.), so that the axis of the + cylinder is generally parallel to the incision. An obliquity in the

incision often produces an obliquity in the principal meridians of the astigmatism. The degree of astigmatism varies, and may be very high. It rapidly reaches its maximum after the operation, and then gradually diminishes for weeks or months, and in some cases completely disappears; hence it is that glasses for permanent use can be better prescribed a month or two subsequently to the operation.

CHAPTER X.

*DISEASES OF THE VITREOUS HUMOUR.

Purulent Inflammation of the Vitreous Humour occurs only as the result of perforating injuries, or of the lodgment of a foreign body, or as an extension of a purulent process from the chorioid (p. 197).

Ophthalmoscopically, a purulent deposit in the vitreous humour gives a yellowish reflection, when light is thrown into the eye with the ophthalmoscope mirror, or on examination with oblique light.

The condition, if at first confined to the vitreous humour, usually soon extends to the surrounding tissues, and leads to panophthalmitis (p. 197) and complete destruction of the eye.

But, in some cases of purulent chorioiditis, where the inflammatory process is not very acute or violent, there may be little or no outward signs of inflammation—there may be no iritis or irritation of the eye. In these cases difficulty is often experienced in making a diagnosis between abscess of the vitreous and glioma of the retina (p. 328), in which latter disease, too, a whitish or yellowish reflex is obtainable from the vitreous chamber. These cases of 'quiet' purulent infiltration or abscess of the vitreous humour (so-called pseudo-glioma), the result of subacute purulent chorioiditis, occur in cerebro-spinal meningitis, the acute exanthemata, with foreign bodies in the vitreous, and under some other as yet obscure conditions. Tubercle of the chorioid may also give rise to the appearance. The history of the case and low tension of the eye in abscess are often the only guides in diagnosis; but iritis, or posterior synechiæ, and retraction of the periphery of the iris, with bulging forwards of its pupillary part, and turbidity of the vitreous, if these be present, speak for abscess, while a lobulated appearance is not so common as in glioma. Occasionally, however, a sure diagnosis is not only difficult, but impossible. Yet if a case of abscess of the vitreous humour be taken for glioma of the retina, the error is not

practically serious, for if excision of the eyeball be recommended for a case of abscess it will be done on an eye which is hopelessly blind, and which would become phthisical and disfiguring. The diagnosis may perhaps be assisted by means of transillumination (p. 224).

* **Inflammatory Affections of the Vitreous Humour, other than the purulent form,** are for the most part the consequence of diseases of the chorioid (including those which accompany high myopia, chap. xv.), ciliary body, or retina, and display themselves as opacities of various kinds. These are either cells derived from the primarily diseased tissue, or they are secondary changes (connective tissue development) in the vitreous humour, the result of the cellular invasion.

The chief *Varieties of Vitreous Humour Opacities* are :—(1) A Dust-like Opacity characteristic of syphilitic disease of the retina and chorioid. It may occupy the entire vitreous humour, but is frequently confined to the region of the ciliary body, or to that of the posterior layers of the vitreous humour. (2) Flakes and Threads. These occur with chronic affections of the chorioid or ciliary body, and may be the result also of hæmorrhages into the vitreous humour. They invade every portion of the humour. (3) Membranous Opacities, which are rare, and are probably the result either of extensive hæmorrhagic extravasations or of chorioidal exudations.

Most of the alterations in the vitreous humour are attended with, or give rise to, fluidity of it, or Synchysis.[1]

The Diagnosis of opacities in the vitreous humour is made with the ophthalmoscope mirror and a not very bright light, or with the plane mirror. If a very bright light and a concave mirror be employed, the finer opacities will not be readily seen. The pupil being illuminated, the patient is directed to look rapidly in different directions, when the opacities will be seen to float across the area of the pupil, as they are thrown from one side of the eye to the other in the fluid vitreous.

Opacities in the vitreous can be distinguished from those in the lens by the fact that the latter are fixed, and are arranged for the most part in a radiating manner.

Another and very fine method for the detection of delicate

[1] σύν, *together* ; χέω, *to pour.*

opacities in the vitreous consists in placing a high + lens, say + 10 D, behind the ophthalmoscope mirror, and then approaching close to the eye, as in the examination of the upright image. Minute opacities will then be seen as black dots floating in the vitreous humour.

The ophthalmoscope does not always detect changes in the chorioid or retina, when opacities are present in the vitreous; and in many such cases we are led to the belief, either that the diseased changes in the chorioid or retina are too fine to be seen with the ophthalmoscope, or that they are situated in the region of the ciliary body which is out of view.

When the optic disc is viewed through a vitreous humour full of fine opacities, it appears redder than the normal, as does the sun on a foggy day, and it may be difficult to decide whether or not neuritis is present.

Vision is affected by opacities in the vitreous humour in proportion to their density, and to the extent to which the vitreous humour is occupied by them. The patients often observe them as floating positive scotomata in their field of vision. These entoptic appearances are caused by the shadows of the opacities thrown on the retina.

The Prognosis depends on the cause of the opacities. The dust-like opacities accompanying specific retinitis are favourable for absorption, while the flake and thread opacities frequently remain as permanent obstructions. Moreover, by shrinking, many of the more organised opacities give rise to detachment of the retina and consequent blindness.

Treatment.—Opacities of the vitreous humour offer special difficulties in their treatment owing to the torpid metabolism of the part, and the consequent difficulty in influencing its tissues by internal remedies. In addition to the medicines suitable for the constitutional state which may be the cause of the opacities, Heurteloup's artificial leech, or dry cupping on the temple, is useful; and in many cases, soon after the application, a marked clearing up of the vitreous is apparent.

Sub-conjunctival injections of a 4 per cent. sterilised solution of chloride of sodium are a valuable treatment for opacities in the vitreous humour, in many chronic or subacute cases. They are not used if acute uveitis be present. Ten to twenty minims are injected under the bulbar conjunctiva, the point of the needle being entered

far back near the fornix, towards which the injection is directed. To prevent the pain which is caused by the injection, and which may be severe and may last several hours, one or two drops of solution of dionine (4 per cent.) are instilled into the eye, followed about two minutes later by a drop or two of solution of cocaine (4 per cent.), and then after a few minutes the saline injection is given. Hot fomentations to some extent relieve the severe pain. The injection is repeated after a day or two, when the swelling and irritation have subsided. Usually not more than two or three injections can be given in a week.

Sub-conjunctival injections enter largely, also, into the therapy of chronic uveal diseases (pp. 192, 195, 196, 197, 210), of certain corneal diseases (pp. 117, 119, 127, 134, 142, 144, 145, 146, 148), and of some other diseases of the eye (p. 284).

The curative action of these injections depends on the hyperæmia to which they give rise, and the consequent increased supply to the diseased part of the healing substances of the blood—the opsonins, bacteriolysins, etc. There is consequently little to be gained therapeutically by the use of solutions of sublimate, cyanide of mercury, hetol, and so on, in preference to the 4 per cent. solution of common salt.

* **Hæmorrhage in the Vitreous Humour.**—This is often caused by blows on the eye, which rupture intra-ocular blood-vessels. It is the result, too, of certain diseases of the retina and chorioid, which are accompanied by hæmorrhages in those membranes; or, of disease of the coats of the retinal or chorioidal vessels. It is seen in old people with atheromatous vessels, and it occurs in pernicious anæmia, syphilis, and malaria.

Some quite healthy young people of both sexes are liable to recurrent hæmorrhages in the vitreous humour, which, when they cease, either leave the vitreous humour clear, or it may remain more or less opaque. Strands of connective may form in it, or it may be followed by retinitis proliferans (p. 317), or by detachment of the retina. No satisfactory explanation for these cases in young people can be offered, but Axenfeld states that many of them are due to tubercular disease of the coats of the retinal or chorioidal blood-vessels. The arterial tension is often high, constipation is often present, and there may be epistaxis.

Hæmorrhages in the vitreous humour, when viewed with the

ophthalmoscope, present the appearance of very black floating masses, between which the chorioidal reflex appears. If they lie in the anterior part of the vitreous chamber, close behind the lens, they may be seen with focal illumination, and then are red. When the vitreous humour is full of blood, no red reflex can be obtained with the ophthalmoscope, and the pupil looks quite black when light is thrown into the eye from the mirror.

Treatment.—Sub-conjunctival saline injections afford the best hope of promoting absorption of vitreous humour hæmorrhages, and the internal administration of citric acid has been recommended on the ground that an increased coagulability of the blood is present. If the coagulability of the blood be reduced, lactic acid or calcium chloride are indicated. Fibrolysin has been employed in these cases apparently with advantage in some of them. But many of these cases are incurable, or undergo only partial cure. In recent cases rest in bed is important.

Mouches Volantes, Muscæ Volitantes, and **Myodesopsia**[1] are terms applied to the motes which people frequently see floating before their eyes, but which do not interfere with the acuteness of vision, nor can the ophthalmoscope detect opacities in the vitreous humour, nor any other intra-ocular disease. These motes are most apparent when a bright surface, such as a white wall or the field of a microscope, is looked at. Mouches volantes have no clinical importance. Those annoyed with them should be strongly recommended not to look for them, as in that case others are very apt to become visible. They depend, probably, upon minute remains of the embryonic tissue in the vitreous humour.

* **Fluidity of the Vitreous Humour,** or **Synchysis,** is not rare. It can only be diagnosed with certainty when the humour contains floating opacities. Low tension of the eyeball does not always indicate fluidity of the vitreous, although soft eyeballs nearly always contain fluid vitreous humour. Trembling of the iris (iridodonesis) is also no sign of fluid vitreous, although it often accompanies it, but merely indicates that the iris is not supported in the normal way by the crystalline lens. Defective zonula of Zinn, however, is often caused by, or is a concomitant of, fluid vitreous; and, by causing displacement of the lens, would allow of trembling of the iris.

[1] *μυῖα, a fly; ὄψις seeing.*

The Causes of synchysis are chorioiditis and staphyloma of the chorioid and sclerotic, and it also occurs as a senile change.

Fluidity of the vitreous humour is not, *per se*, a condition of serious import, unless the eye come to be the subject of an operation involving an incision in the corneo-sclerotic coat, when it renders prolapse of the vitreous more liable to take place.

* **Synchysis Scintillans** is a fluid condition of the vitreous humour, with cholesterine and tyrosine crystals held in suspension in it. The ophthalmoscopic appearances are very beautiful, resembling a shower of golden rain. A satisfactory explanation for the occurrence of these crystals in this position has not yet been given. They usually occur in old people, and seldom cause any marked deterioration of vision.

Foreign Bodies in the Vitreous Humour and Interior of the Eye in General.—One of the most common and most serious accidents to the eye is perforation of the sclerotic, or of the cornea and crystalline lens, by a small foreign body (shot, morsel of iron, copper, stone, or glass), which lodges in some part of the interior of the eye —very frequently in the vitreous humour.

The danger threatened by a foreign body in the eye is great. It is rarely that, whether it remain free, or, as sometimes happens, become encapsuled, it is tolerated permanently in any part of the interior of the eye without inflammatory reaction—except when it lies in the crystalline lens, and there, as a rule, it causes cataract—and freedom from inflammatory reaction should never be reckoned on in the management of such a case.

As a rule, foreign bodies in the vitreous, or elsewhere within the eye, soon produce violent inflammatory reaction. This occurs, either by reason of infective micro-organisms being introduced into the eye with the foreign body, or, it may be caused by the oxidisation of the foreign body, when it is of iron or copper. The form of inflammation may be either a plastic or a purulent uveitis, in the latter case with purulent infiltration of the vitreous humour and hypopyon.

Foreign bodies of copper are more likely to cause purulent inflammation than those of any other kind, and they usually do cause it.

Should a foreign body of iron or steel remain in the eye long enough—months or years—without giving rise to inflammatory

reaction, it is apt to cause siderosis, or rusting, of all the tissues of the eyeball, the iris becoming of a reddish brown hue. Cyclitis and intra-ocular hæmorrhage follow, accompanied by much pain, vision is lost, and the eye has to be excised.

Consequently, when an eye contains a foreign body that is not, or cannot be, at once removed, the eye may be regarded as lost. Moreover, such an eye becomes one of the surest sources of sympathetic ophthalmitis, when it is plastic and not purulent inflammation that is set up in it.

As soon as the case is seen, the first question to be asked of the patient is: What was the size of the foreign body? A minute foreign body, especially if it fly against the eye with force, is likely to perforate the walls of the eyeball and to lodge in its interior; while a large foreign body may cause a perforating wound, but may then fall to the ground. The second question to be asked is: What was the foreign body made of?

It is, therefore, of the utmost importance to decide whether or not a foreign body be in the eye; and if one be there, to remove it if possible, should a reasonable prospect of saving even partial sight exist; and this too, without delay. When the foreign body cannot be removed, the eyeball must be excised.

Means of deciding objectively whether a Foreign Body be in the Eye.—If the case be seen immediately, or soon after the accident, and there be no intra-ocular hæmorrhage to obscure the view, the foreign body may perhaps be detected with the ophthalmoscope in the vitreous humour or fundus oculi as a dark or glittering body, according to its nature; and focal illumination with dilated pupil will often help the surgeon to discover a foreign body situated in the anterior part of the vitreous humour. Or, if it cannot be seen, an opaque streak through the vitreous humour, one end of which corresponds with the sclerotic wound, may indicate the track taken by a foreign body.

In case the foreign body have perforated the cornea, and reached the vitreous humour through the circumlental space, a counter-opening will be found in the iris; while, if it be supposed to have passed through the cornea and lens, the openings both in the anterior and posterior capsule of the lens should be sought for.

In cases where the ophthalmoscope and focal illumination fail us, owing to extravasation of blood, traumatic cataract, etc., it

is sometimes not easy to say whether the foreign body be in the eye, or whether it may have merely punctured the sclerotic, or cornea, and then fallen to the ground, without passing into the eye.

The Röntgen Rays must then be resorted to, should the foreign body be of any metal or of glass, to decide both upon its presence and position, and the Sideroscope is useful for the same purposes, but only if the object be of iron or steel.

* The following is Mackenzie Davidson's method for employing the Röntgen Rays in these cases :—

The patient sits upon a chair in an upright position, with his head fixed in a headpiece (clamped to a table) to keep it steady (Fig. 87), while at the same time a photographic dry plate can be

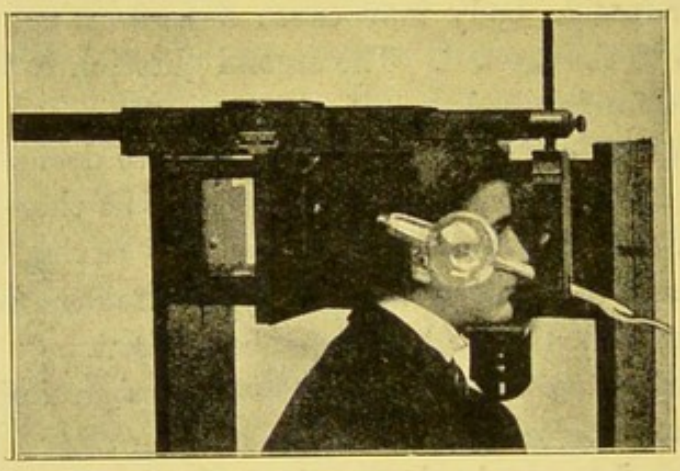


FIG. 87.

placed against the temple on the side of the eye which is to be photographed.

Fig. 88 is a picture of a patient's head in position for taking the right eye. The back of the head rests against a board, and another board, with a thumb-screw sliding in a groove, serves to press and fix his head laterally against two stretched piano-wires, behind which again the photographic plate is placed. The chin is supported on an adjustable projection.

Fig. 89 is a side view of the same patient. The stretched piano-wires are shown. The patient, while the skiagram is being taken, is made to fix his gaze on a distant object, so that his optic axis is parallel to the horizontal wire. Previously, a small piece of lead wire, exactly 1 cm. long, is placed on the lower eyelid, and secured by two strips of adhesive plaster, and the relative position of the

point of the wire (nearest the eye) is carefully noted in relation to the cornea (*e.g.* so many millimetres vertically below the centre of the cornea, or so many millimetres vertically below any corneal scar which may happen to be present); also whether the point is on a level with a vertical line from the centre of the cornea (as it usually is), or how far behind or in front of this plane. These are all the adjustments necessary to be made with the patient.

Before the patient is placed in position, the Crooke's tube is adjusted, so that the fine point on the anode, from which the linear rays originate, shall be exactly opposite the point of intersection of the two stretched piano-wires. When the tube is worked by

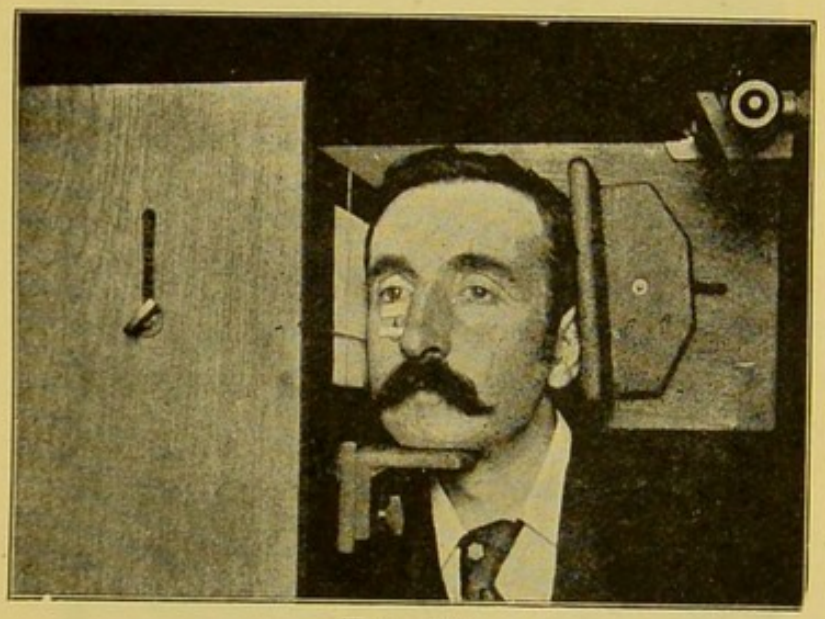


FIG. 88.

the coil, this point shows as a bright incandescent spot on the anode, if it be of osmium; and by means of a fixed 'sight,' placed on this side of the wires, the tube can be so adjusted that this point is exactly opposite the intersection of the wires. The distance is carefully noted: it is usually 28 to 30 cm. The tube-holder is fixed to a bar of wood, which slides horizontally, and by means of marks placed on the bar itself, and upon the edge of the groove in which it slides, it can be displaced in a plane exactly parallel to the horizontal wire. It is to be displaced 3 cm. to one side of the vertical or zero point. Then a photographic plate, protected, as usual, in black paper, is placed against the wires (Fig. 89), and an exposure given of from ninety seconds to two minutes. With exceptionally good osmium tubes ten seconds is enough. The tube

is then displaced 3 cm. to the other side of the zero point—the photographic plate having been removed and a fresh one put in its place—and a second similar exposure is given. The result is two negatives taken from two points of view 6 cm. apart.

A transparent sheet of thin celluloid has two cross lines marked upon it at right angles to each other. One side is varnished, so that it will readily take pencil marks. Immediately after development and fixing, this sheet of celluloid is placed over the film side of the negative, so that its two lines are exactly superimposed upon the white lines left by the wires in the headpiece; while firmly held

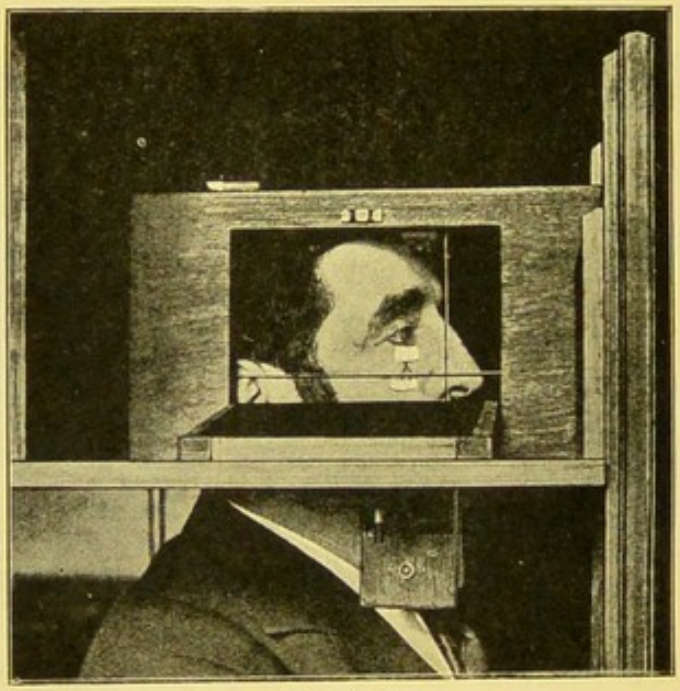


FIG. 89.

in position, the shadow of the leaden wire or landmark, placed on the lower eyelid, is carefully traced. Then the foreign body is traced in the same way. This process of tracing is repeated with the other negative. The result is that upon the sheet of celluloid two tracings of the leaden landmark wire, and two tracings of the foreign body, side by side, are obtained.

This celluloid tracing is now placed upon the horizontal glass stage of the Cross-Thread Localiser. The latter has two fine silk threads coming from two points, which are so adjusted as to occupy relatively the two positions occupied by the anode of the Crooke's tube, and to be at the same distance from the celluloid

tracing, and also in the same relative position to the cross-lines, that the anode of the Crooke's tube had to the photographic plate and to the cross-wires of the headpiece, when the photographs were being taken.

The silk threads are now used to trace the linear paths of the rays. The intersection of the two threads fixes the position of the object in space. Its geometrical relations to the known data can then be measured. First, the three co-ordinates of the known point are ascertained, then the three co-ordinates of the unknown foreign body, and then, by simple subtraction, the minor co-ordinates are obtained, and thus the position of the foreign body is accurately determined. The observer is enabled to say how far horizontally inwards or outwards the foreign body lies from the point of the landmark lead wire; from that point how far vertically upwards or downwards it lies; and finally, how far directly backwards, parallel to the visual axis, it is situated. If care be taken, the position of a foreign body, however small, can be ascertained with great accuracy by this method. Its size also can be discovered. Moreover, the two negatives are stereoscopic, so that, when viewed either in a Wheatstone's reflecting stereoscope, or by converging the optic axes, and so fusing the pictures, a single picture in relief is seen, showing the relative position of the parts in a very beautiful manner.

* *The Sideroscope* is used for the detection of the presence of atoms of steel or iron in the eye. It consists in a magnetic needle hung by a fine thread, and so mounted that when it is brought close to the eye containing the foreign body, its deflections can be read by means of an astronomical telescope which is attached. The sideroscope is used, too, for ascertaining the position of the foreign body, which is nearest to the part where the deflection of the needle is greatest. This, of course, is only an approximate localisation, and the method is not much employed in these countries, as the Röntgen Ray method fulfils the requirements more completely.

When it has been decided that a foreign body is in the eye, and when its position has been determined, its removal must be attempted.

* *Removal of a Foreign Body from within the Eye.*—In all these operations it is necessary that the patient be deeply under the

influence of an anæsthetic, in order that as little vitreous humour as possible may be lost.

The removal of atoms of iron or steel is more often successful than if the foreign body be of some other substance ; for, in these cases, the magnet renders valuable aid, and makes it unnecessary that the foreign bodies should be visible, if they have been localised by the Röntgen Rays. And even localisation with the Rays may be foregone, where, in a quite recent case, it is important there should be no delay in removing the foreign body. Fig. 90 represents Snell's electro-magnet in two-thirds its actual size. It is a core of soft iron, around which is placed a coil of insulated copper wire, the whole enclosed in an ebonite case. To one extremity of the instrument are attached the screws to receive the connections of a small accumulator. At the other extremity the core projects

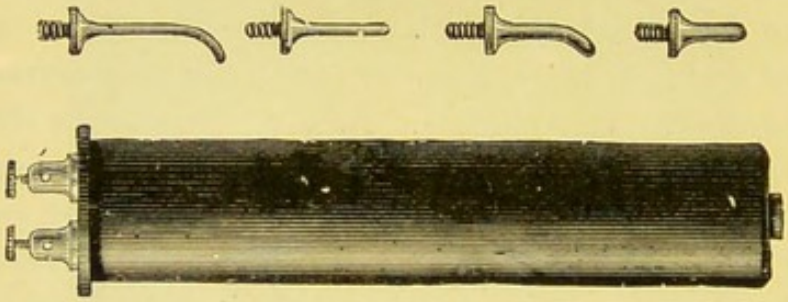


FIG. 90.

just beyond the ebonite jacket, and is tapped, and into it the point is screwed. Points of various kinds or shapes can be adjusted to the magnet, according to the case to be dealt with. A point adjusted to the magnet having been passed through the sclerotic opening, it is advanced towards the foreign body, when the latter adheres to it, and is withdrawn towards the wound. Much care is required in drawing the foreign body through the opening, lest it be rubbed off the point in its passage. A forceps is generally used at this part of the proceeding, either to dilate the wound, or to seize the foreign body and extract it. As short and as large a point as is consistent with the particular case should be employed, so that the greatest possible power of attraction may be obtained. A quart bichromate battery, or the street current, is used. When the foreign body is embedded in the coats of the eye at the back, or in a mass of inflammatory effusion, or is entangled in the ciliary

region, difficulty or failure in the extraction is likely to be experienced. When a traumatic cataract is present, it is well to combine its extraction with that of the foreign body, which latter is fetched out through the cataract incision with the magnet.

Haab's Giant Electro-Magnet (Fig. 91) is also used for extracting morsels of iron or steel from the eye. It is an immense and very powerful magnet, to which the eye is brought close. Care is required in its use, lest even more injury be done to the delicate tissues of the eyeball by the foreign body in its passage towards the magnet, than by its entrance into the eye. As a rule, it is re-

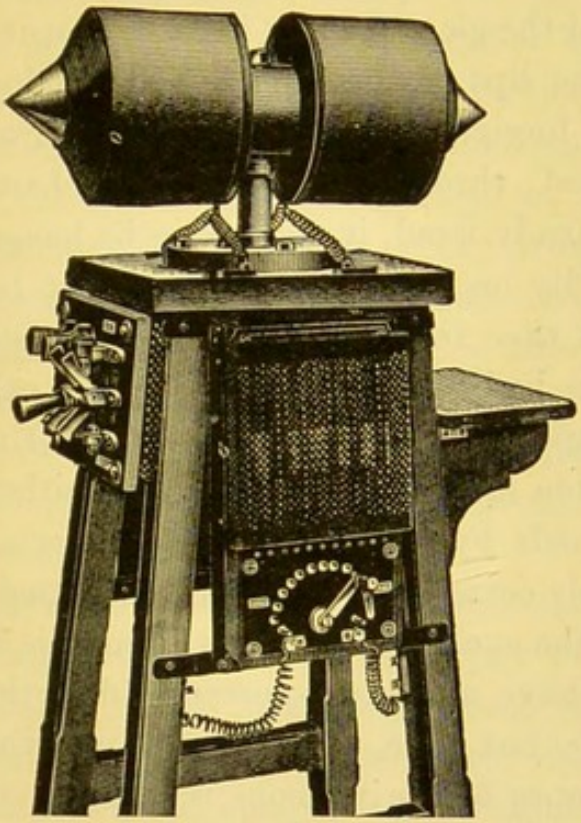


FIG. 91.

commended that the centre of the cornea, in the first instance, be brought opposite and close to the point of the magnet; for, by so doing, entanglement of the foreign body in the ciliary processes, from which it is not easy again to disengage it, may best be avoided. Foreign bodies which are in the vitreous humour, or which are not too firmly fixed in the retina, slide round the lens and bulge the iris forwards. As soon as this occurs the current is switched off, and the patient's head withdrawn from the magnet. By a suitable turning of the patient's head and eye, the latter being again approached to the magnet and the current switched on, the foreign

body is drawn from behind the iris, through the pupil, which has been well dilated with atropine and cocaine, and into the anterior chamber. Should it not be possible to get the foreign body away from behind the periphery of the iris with the magnet, an iridodialysis may be formed with a keratome, and the foreign body drawn away with a Snell's magnet or with a forceps. It must not be attempted to draw the foreign body by the magnet through the iris, or else the latter may be partially or entirely pulled away. Having got the foreign body into the anterior chamber through the pupil, an incision with a Græfe's knife is made in the cornea, if possible without allowing the aqueous humour to flow away, and through the incision the sharp point of the giant magnet is passed, or it may be sufficient to apply it to the lips of the wound, and the foreign body is extracted. Even foreign bodies which enter through the sclerotic are best removed through the anterior chamber. When the foreign body is firmly fixed, it may often be loosened by switching the current rapidly on and off, or it may first be drawn towards the equator, and then towards the anterior chamber.

If the foreign body be of some substance other than iron or steel—glass, copper, stone, etc.—it may sometimes be removed through an incision in the sclerotic, which is either an enlargement of the opening made by the foreign body, or is a special one, at a point more nearly corresponding with the actual position of the foreign body in the eye. This incision should lie between two recti muscles, should have an antero-posterior direction, and, in order that it may gape but little, should be a puncture with a broad keratome. Prolapse of the vitreous is then produced by pressure on the eyeball, and the foreign body is evacuated.

This method may be employed only when the foreign body is situated in the periphery of the vitreous, and towards the equator of the eye, where the opening for its exit can be made in its immediate neighbourhood; but the proceeding is often attended with disappointment, much vitreous being lost, while the foreign body remains in the eye.

Or, a forceps is passed through the opening, and while the foreign body is kept in view with the ophthalmoscope it is seized and drawn out. This plan, too, often fails, as, loss of vitreous occurring, the cornea becomes flaccid, and the view of the foreign body is soon obscured.

It is sometimes preferable to make the opening not close to the foreign body, but exactly at the opposite side of the eyeball, by which means the foreign body can often be reached with greater ease, and with less injury to the tissues.

* **Cysticercus in the Vitreous Humour** was not until late years very rare in some parts of Germany, but there have not been many cases observed in the British Isles. One occurred not long ago in Ireland.

The original seat of the entozoon is usually beneath the retina (chap. xi.), through which it breaks to reach the vitreous humour; but it also sometimes makes its first appearance in the vitreous. It is recognised by its peculiar somewhat dumb-bell shape, its iridescence, and its peristaltic motions. The vitreous humour often becomes full of peculiar membranous opacities, as a consequence of the presence of the cysticercus.

Treatment.—Removal by operation. The prospects for the eye are very much worse than in the case of a sub-retinal cysticercus.

* **Blood Vessels** are sometimes formed in the vitreous humour. They spring from the retinal vessels, often in connection with connective tissue formations which accompany hæmorrhages; but sometimes small loops arise in the neighbourhood of the disc, without any hæmorrhagic disease.

* **Persistent Hyaloid Artery.**—In intra-uterine life the hyaloid artery is a prolongation of the central artery of the retina, and runs from the papilla to the posterior surface of the crystalline lens. It completely disappears prior to birth, except in those rare cases where it remains as an opaque string, which may stretch the whole way from papilla to lens, or may extend only part of the way. It is then thrown into wave-like movements by the movements of the eyeball, and is easily recognised with the ophthalmoscope. It does not usually cause any disturbance of vision.

CHAPTER XI.

DISEASES OF THE RETINA.

Diseases of the Retina may be conveniently grouped as follows for the purpose of description :—Alterations in Vascularity, Inflammation, Atrophy and Degeneration, Diseases of the Blood Vessels, Injury by Strong Light, Tumours, Parasitic Disease, Detachment, and Traumatic Affections.

Alterations in the Vascularity of the Retina.

Hyperæmia and **Anæmia** of the retina, due to changes in the capillary vessels, cannot be seen with the ophthalmoscope, hence these terms are used to denote apparent enlargement or diminution of the principal branches of the central vessels. *Venous Engorgement* may occur as a local condition, as in papillitis, retinitis, thrombosis of the central vein, or as part of general venous obstruction in cardiac and pulmonary diseases. *Contraction of the Arteries* may also be due to local disease of the vessels (embolism, albuminuric retinitis, etc.) and spasm (malaria, quinine), or, more rarely, to diminished blood supply from general causes (cholera). The opposite conditions, namely, diminution in the size of the veins, and dilatation of the arteries, are rarely noticeable.

Pulsation of Retinal Vessels.—*Pulsation in the Retinal Veins* is present under normal conditions in some eyes, and can be produced by slight pressure on the eyeball in all eyes. It is best observed on the optic disc and in the upright image. In cases of insufficiency of the aortic and tricuspid valves, the venous pulsation is often very marked, and extends some way into the retina. There is normally no perceptible *Pulsation in the Retinal Arteries*. It occurs under conditions such as glaucoma, and also sometimes in cases of orbital tumours and of optic neuritis, where an impediment

to the entrance of blood into the eye is present, and where it can be driven through the artery at the systole only. Arterial pulsation is also often present with insufficiency of the aortic valves. It is most easily observed on the optic disc.

Inflammation of the Retina : Retinitis.

* Retinitis, in general, is characterised by the following ophthalmoscopic appearances : *diffuse cloudiness*, especially of the central portion of the fundus, due to loss of transparency in the retina, and consequent veiling of the chorioid ; the *optic papilla* becomes more or less congested, with indistinctness of its outline, which in the erect image resolves itself into a delicate striation ; *vascular engorgement*, the retinal veins especially becoming enlarged and tortuous. The inflammation in some cases may subside at this stage, but as a rule *hæmorrhages* and whitish *exudations* soon make their appearance.

The various forms of retinitis are distinguished by the predominance of some of the above signs, and also by the peculiar appearance and grouping of the exudations.

If the optic papilla be not merely congested, but also swollen, the condition is called Neuro-Retinitis.

In some cases of retinitis the chorioid is also involved, and to these the name Chorio-Retinitis is given.

Inflammation of the retina is rarely a local affection, being in the majority of cases due to general diseases, and hence it most commonly occurs in both eyes.

* **Syphilitic Retinitis** (or Syphilitic Chorio-Retinitis). (Plate III. Fig. 1).—Inherited or acquired syphilis is liable to induce a form of chronic diffuse retinitis. In the acquired disease it is a later secondary symptom, coming on between the sixth and eighteenth month, and often in one eye only.

With the Ophthalmoscope a slight opacity of the retina is seen extending from the papilla some distance into the retina, and very gradually disappearing towards the equator of the eye. The papilla is but slightly hyperæmic, while its margins are indistinct, like those of the moon seen through a light cloud. The artery is not generally altered, and the vein is but slightly distended. Opacities in the vitreous humour are not uncommon. They may

be membranous or thread-like, but a diffuse dust-like opacity, filling the whole vitreous humour, is almost pathognomonic of a syphilitic taint (p. 296), and often creates much difficulty in the ophthalmoscopic diagnosis of the retinal affection.

Disseminated chorioidal changes, in the form of small yellowish spots with pigmentary deposit, are very frequent, especially towards the equator of the eye. Many observers, indeed, hold that the whole process is primarily in the chorioid, and that the retina is only secondarily affected. Fine whitish dots and pigmentary changes often occur about the macula lutea. The hereditary form of the disease sometimes bears a resemblance to retinitis pigmentosa.

Occasionally, instead of the diffuse retinitis, syphilis causes a circumscribed yellowish-white exudation in the neighbourhood of the macula lutea, or on the course of one of the large retinal blood-vessels (p. 314).

Vision may be but slightly affected, but in the advanced stages it is usually much lowered. Central, or peripheral, or ring scotomata, or concentric defects of the field, are found. The scotomata are often positive—*i.e.* they can be seen by the patient as dark spots in the field. Night-blindness is a constant symptom, and the light-sense is enormously diminished. The patients sometimes complain of sparks or lights, which seem to dance before their eyes, and occasionally also of a diminution in the size (micropsia) of objects, or of a distortion (metamorphopsia) of their outlines. The micropsia is believed to be due to a separation from each other of the elements of the layer of rods and cones by sub-retinal exudation. The image of an object then comes into relation with fewer of these elements, and hence the mental impression is that of a smaller object than is conveyed by the image formed in the sound eye, or on a sound part of the same retina.

The Progress of the Disease is very slow, and is liable to relapses. In the late stages extensive pigmentary degeneration of the retina may come on, or disseminated chorioiditis (Plate III. Fig. 1). But if the cases come under suitable treatment in an early stage, a cure may often be effected.

Treatment.—The only remedy which has been of real value is mercury, and that in an early stage. Probably salvarsan will prove useful. Mercury should be used in a protracted course of some weeks by inunction, combined at discretion with small doses of

calomel internally. Or, the method by intra-muscular injection of mercury may be employed. If mercurialisation be effected, it should not go further than very slight stomatitis. Turkish baths, and the artificial leech at the temple, may be employed as adjuncts to the treatment. When the mercurial course has been completed, iodide of potassium should be prescribed as an after-treatment. Complete rest of the eyes, and protection from strong light by dark glasses, are also necessary in this, as in many forms of retinitis.

* **Hæmorrhagic Retinitis.**—In this affection the retina contains a number of small hæmorrhages. They occur chiefly between the fibres of the inner, or nerve-fibre, layer, and consequently present a flame-like appearance as seen with the ophthalmoscope. Any which lie in the outer layers are more apt to be round or irregular in shape. In addition to the hæmorrhages, there is diffuse opacity of the retina, and sometimes white spots of degeneration. The papilla is often much swollen, and the retinal veins are distended and tortuous, while the arteries are small; but these appearances, as well as the number of the hæmorrhages, vary much in different cases. When there are but few hæmorrhages, they are situated in the neighbourhood of the papilla and macula lutea. The appearances occasionally resemble those of albuminuric retinitis, but in the latter, as a rule, the proportion of white spots to hæmorrhages is greater than in this affection. Probably many cases regarded as hæmorrhagic retinitis are due to thrombosis of the central vein (Plate VII. Fig. 2). In a small proportion of cases secondary glaucoma supervenes (p. 256).

Causes.—The affection is found most commonly in connection with cardiac disease—*e.g.* valvular insufficiency, and hypertrophy of the left ventricle; or with diseases of the vascular system—*e.g.* atheroma, and aneurisms of the large vessels. Where it is due to disease of the coats of the arteries, the ophthalmoscope will occasionally reveal an arterial branch altered to the appearance of a white thread; but usually the degenerative change does not interfere with the transparency of the vascular coats. In the majority of cases dependent on cardiac or vascular disease the retinal affection is monocular. This, and the frequently sudden onset of the retinitis, suggests some second factor for its occurrence, probably multiple embolisms of the small branches of the central artery. Suppression of menstruation, or other wonted discharge—such as that from

piles—has been observed as an immediate cause of hæmorrhagic retinitis.

A peculiar form of hæmorrhagic retinitis is sometimes associated with secondary syphilis. In addition to the usual opacity of the retina in syphilitic retinitis (p. 311), a portion of the retina is covered with numbers of small round hæmorrhages lying in the different layers of the retina, while a connective tissue development is occasionally found in the nerve-fibre layer, in the form of white striæ along the course of the blood-vessels.

The disturbance of vision is considerable, especially if the neighbourhood of the macula lutea be much involved.

The Prognosis is unfavourable in severe cases of hæmorrhagic retinitis. Relapses are common, while the ultimate tendency is towards atrophy of the retina and papilla. In very mild cases recovery may come about.

The Treatment must be chiefly expectant, or directed, at most, towards procuring rest for the general system, or for the organ primarily at fault. Dry cupping on the temple, hot foot-baths, and iodide of potassium internally may be employed.

Retinitis Albuminurica occurs as a complication in many cases both of acute and chronic nephritis, and in the albuminuria of pregnancy. It is most common with the small granular kidney, but may attend any chronic form of Bright's disease, and occurs in 6 or 7 per cent. of these cases.

The Defect of Vision in the chronic form, although often the first symptom which causes the patient to seek advice, is never associated with an early stage of the kidney disease, but rather with a late stage of it, and with dilated left ventricle. Both eyes as a rule are affected, although often not equally so. Vision is much lowered, and even perception of light may be wanting; but the blindness is not always all due to organic changes in the retina, being often largely the result of uræmia. (See Uræmic Amblyopia, chap. xiii.)

Ophthalmoscopic Appearances (Plate V. Fig. 1).—These are venous hyperæmia, with œdematous swelling of the papilla, and of the retina in its neighbourhood; hæmorrhages on the papilla, and in the nerve-fibre layer of the retina; and round or irregularly shaped white spots in the retina, arranged in a zone around the papilla, some three papilla diameters removed from it. These changes take place in the order enumerated. The hyperæmia and

PLATE V

(To face page 314)

Fig. 1.—There is a slight cloudiness of the retina, veiling the retinal vessels and the outline of the optic disc. Note the flame-shaped retinal hæmorrhages and round soft-edged white exudations, some of which lie anterior to the retinal vessels. The fovea centralis is surrounded by brilliant white radiating lines and dots, the so-called 'star at the macula' which is very suggestive of albuminuric retinitis.

Fig. 2.—The detached portion of the retina is of a bluish grey colour and is thrown into folds, on the elevations and depressions of which the dark retinal vessels pursue an irregular wavy course. To the right the detachment is shallower and the retina has partially preserved its transparency. A triangular rent in the retina is visible to the left.

PLATE V

(*To face page* 314)

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FIG. 1. Albuminuric Retinitis.



FIG. 2. Detachment of the Retina.

engorgement of the veins, often very great, become less, according as the white spots become more developed. Near the macula lutea no very coarse changes usually occur; but fine white dots are found, with a star-like arrangement converging towards the macula. In some cases these fine white dots are present only on the inner side of the macula in the space between it and the papilla.

The degree in which all these different changes are present varies in different cases, no one of them being pathognomonic of the kidney affection, but rather the grouping of the whole picture being suggestive. Sometimes the papillitis is so intense as to simulate that known as congestion papilla in cases of intra-cranial tumour; while the white spots are sometimes developed to such a degree as to become confluent, and to form one large white plaque. Again, the papillitis, or white spots, or both, may be but slightly marked. The number and size of the hæmorrhages are also liable to great variation. Detachment of the retina has been observed in a few cases; and sometimes the hæmorrhages burst into the vitreous humour.

Some of the white spots are caused by fatty infiltration of the outer layers of the retina (the retinal vessels passing over them) and of the nerve-fibre layer (the retinal vessels hidden by them). The fine dots about the macula lutea are the result of fatty infiltration of the inner ends of Müller's fibres. Small aneurismal dilatations of the arteries occur very occasionally, and detachment of the retina is sometimes seen.

The retinal changes are the result of the renal disease. The fat is carried into the retina by wandering pigment-cells which have lost their pigment. The retinal changes are not caused by arteriosclerosis, for the vessels are usually healthy in early stages and in acute and puerperal cases, although in the later stages of chronic cases they do become diseased, by retardation of the blood-stream, from failure of the heart, or from diminution in size of the smaller retinal vessels (Leber).

Prognosis.—In chronic cases the prognosis as regards the patient's life is bad. The majority die within eighteen months or two years; but, if the general disease remain stationary, or improve, or recover, the retinal changes may improve or disappear, and may leave the retina with normal appearances and functions; or, the swelling, hyperæmia, white spots, and hæmorrhages may give place to optic

atrophy, with diminution in size of the arteries, pigmentary alterations in the retina, and blindness. In the albuminuria of pregnancy, and in that due to acute nephritis, the retinal complication may disappear with the renal disorder, leaving good vision.

Treatment.—No treatment other than that for the primary renal disease is of avail. Taking into consideration the serious import of this eye-symptom for the life of the patient, it is a question whether, in many cases of pregnancy with albuminuric retinitis, abortion should not be resorted to, especially if the pregnancy have still some months to run. But, on the whole, the prognosis is more favourable in the albuminuria of pregnancy than in interstitial nephritis.

Retinal Affections in Diabetes.—There is no one condition of the retina characteristic of diabetes, although undoubtedly retinal affections occasionally do complicate it in an advanced stage. Small retinal hæmorrhages, with fine changes in the form of glistening dots about the macula lutea, somewhat similar in appearance to those which occur in Bright's disease, except that they rarely form the well-marked star, are perhaps the most common and suggestive appearances. In other cases retinal hæmorrhages alone are found, and in others hæmorrhagic retinitis; while, again, the so-called typical appearances of Bright's disease may be presented. There are often opacities of hæmorrhagic origin in the vitreous humour, which, if copious, may destroy vision.

It is an important rule of practice that, in all cases of retinal hæmorrhages and of retinitis hæmorrhagica, the urine should be examined for sugar and albumen. The retinal disease is sometimes the first indication of the general disorder.

Embolism of the central artery, and thrombosis of the central vein, have been observed in diabetes.

With the marked lipæmia which is present in some cases of diabetes, the retinal vessels appear as bright lines on a red background, the arteries and veins being difficult to distinguish from each other. This is not due to a fatty embolism of the vessels, but rather to the blood being altered to a fat-emulsion throughout the entire system. (See also p. 354.)

* **Retinitis Leucæmica.**—In not more than one-third or one-fourth of the cases of leucocythemia, or pseudo-leucæmia, does a retinal affection occur, and it is not always of the same type. It

may consist in a slight diffuse retinitis, accompanied by some extravasations of pale blood; while the blood-vessels are also pale, the veins being much enlarged, and flattened rather than over-distended, the arteries small, and the chorioid of an orange-yellow colour. Or, it may resemble a case of ordinary hæmorrhagic retinitis.

The Appearances most characteristic of the affection are: a pale papilla with indistinct margins; slight opacity of the retina, especially along the vessels; small hæmorrhages; round, white, elevated spots up to 2 mm. in diameter, with a hæmorrhagic halo, situated by preference towards the periphery of the fundus and at the macula lutea, but not at all, or only in very severe cases, in the zone between the macula and the equator of the eye. These white spots consist of extravasations of leucæmic blood, the result, probably, of diapedesis, and they are sometimes distinctly prominent.

Vision may be but little affected if the macula lutea be fairly free. Hæmorrhage into the vitreous humour may cause complete blindness.

* **Development of Connective Tissue in the Retina,** or **Retinitis Proliferans.**—Extensive white striæ, formed of connective tissue, are sometimes seen in the retina, and may even conceal the vessels and papilla. They often protrude into the vitreous humour, and contain newly formed vessels, which are prolongations of the retinal vessels. These striæ are the result of hæmorrhages, traumatic or otherwise, and of inflammatory processes, and are formed by proliferation of Müller's fibres, and by new growth of connective tissue. Hæmorrhages in the retina, or in the vitreous humour, or in both, are generally present at some period. Vision is often but slightly affected, but the danger of recurrence of the hæmorrhages renders the ultimate prognosis unfavourable as a rule.

Treatment.—Heurteloup's leech. Iodide of potassium, or perchloride of mercury. Lactate of calcium. Thyroid extract. Some cases are on record where, one eye having been lost from this disease, and the sight of the other eye seriously threatened, the common carotid was ligatured on the side of the second eye, with the desired result of arresting the recurrence of hæmorrhages. The effect of the procedure is held to be due to reduction of the pressure on the walls of the ophthalmic artery.

* **Retinitis Circinata** is a rare disease. It occurs in old people, chiefly women, and is characterised by remarkable appearances. At the macula there is a grey or yellowish cloudy patch, which may attain the size of the papilla, and sometimes presents hæmorrhages on its surface; surrounding this, but separated from it by a healthy zone, is a ring composed of numerous closely set, small white spots, which are confluent in places. The sight gradually becomes much deteriorated. A large central scotoma develops, and vision is finally reduced to finger-counting centrally, although for a long time the peripheral field may not become contracted. Total blindness rarely results.

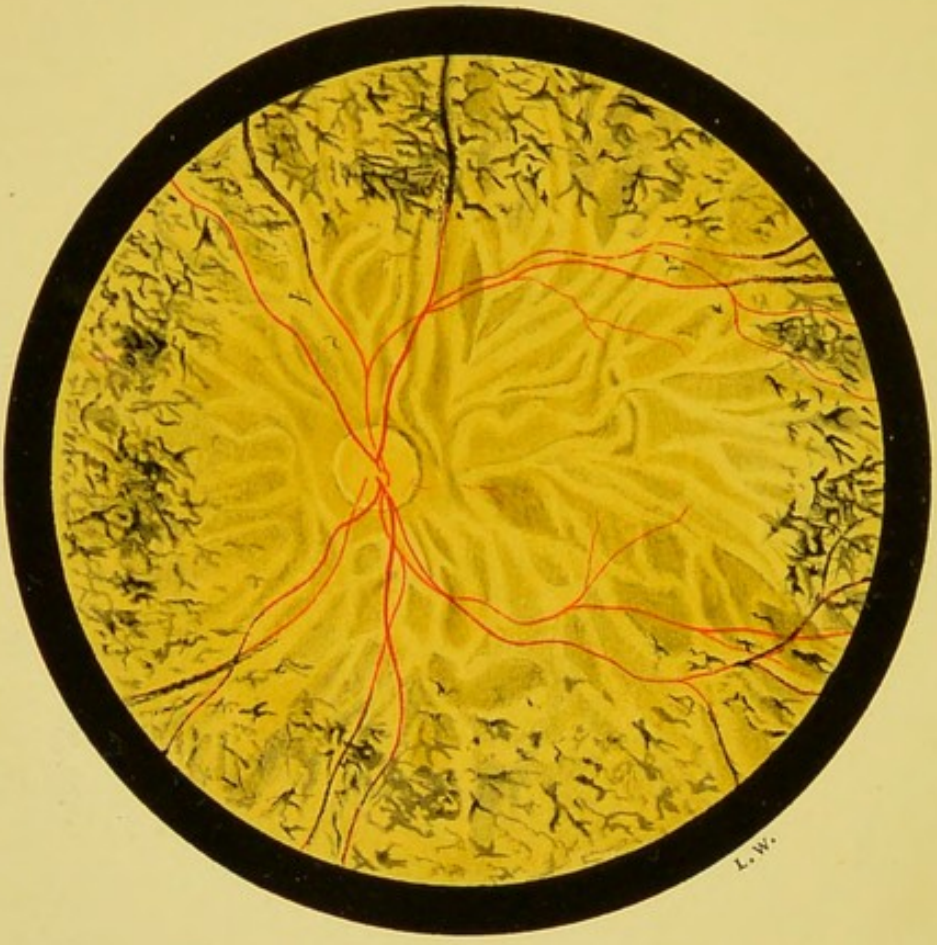
* **Purulent, or Metastatic, Retinitis** is observed as the result of septic embolism of the retinal arteries in septicæmia after surgical operations, etc., and very frequently in cases of metria, and it is usually, in the latter condition, a fatal sign. In an early stage the ophthalmoscope shows a number of small hæmorrhages in the retina, with general cloudiness of the retinal tissues, while the actual embolisms, which are usually multiple, may not be visible. The inflammation makes rapid progress, soon destroying sight, and extending to the chorioid, iris, and vitreous humour, until finally the stage of panophthalmitis is reached. The retina is sometimes alone the primary seat of the embolic attack, and sometimes the chorioid is also involved. The embolisms are often little more than masses of micrococci. Mild cases, which stop short of suppuration, also occur, and are probably from toxins only.

The retina, of course, becomes secondarily implicated in many purulent processes, which commence in other parts of the eye.

Atrophies, and Degenerations, of the Retina.

* **Retinitis Pigmentosa** is a degenerative, rather than an inflammatory, affection of the retina. It is extremely chronic in its progress, coming on most commonly in childhood, and often resulting in complete, or almost complete, blindness in advanced life.

Vision is much affected, but the symptom chiefly complained of is night-blindness, due rather to defective power of retinal adaptation than to defective light-sense. The field of vision, moreover, becomes gradually contracted, until only a very small central



Retinitis Pigmentosa.

PLATE VI

(*To face page* 319)

The pigment is arranged in a circle towards the periphery. Note the stellate spots and the absence of patches of atrophy, and also the pigment covering the vessels (cf. with Plate III., Fig. 2). The optic disc is yellowish, the retinal vessels thread-like, and the chorioidal vessels are visible all over the fundus owing to disappearance of the pigment-epithelium.

PLATE VI

(To face page 319)

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portion remains; so that, although the patient may still be able to read, he cannot find his way alone—a function for which the eccentric parts of the field are the important ones. A ring scotoma in the field of vision is present in some cases. Finally, the last remaining central region becomes blind.

The Ophthalmoscopic Appearances (Plate VI.) consist in a pigmentation of the nerve-fibre layer of the retina, which commences in the periphery, but not at its extreme limits, and in the course of years advances towards the macula lutea. The pigment is arranged in stellate spots, of which the processes intercommunicate, so that the appearance reminds one of a drawing of the Haversian system of bone. Pigment is also deposited along the course of many of the vessels, hiding them from view. The degree of pigmentation varies much, and in some cases is quite absent, and the diagnosis then has to depend upon the other appearances and on the symptoms. The papilla is of a greyish-yellow colour, never white, and the vessels are very small, and in the majority of cases the chorioidal vessels are visible owing to disappearance of the pigment-epithelium (Plate VI.).

The chorioid is sometimes slightly affected, irregularity in its pigmentation being observable. At the posterior pole of the crystalline lens there is often a star-shaped opacity (p. 268). A few thread-like opacities may be found in the vitreous humour.

Pathology.—The pigment in the retina is believed to wander into it from the pigment-epithelium layer. The other pathological changes in the retina consist in hyperplasy of its connective tissue elements, and thickening of the walls of the vessels at the expense of their lumen.

The chorioidal vessels, too, are altered, owing to endarteritis, which causes hypertrophy of their coats, with more or less obliteration of their lumen. In fact, it seems probable that the primary seat of the diseased process is in the chorioid; and, that it is the changes in it which cause the pigment from the pigment-epithelium layer to wander into the retina.

Causes.—Retinitis pigmentosa often affects more than one member of a family; and the patients, too, are frequently defective in intelligence, or deaf and dumb. Many of them are the offspring of marriages of consanguinity, and in others an inherited syphilitic taint is present, while in others no cause can be assigned. Other

congenital defects, supernumerary digits, etc., are sometimes present.

Treatment is of little use. At best one may stimulate the torpid retina temporarily by hypodermic injections of strychnia, or by the continuous current. Doyne has found that when there is an opacity at the posterior pole of the lens, although it may be of only slight degree, a remarkable improvement in vision can be effected by extraction of the lens.

* **Retinitis Punctata Albescens.**—This disease commences in early childhood, or is perhaps congenital. It often occurs in more than one member of a family, and the parents are frequently blood-relations. The main symptom is night-blindness; in good daylight central vision is usually not defective to any marked degree. The field of vision is contracted. Ophthalmoscopically, the fundus, with the exception of the macula lutea and its immediate neighbourhood, is sprinkled over with innumerable small white dots, which, for the most part, are free from any pigmentary disturbance in their neighbourhood. In some cases, towards the periphery of the fundus, signs of chorioidal atrophy are present, or, there may be pigment in the retina there. The retinal vessels and the optic papilla are unchanged. It is thought by some that this disease is related to retinitis pigmentosa.

Treatment is of no avail.

* **Gyrate Atrophy of the Retina and Chorioid.**—This disease, which is rare, is apt to occur in more than one member of the same family, and in children whose parents are blood-relations. The first symptom appears in childhood as night-blindness. The optic papilla is atrophied, as in retinitis pigmentosa, and atrophy of the retina is shown by the narrowing of its vessels. The characteristic feature is the peculiar form of chorioidal atrophy. In a zone with the papilla for its centre, and extending nearly to the latter, white atrophic dots with sharp margins form, and gradually increase in size, until they become confluent. The atrophy involves both the pigment epithelium and the stroma of the chorioid. The papilla is finally surrounded by a broad white girdle, from which it is separated by a band of normally coloured fundus. The edge of the girdle towards the papilla is scalloped, because the separate rounded parts of which it is composed extend backwards in varying distances, while the remains of the normal fundus project forwards

between them in sharp processes. There is often, as in retinitis pigmentosa, a star-shaped posterior polar cataract. In addition to the night-blindness, central vision is much lowered, even in good light, and the field of vision is much contracted. This disease, too, is closely related to retinitis pigmentosa.

Diseases of the Retinal Vessels.

*** Apoplexy of the Retina.**—This differs from hæmorrhagic retinitis, in that the hæmorrhages are found in a retina free from other diseased appearances.

With the Ophthalmoscope the extravasations of blood appear as red, or almost black, spots of various sizes and shapes. Their number and position in the fundus are also variable. They may be in any layer of the retina, and sometimes burst into the vitreous humour, and sometimes become extravasated between the retina and chorioid.

Large, round, well-defined hæmorrhages of dark colour occur at the posterior pole, or macular region. Often the upper portion of the hæmorrhage is bounded by a straight horizontal line, caused by gravitation of the red blood-corpuscles. These are pre-retinal hæmorrhages (also called sub-hyaloid hæmorrhages), and occur between the innermost layer of the retina and its membrana limitans interna.

Vision is interfered with according to the position and extent of the hæmorrhages. Wherever an apoplexy be situated, the function of the retina at that place is suspended. If it be at the macula lutea, central vision will be seriously impaired; while the scotoma produced by an apoplexy at the periphery of the fundus may pass unnoticed by the patient. When a pre-retinal hæmorrhage becomes absorbed, vision often recovers to the normal, as the retinal elements need not be injured.

Causes.—Retinal apoplexies are due to :—atheromatous disease of the vessels, which affects the retinal vessels as well as those of the general system; local disease of the retinal vessels, as in high myopia; altered states of the blood, as in pernicious anæmia, purpura, and other exhausting diseases; hypertrophy of the left ventricle; suppression or irregularity of menstruation, or at the climacteric period; the sudden reduction of tension of the eyeball after irid-

ectomy for glaucoma; and to thrombosis of the retinal veins. Retinal apoplexies are perhaps most common in advanced life, with atheroma of the blood-vessels, and are then valuable as a warning of possibly impending cerebral mischief.

In young people of both sexes, from the fourteenth to the twentieth year of age, large retinal apoplexies, which may extravasate into the vitreous humour (p. 298), are sometimes seen, and it is difficult to assign a cause for them. Some of the subjects are weak or anæmic, while many of them are in perfect health. But retinal hæmorrhages may be the first sign of a developing retinitis.

Prognosis.—The apoplexies are observed, in the course of weeks or months, to become paler and smaller, often leaving after them chorioidal changes, or greyish spots dependent on degeneration of the retina, and in some extreme cases atrophy of the whole retina may result.

Occasionally, absorption of the hæmorrhages is accompanied by complete restoration of vision, but usually the scotomata remain. Recurrences of the hæmorrhages are very common. Glaucoma comes on as consecutive to retinal apoplexies in some instances, and is then known as hæmorrhagic glaucoma, an incurable form of the disease (p. 256). In other cases the hæmorrhage, having invaded the vitreous humour, gives rise to dense permanent opacity in it, followed, perhaps, by detachment of the retina.

Treatment.—Active measures are of little use. Cold compresses at first, with a pressure bandage, and dry cupping to the temple, may be employed. The general state of the patient must be attended to, with rest of the body. Some oculists have found much advantage from sub-conjunctival saline injections.

*** Embolism, and Thrombosis, of the Central Artery of the Retina** (Plate VII. Fig. 1).—Sudden or very rapid blindness, beginning at the periphery of the field, and advancing towards the centre, is the only symptom experienced by the patient.

Immediately after the attack, the *Ophthalmoscope* shows a marked pallor of the papilla, while the artery and its branches are empty of blood, resembling fine white threads, and the veins are diminished in size at the papilla, but somewhat increased in size towards the periphery. Pressure on the eyeball produces neither pulsation nor change in calibre of the vessels, as it does in a sound eye. Usually, within a few hours, the central region of the retina begins to assume

PLATE VII

(*To face page* 322)

FIG. 1.—Note the pallor of the optic disc, the thread-like arteries, the 'cherry-red spot' at the macula lutea, and the surrounding cloudiness of the retina.

FIG. 2.—The inferior retinal vein is engorged and tortuous, and darker in colour. There is slight cloudy œdema of the retina, and numerous flame-shaped and blotchy hæmorrhages; in the centre of one large hæmorrhage are some white spots due to absorption, or to fatty degeneration.

Fig. 2 *legend*, for "Thrombons" read "Thrombosis."

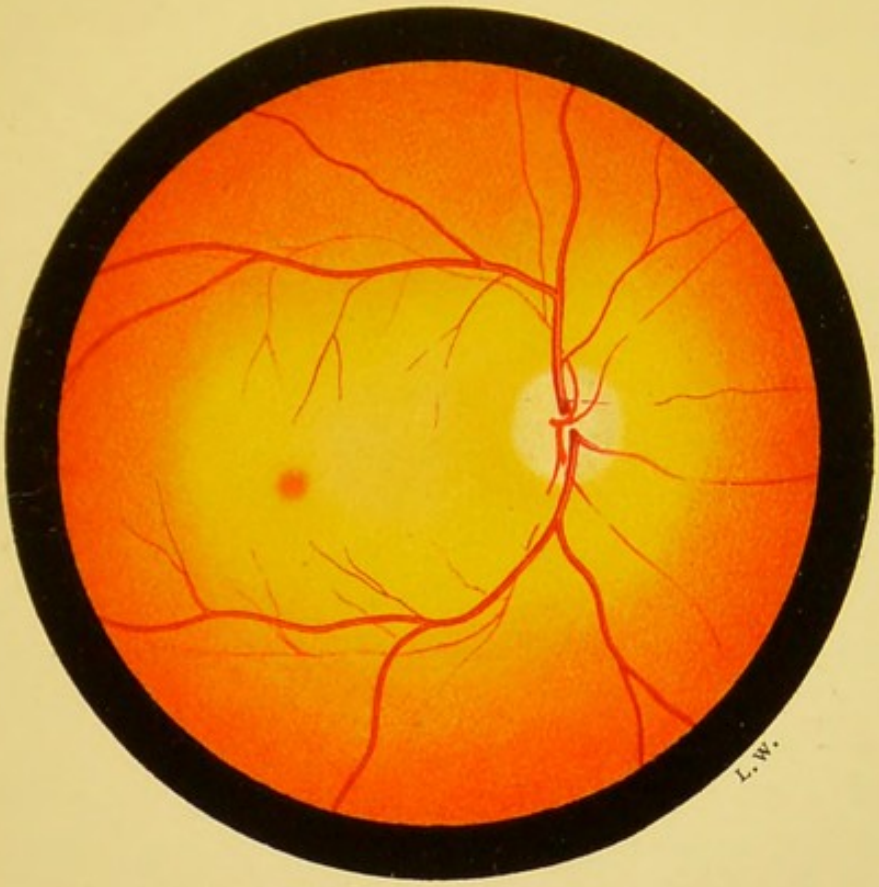


FIG. 1. Embolism of Central Artery of Retina.



FIG. 2. Thrombons of Inferior Retinal Vein.

a greyish-white opaque appearance, consequent on œdema of the nerve-fibre layer, in the midst of which the macula lutea is seen as a cherry-red spot. The little blood contained in the vessels may soon be observed to divide into short columns with colourless interspaces, and these short columns move along the vessels with a slow jerky motion. Minute hæmorrhages often occur, most commonly between the macula and the papilla.

The cherry-red spot at the macula lutea is not due to hæmorrhage. It is a contrast effect, the red colour of the chorioid shining through, where no nerve-fibre layer and consequently no œdema, is present.

The œdema of the retina passes away in a few weeks, and with it the peculiar appearance of the macula lutea, while atrophy of the retina and papilla supervene.

Embolism of a branch only of the central artery has been observed. In these cases the œdema and the defect of vision are confined to the part of the retina supplied by the embolised branch.

It is not possible with the ophthalmoscope to make the diagnosis between embolism and thrombosis of the central artery. In thrombosis there are often previous attacks of transient blindness, in one or both eyes, and faintness, giddiness, and headache at the onset of the blindness.

Prognosis.—Vision may improve for a time, but when atrophy commences it falls back; and, finally, power of perception of light is lost. Cases of embolism of a branch of the central artery are more likely to recover.

Causes.—Endocarditis; mitral disease; aneurism of the aorta; pregnancy; Bright's disease. A few cases of chorea with embolism of the central artery are recorded. But it occurs, too, in apparently healthy persons, without any discoverable cause.

Thrombosis is apt to be caused by any condition which slows the flow of blood, disease of the walls of the vessels, or alteration in the quantity or quality of the blood.

Treatment.—Paracentesis of the anterior chamber has been tried with the object of suddenly reducing the tension, and thereby causing a sudden rush of blood behind the obstruction which may sweep the latter away. Such attempts have very rarely been successful, and can be of avail only if employed almost immediately

after the attack of blindness; that is to say, before the retinal tissue dies.

Several cases have been published, in which the circulation, which probably was not completely impeded by the embolos, or thrombos, was restored, and good vision regained; the recovery being probably due to the manipulations of the eyeball made in each case for the purpose of observing the effect of pressure on the vessels. So long as the pressure was maintained, a column of blood was being stored up behind the embolos, and, on removal of the pressure, it rushed forward against the impediment, carrying the latter into some more remote vessel, or into the general vascular system. In fresh cases, massage of the eyeball suitably applied would, therefore, always be worth the trial.

* **Thrombosis of the Retinal Vein** is seen chiefly in old people with atheromatous arteries or cardiac troubles. Orbital cellulitis, due to erysipelas or other causes, may also produce it.

The Ophthalmoscopic Appearances (Plate VII. Fig. 2) consist in extreme engorgement of the retinal veins, with great narrowing of the arteries; the whole fundus is thickly studded with dark hæmorrhages; the optic papilla after a time becomes pale, and undergoes atrophy, and the hæmorrhages, having become absorbed, leave an atrophied retina with thready arteries. If the thrombosis be only of a branch of the central vein, the ophthalmoscopic appearances will be confined to the corresponding portion of the retina, owing to the absence of anastomosis in retinal vessels.

The Prognosis is very bad, sight becoming permanently damaged or lost. It is more favourable when a branch only is thrombosed. *Treatment* must be directed to the general condition.

* **Sclerosis of the Retinal Vessels** (Perivasculitis, or, more rarely, Endarteritis) reveals its presence by narrowing of the blood column, and by the appearance of white lines along the vessels. It usually begins in the large trunks on the papilla, and may not extend much beyond the latter, as in some cases of optic atrophy (Plate VIII. Fig. 2); while in other cases (Bright's disease, hereditary syphilis) it involves the small branches as well, and promotes thrombosis and retinal apoplexies, and may even ultimately lead to obliteration of the lumen of the vessels, so that they look like white branching streaks. The arteries are more liable to this condition than the veins.

Quinine Amaurosis.—Quinine in large doses, and very occasionally in small doses, is liable in some individuals to cause amblyopia, which may come on almost suddenly, and may amount to absolute blindness, accompanied for some hours or days by great deafness. This absolute blindness is rarely more than temporary, although it may last for some weeks; but, in severe cases, concentric contraction of the field is apt to remain permanently, with or without some defect of central vision. In a serious instance, the colour and light-senses, notwithstanding the contracted field and marked seeming optic atrophy, were normal; but the adaptation of the retina, as shown by considerable night-blindness, was defective.

Yarr finds that doses of sulphate of quinine of more than 20 grains are dangerous to the sight, and that more than 40 grains should not be given in twenty-four hours. During the early stages, the pupils are widely dilated, and the cornea and conjunctiva are sometimes anæsthetic.

In what may be called the acute stage, the *Ophthalmoscopic Appearances* are sometimes normal, but pallor of the optic papilla, with scarcity and smallness of the retinal vessels, is the more usual condition. Where the case is chronic—the fields remaining contracted, although central vision has improved—the ophthalmoscope may discover a very pale optic papilla with minimal vessels.

The retinal ischæmia is doubtless the immediate *Cause* of the amblyopia, and is the result of diminished heart's action and lowered arterial tension, both of which have been shown to be produced by large doses of quinine. Destruction of the ganglion cells of the retina towards its periphery has been found, and to it may be referred the permanent contraction of the field of vision in some cases.

Treatment.—Cessation of the use of quinine. Digitalis internally to raise the arterial tension, nitro-glycerine, hypodermic injections of strychnia, and general tonic treatment. Yarr has found that nitrite of amyl causes only temporary improvement of vision.

* **Amaurosis from Filix Mas.**—In the rare cases of this kind due to large doses (3j to ij) of extract of male fern, the blindness is usually preceded by headache, vertigo, tinnitus, prostration, diarrhœa, and coma or convulsions: sometimes, too, by pain at the back of the eye and on movement. Ophthalmoscopically, great diminution in calibre of the retinal arteries with congestion of the veins, and

extreme œdema of the retina, seem to be the initial appearances, followed at a later period by atrophy of the optic nerve. In severe cases vision does not return.

Injury of the Retina by Strong Light.

* **Blinding of the Retina by Direct Sunlight.**—This is especially likely to occur on the occasion of solar eclipses, by observation with unprotected eyes.

Immediately after the exposure, the patients complain of a dark or semi-blind spot in the centre of the field of vision—a positive scotoma, in short, which may even be absolute, and which interferes with vision in proportion to the length of the exposure. There may also be a central defect for colours, which may extend over a larger area. A peculiar oscillation, or rotatory movement, is frequently observed by the patient in the scotoma, and is very persistent. Objects may also seem twisted or otherwise distorted (metamorphopsia).

The Ophthalmoscopic Appearances may be normal, but as a rule some changes exist, such as an alteration or loss of the light reflex at the macula, or a minute pale orange spot near the fovea, with, especially in the later stages, some darkening or pigmentation. When the cases are not severe, improvement in vision takes place, but complete recovery is not common. Hitherto no case in which the vision had been reduced to less than $\frac{1}{3}$ has regained good sight.

Treatment.—Hypodermic injections of strychnia, the constant galvanic current, dry cupping on the temple, and sub-conjunctival saline injections, afford the best chances for promoting the cure. Rest and dark protection glasses are important.

* **Snow-Blindness.**—Exposure of the unprotected eyes for a length of time to the glare from an extensive surface of snow produces, in some persons, a peculiar form of ophthalmia, which may be followed by temporary or even permanent amblyopia. Although this condition is chiefly an affection of the conjunctiva, it is described here in order to compare it with the effects of sunlight and electric light.

Snow-Blindness begins with sensations of a foreign body in the eye, photophobia, blepharospasm, and lacrimation; later on chemosis, with small opacities, or ulcers, of the cornea, comes on,

The condition passes off in three or four days without leaving any permanent ill results, except in rare cases, when there may be some secondary hyperæmia of the retina. It is held to be the ultra-violet-rays which cause snow-blindness.

Treatment.—The preventive treatment consists in the wearing of dark smoked, yellow, or, best of all, euphos glasses when travelling on the snow; while, for the ophthalmia and to relieve the distressing symptoms, cold applications and cocaine with adrenaline are recommended.

* **Effects of Electric Light on the Eyes.**—The degree of intensity of electric light required to produce injurious effects on the eye is not known; but no bad results have been observed from the ordinary use of the incandescent electric light, for reading, writing, etc.; on the contrary, it may be regarded as the best artificial light for these and other domestic uses. It has a greater illuminating power, produces less heat and no products of combustion, and hence it does not vitiate the atmosphere, nor tend to cause conjunctival irritation. The electric light is steadier than gas; and, on account of the smaller quantity of red rays it contains, it more nearly approaches daylight than does gas, unless the latter be used with the incandescent mantle. It should, however, be so arranged for use that the rays may not enter the eye directly, or discomfort in the form of smarting, burning, and headache may result, by reason of its being rather rich in ultra-violet rays. Two groups of symptoms are observed from the action of strong electric light on the eyes:—

(*a*) *Electric Ophthalmia.* This has been chiefly seen in those employed in electric welding operations, and less frequently in electricians who use strong arc-light. The symptoms begin shortly after exposure to the light, always within twenty-four hours, and are the same as those present in snow-blindness; the lids also are swollen, and even erythematous at times. The pupils are contracted. A slight muco-purulent secretion from the conjunctiva appears after the subsidence of the above symptoms. Recovery takes place in a few days, with complete restoration of vision, except in rare cases.

(*b*) *Blinding of the Retina by Electric Light.*—This is the same affection as the blinding of the retina by direct sunlight. The central scotoma may persist after an attack of electric ophthalmia, or may occur without it. The injurious action of the electric light

on the eye is attributable to the chemical action of the ultra-violet rays. Widmark's experiments show that changes can be produced in the retina by the electric light, without any heat coagulation. These changes consist in œdema, with more or less destruction of the nervous elements of the retina—namely, the outer layers, including the rods and cones, and the inner layer of nerve-fibres.

Treatment.—The preventive treatment consists in the use of coloured glasses. Yellow glass has been recommended by Maklakoff, and the new euphos glass, a peculiar shade of yellow, of Schanz and Stockhausen is coming into use. The object of this glass is to cut off the ultra-violet rays.

Tumour of the Retina.

*** Glioma of the Retina.**—This is a malignant growth and is found almost exclusively in young children, or may even be congenital, and occasionally occurs in several children of the same family. It is sometimes in each eye. Owing to the age of the patients, the incipient stages of the disease are seldom observed, for they are unattended by pain or inflammation.

The growth commences as small, white, disseminated swellings in the retina, usually in one or other of the granular layers, more rarely in the nerve-fibre layer. The retina is apt to become detached at an early period ; but there are exceptions to this, especially when the disease starts from the nerve-fibre layer. Glioma may be endophytic, growing inwards towards vitreous humour, or exophytic, growing outwards towards chorioid. In the early stages there is no iritis, cyclitis, or opacity of the vitreous humour, and the iris periphery is not retracted—points which especially enable us to distinguish it from pseudo-glioma (p. 198). Secondary glaucoma finally comes on. The optic nerve may become involved at an early period ; but sooner or later it invariably does so, leading then by extension to glioma of the brain. When the tumour has filled the eyeball, it bursts outwards, usually at the corneo-sclerotic margin, and then grows more rapidly, and often to an immense size, as a fungus hæmatodes. The orbital tissues become involved, and even the bony walls of the orbit ; while secondary growths in other organs, more especially in the liver, are not rare.

The diagnosis between glioma of the retina and tubercle of the

chorioid (p. 227), when the latter occurs in young children, is sometimes difficult or impossible; but, in view of treatment, it is not of great importance, as in either case the eye must be enucleated.

In glioma of the retina, as in sarcoma of the chorioid (p. 226), phthisis bulbi with regressive metamorphosis of the new growth may come on, and give the appearance, for a lengthened time, of a cure of the tumour. But, probably invariably, renewed growth of the tumour takes place.

Treatment.—The only hope of saving the patient's life lies in enucleation at an early stage, or before the optic nerve becomes diseased. It is important in removing the eyeball, as in every intra-ocular growth, to divide the nerve as far back as possible (p. 211); and, if the orbital tissues be already diseased, to remove all suspicious portions of them. Several cases in which there was no return of the growth have been observed, even after removal of both eyes; and in a case of the latter kind under the care of one of us, the patient continues healthy five years after removal of the eyes.

* **Tubercle of the Retina.**—Primary tubercle of the retina is exceedingly rare, and presents the appearance of a more or less extensive and slightly elevated white area, at the posterior pole of the eye, involving the optic disc or macula lutea or both. When the disease occurs in a young child, the diagnosis from glioma of the retina will present difficulty. Or, there is in the region of the posterior pole a large yellowish-white mass spreading out in all directions from a detached and non-translucent area of retina, while towards the periphery there are multiple hæmorrhages and yellowish deposits of various sizes; the optic papilla and retinal vessels being normal. More commonly, tubercular disease of the retina is secondary to tuberculosis of the uveal tract, or optic nerve.

Treatment.—Tuberculin (p. 189).

Parasitic Disease.

* **Cysticercus under the Retina.**—The cysticercus of the tænia solium in the eye is very rare. Its most frequent seat is between the retina and chorioid, where it is recognised with the ophthalmoscope as a sharply defined bluish-white body, with bright orange margin. At one point of the cyst there is a very bright spot, which corresponds with the head of the entozoon. Wave-like motions

along the contour of the cyst should be looked for to confirm the diagnosis. The cysticercus may move from its original position, and in so doing cause considerable detachment of the retina. Delicate veil-like opacities are apt to form in the vitreous humour, and are almost characteristic of the presence of cysticercus.

The entozoon may become encapsuled behind the retina; or it may burst into the vitreous humour (p. 309); and finally chronic irido-cyclitis, with total loss of sight and phthisis bulbi, is apt to come on.

Treatment.—There is no anthelmintic which will act upon the entozoon in the eye. Removal of the cyst by operation is the only means by which the eye can be saved; and this measure can only be resorted to when the position of the cysticercus is favourable —*e.g.* when it is close to the equator of the eyeball. In such cases, by a well-placed puncture through the sclerotic and chorioid, the entozoon may be evacuated. If this cannot be accomplished, the eye must be excised.

Detachment of the Retina.

The normal retina is firmly attached at the optic disc and at the ora serrata only. Between these it adheres merely by prolongations of the pigment epithelium, which run between the rods and cones, and hence, under certain conditions, it readily becomes detached or separated from the chorioid. Even when there is 'total detachment' of the retina, it remains adherent at the optic disc and ora serrata. In detachment of the retina the space between retina and chorioid is occupied by a clear serous fluid. It is not usual to employ the term, when it is a solid neoplasm only that lies between retina and chorioid.

If the media be clear, and the detached portion extensive, the diagnosis is not difficult.

The Ophthalmoscope (Plate V. Fig. 2) shows a greyish reflex from a position which is anterior to the fundus oculi, and to the surface from which the greyish reflex is obtained a wave-like motion is imparted when the eyeball is moved. Over this greyish surface the retinal vessels run, and they serve to distinguish a detached retina from any other diseased condition with a somewhat similar appearance. The vessels seem black, not red, in consequence of

absorption of the light reflected back from the fundus, and they are hidden from view here and there in the folds of the detached retina. The detachment renders these parts of the fundus hypermetropic. In many cases a rent in the detached retina, usually towards the ora serrata, through which the chorioid can be discerned, will be discovered. In some cases the detached part retains its transparency, and does not become grey or opaque; and then it is the reflexes from the folds of the detachment, the dark retinal vessels, and the fact that both folds and vessels lie in front of the true fundus oculi, which enable the diagnosis to be made.

The detachment may commence in any portion of the fundus, but most commonly does so above; yet, owing to gravitation of the fluid, it ultimately settles in the lower half of the fundus, and hence this is the most common place to find it, the part first detached having become replaced. The diagnosis is more difficult if there be but little fluid behind the retina, or if there be opacities in the vitreous humour.

Vision is affected according to the position and extent of the detachment. Central vision may be quite normal if the macula lutea and its immediate neighbourhood be intact. The patients complain of distortion of objects looked at, of a black veil or curtain which seems to hang over the sight, and sometimes of black floating spots before the eye, due to opacities in the vitreous humour. These symptoms often come on suddenly in an eye which has hitherto had good sight.

The field of vision, on examination, will show a defect which corresponds with the position of the detachment. If, for example, the detachment be below, the defect will be in the upper part of the field. If the detachment be recent, the retina not having yet undergone secondary changes, and if the quantity of subretinal fluid be not great, the defect in the field may only amount to an indistinctness of vision; while later on, when—owing to derangement of its nutrition from its being separated from the chorioidal capillaries—infiltration and degeneration of the detached part come about, fingers may not be counted in the defective area of the field.

Should the detachment become complete, little more than mere power of perception of light may be present. Total detachment

is followed by cataract, and often by iritis, cyclitis, and phthisis bulbi. The detachment may remain stationary, and may not extend to the whole fundus, or the retina may return to its normal position; but this latter event is most rare. For the diagnosis of detachment of the retina from tumour of the chorioid see p. 224.

Causes.—Myopic eyes—which we know are so frequently affected with chorioiditis and disease of the vitreous humour—are those most subject to detachment of the retina (chap. xv.); but idiopathic detachment occurs also in eyes which are apparently healthy. Blows upon the eye may produce detachment, the retro-retinal fluid being serous or bloody; and some punctured wounds of the sclerotic, in the course of healing, by dragging on the retina, give rise to it. Chorioidal tumours, especially those situated in the posterior segment of the fundus, usually cause detachment in an early stage of their growth, and the complication renders their diagnosis more difficult (p. 224).

Leber observed that, in non-traumatic detachment, a perforation or rent in the detached portion is very frequently to be seen with the ophthalmoscope, and holds that it is probably always present, although sometimes, from being hidden behind a fold of the retina, it cannot always be found. From this, and from his pathological investigations and experiments upon animals, he was led to the opinion that the detachment was due to shrinking of a diseased vitreous, which first became slightly separated from the retina, and that then—at some place where the retina and hyaloid had become adherent by reason of an inflammatory process—a rent was produced in the retina by the shrinking process in the vitreous. He concluded that through this rent the fluid, which is always present behind the vitreous in cases of detachment of that body, makes its way behind the retina, and separates the latter from the chorioid. The suddenness with which detachment often comes on is accounted for by this theory. Nordenson's pathological researches went to corroborate this. He ascertained, too, that disease of the ciliary body and chorioid is the primary cause, although we may not be always able to detect it with the ophthalmoscope, and that the pathological change in the vitreous humour consists in an alteration in its connective tissue elements, resulting in the deleterious shrinking.

Raehlmann, however, from the results of experiments, and also

from clinical observation, concludes that detachment of the retina is due to exudation from the chorioidal vessels of a fluid, which is more albuminous than the fluid in the vitreous humour. Hence, he thinks, diffusion takes place through the retina, and a greater quantity of the less albuminous vitreous fluid passes through the retina, thus producing and increasing the detachment. Rupture of the retina is not, in his view, a necessary factor in the causation, but it may occur if the tension behind the retina be higher than that in front of it.

Treatment.—The dorsal position in bed, with a pressure bandage on the eye, and diaphoretics internally, the treatment being continued for from four to six weeks, brings about reposition of the detachment in some cases. To this treatment sub-conjunctival injections of a 5 to 10 per cent. saline solution may be added. The method, if properly carried out, is trying to the patient.

Evacuation of the subretinal fluid by puncture of the sclerotic is employed. The instrument used resembles a broad needle, with blunt edges, which is entered through the sclerotic and chorioid at a place corresponding with the position of the detachment, but not so deeply as to reach the retina, lest thereby it be further displaced. The instrument is then given a quarter of a rotation, to make the wound gape, so as to admit of the flowing off of the fluid. If possible, a position near the equator of the globe, and between two recti muscles, should be selected for the operation. Moreover, the incision should lie parallel to the direction of the muscles, so that the chorioidal vessels may be injured as little as possible. A firm dressing and bandage is applied, and the patient kept in bed for eight or ten days.

The cures which have been accomplished by these means probably depended upon the retina again coming in contact with the chorioid, and, owing to some slight inflammatory process, adhering to it. For the most part the cure is but temporary, and in such cases we may suppose that no adhesion sprang up, but that the temporary cure was due to a return of the subretinal fluid, through the hole in the retina, to its original position between the retina and vitreous. Soon, however, it makes its way back again through the opening, and the detachment recurs.

To promote adhesion between retina and chorioid, Dor touches the sclerotic corresponding with the detachment lightly with a small

cautery, injects rather strong (10 per cent.) solutions of common salt under the conjunctiva, and keeps the patient in bed. He reports some cures by this method.

The foregoing are the principal methods of treatment for detachment of the retina, and there are many others. *The Prognosis* of every case of detached retina is bad, spontaneous cure being extremely rare, and cures effected by any one or by any combination of methods of treatment being few and far between; while, even when the retina returns to its place, there is the danger of a recurrence of the detachment. Moreover, both eyes often become affected, one after the other. It is important therefore to explain the prospects of the treatment to the patient before it is commenced. The most favourable cases are those due to chorioiditis, the most unfavourable those due to posterior staphyloma.

Traumatic Affections of the Retina.

In addition to detachment and rupture of the retina, the undermentioned conditions occur as the results of injuries.

* **Traumatic Anæsthesia of the Retina.**—A blow on the eye from a fist, cork from a bottle, etc., is liable to produce considerable amblyopia, with concentric contraction of the field, which may continue for a long time, while the *Ophthalmoscopic Appearances* are normal. Ultimately these cases usually recover, an event which may be promoted by the use of strychnine hypodermically; but very defective sight sometimes remains permanently.

* **Commotio Retinæ,** or **Traumatic Œdema of the Retina,** is the result of a blow upon the eye. Immediately after the blow there is marked episcleral injection, and the pupil can be dilated but slowly with atropine. Within a few hours after the accident the *Ophthalmoscope* reveals a white cloudiness (œdema) of a portion of the retina, usually in the neighbourhood of the optic papilla and macula, but sometimes more eccentrically; and sometimes there are two such opaque patches. The opacity increases in intensity, and spreads somewhat. The retinal vessels remain normal; there may be some small hæmorrhages, and sometimes the papilla is redder than normal. These appearances completely disappear in the course of a few days. Vision is only slightly affected, and recovers as the retinal changes pass off.

* **'Holes' at the Macula Lutea.** (Retinitis atrophicans centralis, of Kuhnt).—Blows on the eye sometimes give rise to a remarkable lesion at the macula lutea. The ophthalmoscopic appearances suggest a punched-out hole, generally of a circular or oval shape. This area is depressed below the level of the surrounding retina, its floor is of a deep red colour, and its margin is sharply defined, or it is surrounded by a light cloud which fades off into the retina. On the floor of the hole and around its margin innumerable very fine glittering dots are present in many cases. In some cases there is a shallow detachment of the retina, but in the majority of them there is none. Contrary to what would be expected, the functions of the macula lutea, although diminished, are not completely lost, and an absolute central scotoma is not present in every case. Consequently, it must be concluded that, notwithstanding the apparent serious damage, the delicate tissues at the macula lutea, and the nerve-fibres connecting it with the optic nerve, are not always completely destroyed.

Very similar appearances, without any history of trauma, have been observed occasionally to follow iritis or irido-cyclitis. They have also been seen in the eyes of elderly people the subjects of arterio-sclerosis, and in albuminuric retinitis, retinitis pigmentosa, amaurotic family idiocy, after perforating injuries, operations, or corneal ulcers, followed by inflammation. The pathogenesis of this condition has not been clearly made out. Œdema of the retina seems to be, according to Fuchs, a forerunner of the formation of the hole.

CHAPTER XII.

DISEASES OF THE OPTIC NERVE.

The Optic Nerve may be affected, directly or indirectly, at various parts of its course, from the optic commissure to its termination in the eyeball. For clinical purposes it is convenient to distinguish the following portions of the nerve: the intra-cranial portion, the optic canal portion, the intra-orbital portions behind and in front of the entrance of the central artery of the retina into the nerve, and lastly the termination of the nerve in the eye, known as the optic papilla or optic disc.

Optic Neuritis.—*The Ophthalmoscopic Appearances* (Plate VIII. Fig. 1) of inflammation of the optic nerve vary a good deal with the intensity of the process. Common to every case is hyperæmia and swelling of the papilla, with haziness (so-called "woolliness") of its margins, and increase in the size of the central vein, while the central artery remains of normal dimensions, or is contracted. The swelling and haziness extend but a short distance into the surrounding retina, and the distension of the vein is also not continued to the periphery of the fundus. In slight cases, these appearances may barely exceed the normal. They first appear at the inner margin of the disc.

In extreme instances, the disc is swollen to a great size, and may even assume quite a dome shape, while the veins are enormously distended and tortuous, and the arteries are contracted so as to become barely visible. (Plate VIII.) In some cases greyish striæ extend from the papilla into the surrounding retina, some flame-shaped hæmorrhages are present on or near the papilla, and, occasionally, white spots in the retina, and a stellate arrangement of small white dots about the macula lutea, form a picture which cannot be distinguished from that of albuminuric retinitis (Plate V. Fig. 1). This extreme form is still termed Congestion Papilla

PLATE VIII

(To face page 336)

FIG. 1.—The optic disc is greatly swollen and prominent as shown, more especially, by the enlarged veins, which curve over the surface, and which are, in some places, lost to view under the edge of the swollen disc. The congestion of the disc is somewhat diminished by exudation, and several flame-shaped hæmorrhages are present. This is the type of optic neuritis which accompanies intracranial tumours.

FIG. 2.—The atrophy here has followed on the subsidence of optic neuritis. The disc is very white, 'filled in' in the centre where the origin of the vessels is partly hidden. The inner margin of the disc is 'woolly.' Note the white lines bordering the vessels, due to perivascular itis. Some of the arteries are very narrow.

FIG. 3.—The disc is white and sharply defined, and the lamina cribrosa is visible. The vessels had not diminished in size in this case, although it is more usual to find them much reduced in calibre.

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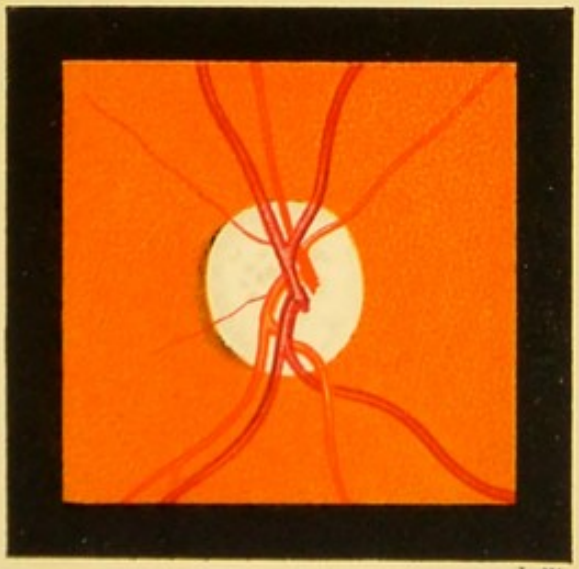
L. W.

FIG. 1. Choked Disc.



L. W.

FIG. 2. Consecutive Atrophy of Optic Nerve.



L. W.

FIG. 3. Primary Atrophy of Optic Nerve.

or Choked Disc, although the theory which originally suggested the term has been abandoned. It is also known as Papillitis.

The Vision, even in cases where the ophthalmoscopic signs are highly developed, is frequently normal; while, again, in other, and possibly less well-marked cases, it may be reduced to perception of light, or even that may be wanting. When due to cerebral tumour, the neuritis appears, as a rule, before the vision becomes affected. This remarkable disproportion between the degree of blindness and the ophthalmoscopic appearances depends, probably, on the extent to which the nervous elements of the optic nerve are pressed on or altered, and this cannot be gauged by the ophthalmoscopic appearances.

Sometimes the field of vision is normal, while again it is concentrically or irregularly contracted, or it may be hemianopic. In cases of choked disc the field for colours is often reversed, as in hysteria (p. 381), the field for red being wider than that for blue (Fig. 12).

Attacks of temporary loss of sight are a common symptom in cerebral tumours; they may occur several times a day, and each one may last from a few minutes to half an hour. By some these attacks are held to be due to cramp of the retinal vessels, and, by others, to sudden elevations of the intra-cranial pressure.

Pathologically, the changes in the papilla consist in venous hyperæmia, œdema, hypertrophy of the nerve-fibres, infiltration of lymph cells, and development of connective tissue. Inflammatory changes, although less pronounced, are also present in the trunk of the nerve and its sheaths.

Causes.—Inflammation of the optic nerve is most commonly found in connection with coarse encephalic disease. A Cerebral Tumour (including syphiloma, tubercle, cyst, and abscess) in particular is the most common cause, and is, moreover, usually present when the papillitis is of an intense type (choked disc). Even a small tumour situated anywhere in the brain is capable of producing optic neuritis. The most intense neuritis is often that attending a cerebellar tumour. The neuritis, except in very rare instances, is bilateral, and it is one of the general symptoms of cerebral tumour. Hemianopsia may be present if the visual centre or fibres on one side be involved. Sir Victor Horsley and others are strongly of opinion that, as a rule, choked disc commences,

and is most marked, on the eye which is on the same side as the cerebral tumour, and that in this sense it has a localising value. Cerebral cysts do not often cause choked disc.

The Connection between Congestion Papilla and Intra-cranial Tumours has given rise to much discussion, and many divergent views are still held on the subject. In these cases a considerable exudation of fluid usually takes place into the cavity of the third ventricle. This, along with the new growth, increases the pressure within the cranial cavity. By reason of this increased intra-cranial pressure, the sub-arachnoid fluid is driven into the sub-vaginal lymph-space of the optic nerve, and produces that dropsy of the sheath which is found, in many cases, on careful post-mortem examination.

Leber holds the view that this fluid probably contains a phlogogenic substance. It may be that the reason why some small cerebral tumours cause optic neuritis, while some large ones do not, is to be sought in the fact that the former may happen to be rapidly growing tumours, and to be accompanied by much ventricular dropsy, while the larger tumours may be slow in growth, and attended by but little dropsy of the ventricles. Moreover, the fluid driven into the sub-vaginal lymph-space of the optic nerve may not be equally rich in phlogogenic substance in every case.

Schieck's view is that, if it be admitted, in accordance with Gifford's experiments, that at the point of exit of the vessels from the trunk of the optic nerve two lymph streams meet, one flowing from the optic papilla in the perivascular lymphatics, the other descending from the brain; it is necessary, for the normal regulation of a common outflow of the two streams through the perivascular lymphatics of the central vessels as they pierce the dural sheath, that they should be under equal pressure. But, when the fluid in the intervaginal lymph-space, which freely communicates with the cerebro-spinal fluid, is placed under abnormally high pressure in consequence of increased intra-cranial pressure, the exit of lymph from the vitreous humour must be blocked, and this lymph must be pent up in the axial portion of the trunk of the optic nerve; while the cerebro-spinal fluid continues to press forwards, and to add to the over-distension of the lymph-spaces. The obstruction to the outflow of lymph in the axial portion of the nerve trunk soon shows itself ophthalmoscopically by swelling of the tissue of

the papilla; and, through compression of the blood-vessels, the venous stasis, indicated ophthalmoscopically by distension of the central vein, is brought about. The œdema then infiltrates the nerve-fibres of the optic nerve, causing their strangulation and disintegration, and as a consequence of this disintegration, and of the decomposition of the retained lymph, a true inflammatory process sets in. Secondary proliferation of the connective tissue elements of the nerve takes place, with consequent destruction of the nerve-fibres, and in this way atrophy ultimately results.

But all are agreed that increased intra-cranial pressure is the primary and essential cause of choked disc in cases of intra-cranial tumour.

Choked disc occurs in about 80 per cent. of the cases of intra-cranial tumour; but it is not usually one of the very earliest signs, headache, nausea, etc., preceding it in the majority of cases. In tumour of the cerebellum choked disc is commonly an earlier symptom than it is in tumour of the cerebrum. Tumours of the pons, medulla, and corpus callosum are those in which it is most likely to be a late symptom. In the course of time, unless death intervenes, the swelling of the discs, and other primary appearances, subside, and complete atrophy of the optic nerves results (Plate VIII. Fig. 2); and even before this stage is reached the patient will have become absolutely and permanently blind.

Treatment.—To avert the latter catastrophe, even where the prospects of life are not for long, and with the object of affording relief from the racking headache, and other distressing symptoms, it has been proposed by Sir Victor Horsley, and has become a recognised practice, to reduce the intra-cranial pressure by a palliative decompression operation. This is accomplished by trephining the skull and opening the dura mater. It should be done as early as possible in the case, and it is held by some to be indicated even before choked disc appears, if the symptom of recurring attacks of blindness be present.

Tubercular Meningitis is a common cause of optic neuritis. Non-tubercular meningitis occasionally gives rise to it, and sometimes, also, cerebro-spinal meningitis.

Other causes for Optic Neuritis are :—

Hydrocephalus.—Here the pathogenesis is probably the same as in the foregoing; but the occurrence of optic neuritis is not very

common with the hydrocephalus of children. It does occur with the rarer hydrocephalus of adults, of which the symptoms may be indistinguishable from those of intra-cranial tumour.

See also Diffuse Sclerosis of the Brain, p. 370.

Tumours of the Orbit.—How these growths bring about papillitis is still unknown.

Inflammatory Processes in the Orbit, such as caries, inflammation of the retro-orbital areolar tissue, erysipelas of the head and face extending to the orbital tissues, and periostitis. The presence of the latter may often be recognised by pain on motion of the eyeball, pain in the eye and forehead, and especially by pain on pressure of the globe backwards, and is frequently of rheumatic origin. Often in these cases one eye only is affected ; and, although the Ophthalmoscopic Appearances are sometimes very slight, yet vision may be quite lost in a few hours or days, atrophy of the nerve then rapidly setting in. Very many of the cases, however, do not go on to atrophy, but end in recovery of useful vision.

Exposure to Cold, especially if the skin be heated and perspiring.

Suppression of Menstruation.—If during the menstrual period the flow be arrested by exposure to cold, wet feet, etc., acute optic neuritis with rapid blindness may come on. Spontaneous amenorrhœa, or even irregularity of menstruation, and the climacteric period are liable to have a similar but more chronic result. Nothing is known with regard to the connection between the uterine and ocular disorder. In these cases the Ophthalmoscopic Appearances, as well as the blindness, are apt to be extreme. Treatment should be directed chiefly to restoring, when possible, the normal uterine functions. Hot foot-baths and Heurteloup's leech to the temples are of use.

Chlorosis.—Here the optic neuritis is due to the disordered state of the blood. The Ophthalmoscopic Appearances are usually slight, but occasionally they are of extreme degree, and resemble choked disc. These latter cases may be taken for cerebral tumour by reason of concomitant symptoms—headache, vertigo, vomiting, and convulsions. The neuritis yields under the influence of iron and arsenic.

Syphilis.—The trunk of one or both optic nerves may be the seat of specific inflammation in connection either with congenital or with acquired syphilis, but this primary specific optic neuritis

is a relatively rare disease. In cases of acquired syphilis it makes its appearance in from six months to two years after the primary infection. The Ophthalmoscopic Appearances may be normal (retro-bulbar neuritis), or may present any grade of neuritis, even to the most pronounced papillitis. In the latter case it would not be possible to say whether the papillitis is a primary one, or is due to a syphilitic gumma within the cranium. The inflammation often extends as far up as the chiasma. The Treatment in these cases of specific papillitis must be active mercurialisation. By this means, even if perception of light be lost for a period of not more than eight to fourteen days, hopes may be entertained of its complete or partial recovery. Cases of double optic neuritis of syphilitic origin have been observed, in which complete recovery took place, the papilla returning to its normal condition. But, as a rule, some optic atrophy, at the least, with slight concentric contraction of the field, results. The prognosis is all the better the sooner the optic neuritis follows upon the primary syphilitic affection.

Rheumatism.—There is no doubt but that the rheumatic diathesis is occasionally the cause of optic neuritis, although this view is not unreservedly accepted by every author. Other manifestations of rheumatism are sometimes well marked, but may be very slight. One or both optic nerves may be attacked. The Ophthalmoscopic Appearances often amount to extreme papillitis, but in many cases fall short of this. If the case come early under suitable treatment the Prognosis is fairly favourable; but when the inflammation is of some standing, consecutive optic atrophy must be feared. The Treatment consists of full doses of salicin, salicylate of sodium, iodide of potassium or of sodium, Turkish baths, and other recognised anti-rheumatic measures.

Lead-Poisoning.—In some cases of lead-poisoning optic neuritis, not to be distinguished from that of primary cerebral affections, is found. Sometimes the Ophthalmoscopic Appearances are slight, and, again, quite pronounced, the changes extending into the retina. They sometimes simulate the retinitis of Bright's disease; and in such cases renal disease is likely to have much to do with the causation of the retinitis. Some authorities, who have good opportunities for forming a correct opinion, deny the existence of a specific lead neuritis, and hold that the neuritic affection in all such cases is to be referred to albuminuria, or to effusion into the

ventricles of the brain and subarachnoid space, or to accompanying suppression of menstruation. Occasionally optic atrophy is the first ophthalmoscopic appearance seen; but it is probably consecutive to retro-bulbar neuritis, as shown by white striæ (perivasculitis) along the vessels. The Vision is often much affected, and it is stated that sudden complete blindness, or hemianopsia, in connection with an intercurrent attack of lead colic may appear and pass off again. Consecutive atrophy is liable to come on, and then vision may be seriously and permanently damaged.

As headache, vomiting, and convulsions are symptoms of the more serious cases of lead-poisoning, it is evident that when intense optic neuritis is added, the diagnosis between this disease and cerebral tumour may be mistaken. The blue line on the gums, and other characteristic signs of lead-poisoning, will prevent such an error. The Treatment is that for general lead-poisoning, or for the immediate cause of the neuritis.

In Peripheral Neuritis optic neuritis is occasionally found.

Disseminated Sclerosis.—In these cases the inflammation is very ephemeral, and rapidly gives place to atrophy. Uhthoff states that it occurs in about 13 per cent. of the cases of this disease (p. 369).

Tabes Dorsalis.—A few cases of this disease are published in which optic neuritis was present. It is probable that the latter depended on co-existent syphilitic cerebral disease, rather than on the spinal disorder as such. In Acute Myelitis, inflammation of the optic nerve is sometimes seen, so that optic neuritis with paralytic phenomena does not exclusively indicate cerebral disease.

Hereditary and Congenital Predisposition.—The disease known as Hereditary Optic Neuritis, as Hereditary Optic Atrophy, and as Leber's Disease, commences with sudden and marked loss of sight, the vision falling perhaps to finger counting at 1 to 4 m. Both eyes are always attacked, with an interval of from a few days to two years. The fundus is at first normal, or slight optic neuritis is present. After a few weeks the papilla becomes pale, especially in its temporal half, and gradually the typical appearance of optic atrophy is developed. Examination of the field of vision shows the presence of a relative or of an absolute central scotoma. The periphery of the field is normal, or but slightly contracted. The disease develops as a rule a few years after puberty—about

the twentieth year. The course and conclusion of the disease is not the same in every instance. Most commonly the acuteness of vision and the central scotoma remain stationary, but in some cases an improvement, falling short of complete recovery of sight, has been noted, while in others complete blindness came on. In the same family the course of blindness is apt to be the same. Grosser derangements of the nervous system, such as epilepsy, mental derangements, etc., do not commonly accompany this eye-disease, but the lighter forms, as migraine, vertigo, palpitation of the heart, are often observed. The hereditary transmission usually occurs through the female members of the family to their male children, the females themselves being rarely affected, while several or all of the sons may be attacked. Treatment is, practically, of no avail. Mercury, iodide of potash, strychnine, and galvanism of the sympathetic have been employed.

Optic Neuritis also occurs occasionally in fevers; it has been observed in Measles, Scarlatina, Typhoid, and Malaria. It may follow Influenza, causing contraction of the field of vision or central scotoma which usually disappear, but may lead to optic atrophy.

* **Retro-Bulbar Optic Neuritis.**—This is ushered in by rapid, although never sudden, loss of sight in one eye, sometimes in both, or they may be attacked with a considerable interval between. Examination of the field of vision discovers a central colour scotoma, or one for white (Fig. 92), which is often absolute, and which is sometimes surrounded by a still wider scotoma for colours, and there is impaired pupil-reaction to light. The patient sees less well in a very bright light. At the commencement, pain in the orbit is complained of, the motions of the eye are somewhat painful, and there is pain on moderate pressure of the globe backwards into the orbit. Often at first there are no ophthalmoscopic changes, but after a time marked optic neuritis shows itself, and this may pass into atrophy, or atrophy may appear without any previous neuritis which can be discerned. It is rare for complete and absolute amaurosis to result, although the optic disc remains white. In most instances the central scotoma disappears, and almost normal vision is soon restored; but in some a more or less well-marked central scotoma, with defective sight, remains.

It is frequently impossible to assign a cause for this affection. Exposure to severe blasts of cold wind on the head, rheumatism,

and influenza are often blamed for it. But it is not rarely an early symptom of disseminated sclerosis (p. 368), and from this point of view it must be regarded with suspicion when it occurs in persons of between twenty and forty years of age. It is also found associated with inflammatory processes in the sphenoidal or ethmoidal sinus. (See also Toxic Amblyopia, p. 345.)

Treatment.—Iodide of potassium in large doses and salicylate of soda.

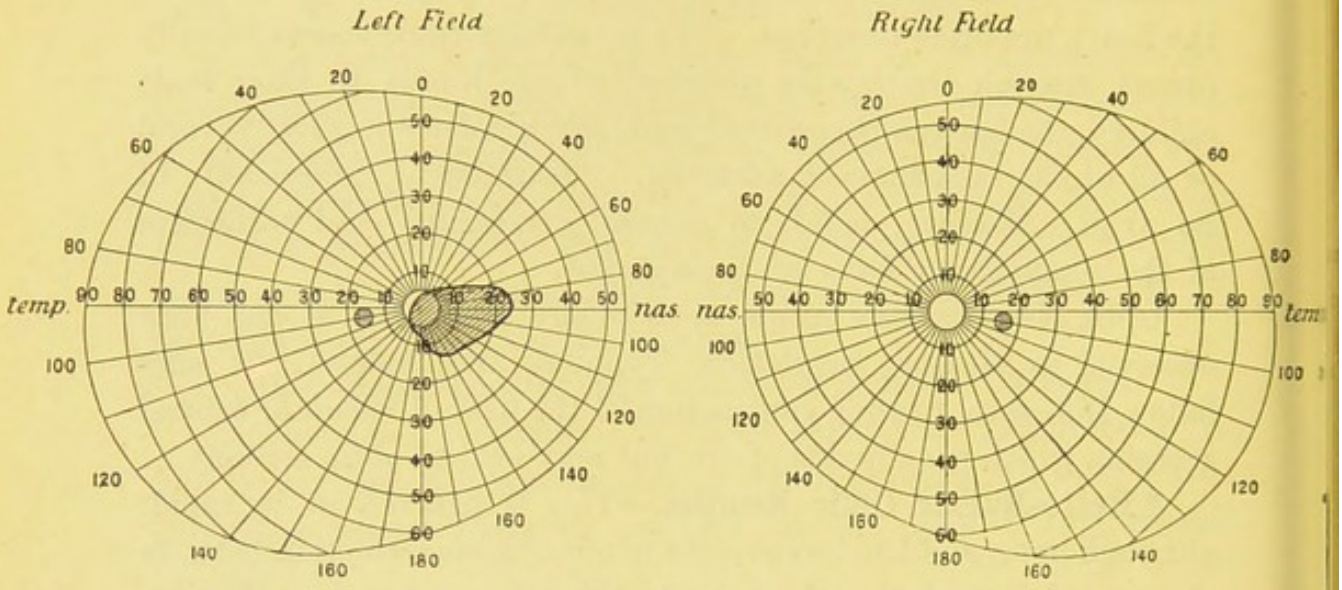


FIG. 92.—*Case of Retro-bulbar Neuritis in Left Eye.* Relative central scotoma for white. Central V = finger counting at 1·0 m. Movements of eye somewhat painful. Pressure backwards on eyeball caused pain. Slight cloudiness of margin of disc. Caused by chill through exposure to cold fog when heated. Almost complete recovery of V. after nine months. Some pallor of disc remained. Right eye normal throughout.

* **Optic Neuritis associated with Persistent Cerebro-Spinal Rhinorrhœa.**—A good many cases of persistent dropping of a watery fluid from the nostril have been recorded, and in a considerable proportion of them the eyesight was much affected, owing to optic neuritis or consecutive atrophy. More or less severe cerebral symptoms are usually also present, such as violent headache, epileptic attacks, vomiting, stupidity, drowsiness, unconsciousness, delirium, and weakness of the lower extremities. The severity of the head symptoms varies very much in different cases. Headache is the most constant of these symptoms, but even it may be absent. In one case there was loss of smell, and in another palpitation of the heart with prominence of the eyes. The fluid

which runs from the nostrils is identical in its analysis with that of the cerebro-spinal fluid. The cerebral symptoms are usually brought on, or increased in violence, if the fluid should occasionally cease to flow. Leber's case proved to be one of internal hydrocephalus, and the others were probably of similar nature. He thinks the fluid comes from the third ventricle through a small opening in the ethmoid bone, or the fluid possibly passed from the sub-dural space along the lymph-spaces which surround the olfactory nerves.

The affection usually commences in early adult life, and no rational treatment has been suggested. The flow may cease spontaneously for periods varying from a few hours to several months. In some cases it ceased altogether, or at least had not recurred after five or even fourteen years. Most of the cases were lost sight of, but some are recorded as having died of meningitis.

Central Toxic Amblyopia.—*Symptoms.*—The defect of vision comes on rather rapidly. The patients often complain of a shimmering mist which covers all objects, especially in a bright light, and generally state they can see better in the dusk than in broad daylight. At the commencement there is general dimness of vision but no defect in the field. At a later stage, examination of the field discovers no defect for a white object: yet, if a small pale green object be employed, it usually will be ascertained that, at a region close to the point of fixation, the colour is not recognised, but seems grey or white; pink may seem blue, and red may appear brown or black. This is a central colour-scotoma, and when it is very small it is easily overlooked in the examination, unless a very small test object be used. As the disease advances, a white object will be but indistinctly seen in the scotoma (relative scotoma for white); and in some rare cases all power of perception within its area may be lost, even the flame of a candle not being recognised (absolute scotoma). The scotoma is usually of an oval shape, with its long axis horizontal, and it extends from the fixation point towards the blind-spot (paracentric scotoma). Occasionally it is of much larger dimensions, and sometimes surrounds the fixation point (pericentric scotoma) (Fig. 93). The peripheral boundaries of the field of vision remain normal, both for colours and for white.

Even when the scotoma is very pronounced it remains negative

—*i.e.* it is not observed by the patient as a dark spot in the field, as is a scotoma due to disease in the outer retinal layers. The affection is almost always binocular, and as a rule there is but little difference between the vision of the two eyes.

The Progress of the disease is slow, occupying weeks or months. Restoration of normal vision usually takes place if the defect of vision, although of extreme degree, be not of old standing. In the latter case these patients, although incapacitated from reading, writing, and other fine work, do not lose their power of guiding themselves, as the functions of the periphery of the field are maintained.

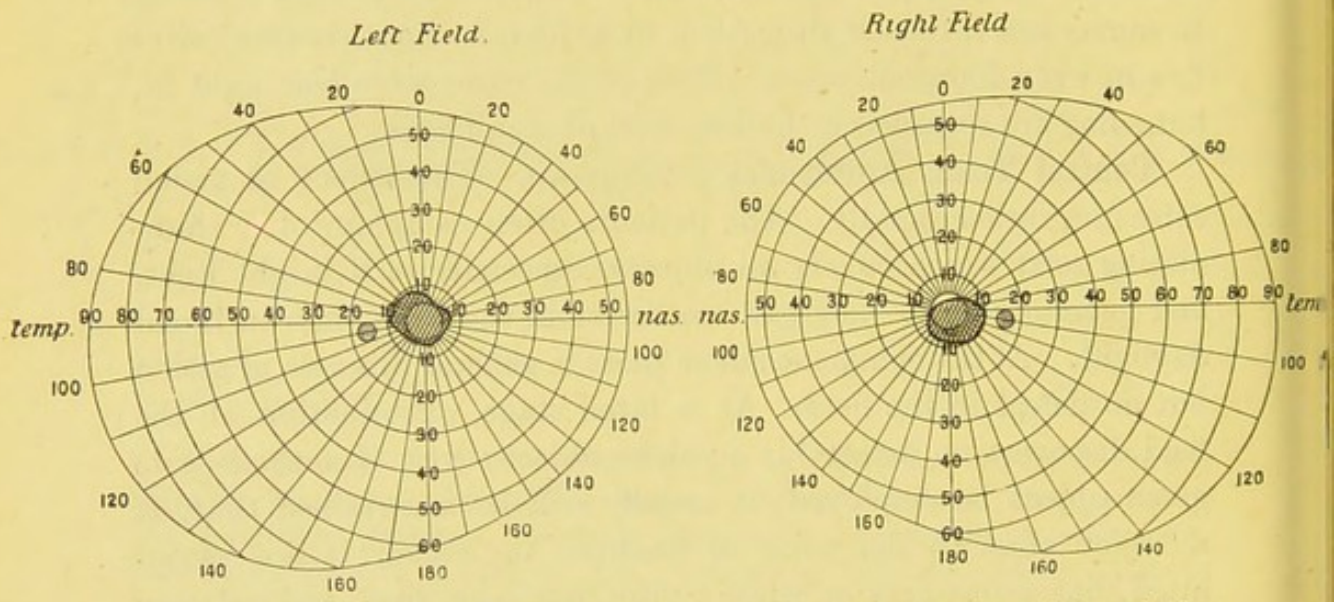


FIG. 93.—*Case of Toxic Amblyopia.* Central (pericentric) relative scotoma for white in each eye. V. in R.E. fingers at 2·0 m.; in L.E. fingers at 5·5 m. Pipe, 1 oz. strong tobacco per diem, and drank much whisky. Outer third of each disc too pale. By abstention from tobacco and alcohol, with strychnine and phosphorus internally, almost complete recovery in four months.

Causes.—With but few exceptions the subjects of this disease are men, and the most common cause is excess in the use of alcohol, or of tobacco, or of both. The kind of alcoholic indulgence most likely to develop the disease is the frequent drinking of small doses of the stimulant. The individual who often gets thoroughly intoxicated, and between times drinks but little, is less liable to contract central amblyopia than he who, although never incapable of transacting his business, takes many half-glasses of whisky or brandy during the day. Dyspepsia and loss of appetite are con-

stantly present in these cases. Other signs of chronic alcoholism need not be present, but one often sees trembling of the hand and head, sleeplessness, and even delirium tremens. The kind of tobacco most likely, when used in excess, to give rise to central amblyopia is shag or twist. Other kinds of pipe-tobacco and cigars may cause it, but we have not known of a case due to cigarette-smoking.

Excess in alcohol is usually combined with excessive smoking, usually over two ounces of strong tobacco in the week; but cases of pure alcohol-amblyopia certainly do occur—although some authors deny it—as well as pure tobacco-amblyopia. The most common age for tobacco-amblyopia is from thirty-five to fifty—a time of life when men do well to give up, or to reduce very much, their use of tobacco, as well as of alcohol.

Central toxic amblyopia has also been observed in diabetes; in poisoning from bisulphide of carbon, largely used in the manufacture of india-rubber; from dinitro-benzol, used for explosives; and in poisoning with iodoform, stramonium, cannabis indica, opium, arsenic, and lead.

The Ophthalmoscopic Appearances in the beginning are usually quite normal. It is rarely that there is slight hyperæmia of the papilla and retinal vessels; or, in addition, slight indistinctness of the margins of the papilla, and sometimes white striæ along the vessels, especially before they leave the papilla. All the primary appearances, if any be present, soon pass away, and give place to a greyish whiteness of the temporal side of the papilla, while the nasal portion remains of normal appearance, as do also the vessels. At a very advanced stage, in some cases, the whole papilla presents the appearance of white atrophy.

The Pathological Changes, in the optic nerve, consist of an interstitial neuritis at its axis, commencing so high up as the optic foramen, and gradually leading to proliferation of connective tissue and to secondary descending atrophy of one bundle of fibres in the optic nerve. These are the papillo-macular fibres which specially supply the region of the macula lutea, and which are exceedingly vulnerable to the influence of certain toxic agents. The changes may be regarded as analogous to those which take place in the liver and brain as the result of chronic alcoholism.

Treatment consists, above all, in total abstinence from the poison

in question; partial abstention is of little or no avail. If the patients act up to their good intentions in this respect, improvement rapidly takes place in most cases which are not too far advanced without any other treatment; but the cure may be promoted by the use of iodide of potassium in large doses, Heurteloup's artificial leech or dry cupping to the temples, hot foot-baths, and Turkish baths. Strychnine hypodermically ($\frac{1}{30}$ grain daily) in the temple is often of use, and phosphorus and strychnine may be given internally. Whatever remedy be used internally, care should be taken that it does not produce or increase dyspepsia; and it may be necessary to restrict the internal medicine for a time, or altogether, to a stomachic tonic, with abundant drinking of hot water. Sleeplessness should be combated with sulphonal, or bromide of potassium. Treatment may have to be continued for some weeks, before a cure can be noted.

A yet more serious blindness than that from ethyl alcohol or tobacco is caused by drinking methylated spirit, or by inhaling its fumes. This toxic amblyopia is much more common in the United States than elsewhere, for a peculiarly dangerous form of methylated spirit is on sale there for many trade purposes. It is known as wood alcohol, or Columbia spirit, and contains 95 per cent. of methyl alcohol. The symptoms after a debauch have been weak heart action, nausea, sweating, intense headache, vertigo, delirium, and coma. Some twenty-four hours later dimness of vision in each eye comes on, and passes rapidly into absolute blindness. The attack of blindness is accompanied by pain on movement of the eyes and on pressure of the eyeball backwards, symptoms which would tend to place the condition in the category of retro-bulbar neuritis. The pupils are dilated, and the light-reflex is absent. A characteristic feature is that partial restoration of vision soon takes place, to be followed, in the course of a few days or weeks, by more or less complete and permanent blindness. In the early stages there is optic neuritis, which is followed by optic atrophy. As regards the field of vision, there is an absolute central scotoma, and, moreover, the field is nearly always contracted. In many of the cases death has occurred within a few hours after the poisonous dose has been taken. There also have been recoveries of sight as well as of health.

Atrophy of the Optic Nerve.—This disease may be secondary

to some other optic nerve or retinal affection, or it may be a primary disease. *The Vision* is seriously affected, and complete blindness is the usual result. With the *Ophthalmoscope* the optic papilla is seen to have lost its delicate pink colour, and to have become white or greyish, while it is often cupped, and the vessels are apt to be diminished in calibre (Plate VIII. Figs. 1 and 2).

SECONDARY ATROPHY OF THE OPTIC NERVE may result :—

1. *From Optic Neuritis* (Plate VIII. Fig. 2).—The ophthalmoscopic appearances consist in a white or greyish-white papilla, with very diminished retinal vessels ; and along both sides of the vessels, far into the retina, are white lines, which sometimes even obscure the vessels, and which are due to hypertrophy of their coats. The diminution in calibre of the vessel is a sign of neuritic atrophy, but is not always present, and is found moreover with other forms of atrophy. Other signs of this form, also not constant, are : a certain opacity of the papilla, and that the lamina cribrosa is not generally visible, owing to development of connective tissue at the papilla. It is evidently not always possible to recognise any given case as of neuritic origin.

Symptoms.—The acuteness of vision is lowered, and as a rule the field of vision becomes contracted, usually more at the nasal than at the temporal side. Subsequently the temporal side of the field becomes contracted, and finally a small eccentric portion of the field to the temporal side may be all that remains, or even this may disappear, and absolute amaurosis result. The colour-vision is always much affected. The light-sense is affected, so that there is diminished sensibility for differences of illumination ; while, in chorioido-retinal diseases, there is defect in the quantitative perception of light, the minimum quantity being larger than normal.

2. *From Pressure.*—This may be brought about by a tumour anywhere in the course of the nerve, by inflammatory exudations, by a splinter of bone in cases of fracture of the skull, and, also, by pressure upon the chiasma by the floor of the distended third ventricle in cases of internal hydrocephalus.

3. *From Embolism of the Central Artery of the Retina.*—In these cases the contraction of the vessels is usually extreme.

4. *From Syphilitic Retinitis, Retinitis Pigmentosa, and Chorioido-retinitis* (Plate VI.).—The vessels here are much attenuated, and

the altered colour of the optic disc is a dull yellow, rather than white or grey.

PRIMARY OPTIC ATROPHY is often found associated with :—

Hereditary Optic Atrophy. Leber's Disease.—(See p. 342.)

Disease of the Spinal Cord (*Spinal Amaurosis*), especially locomotor ataxy. Optic atrophy is often an early symptom in the latter disease ; but, again, it may not come on until the affection of the gait is well pronounced, while in other cases it is not present at

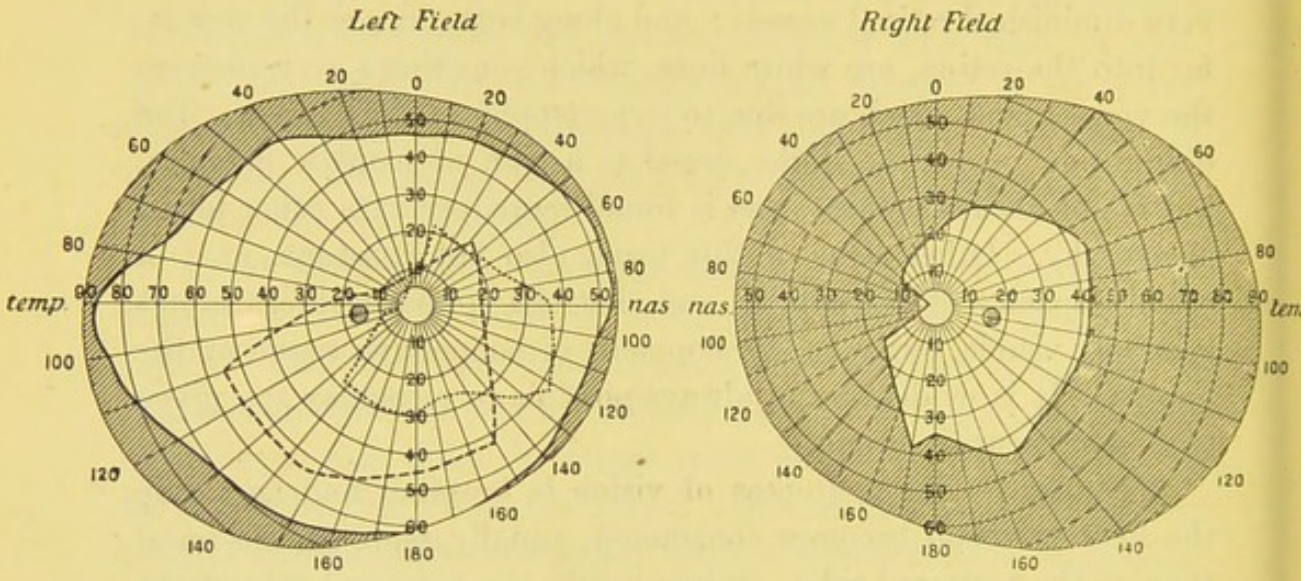


FIG. 94.—*Case of Locomotor Ataxy.* Atrophy of each optic nerve. R.E. Marked contraction of field—absolute defect for white. No colour perception in remaining portion of field. Central V = fingers at 3·0 m. Very white optic disc. Became quite blind five months later. L.E. Only slight loss in periphery of field. Fields for colour irregularly contracted. Outer boundary for red..... for blue---- Central V = 6/12. White optic disc. Became quite blind a year later.

any stage. It is a remarkable and important fact, first pointed out by Benedikt of Vienna, that there is an antagonism between atrophy of the optic disc and the other symptoms of tabes dorsalis ; that is to say, it is rarely that a tabetic patient, in whom optic atrophy comes on in an early stage of his disease, becomes ataxic ; and frequently, in these cases, when the blindness has advanced, the pains, too, become less severe. But if amaurosis do not come on until the ataxy is well developed, no improvement in the latter is likely to be noted.

More rarely, atrophy is found with disseminated sclerosis, and

lateral sclerosis of the spinal cord. In general paralysis of the insane, although spinal disease is not always present, atrophy of the papilla frequently occurs.

It is probable that the disease commences at the papilla in spinal cases. The ophthalmoscope displays a papery-white or bluish-white papilla, which in advanced stages often becomes cupped. The retinal arteries are usually extremely reduced in calibre, and the veins, too, may be small; but, again, the retinal vessels may differ but little, or not at all, from the normal.

Symptoms.—Central vision is affected at an early stage in the disease, and eccentric contraction of the field (Fig. 94) usually appears at the same time. The contraction may be concentric, or it may be more marked in one direction than another. This concentric contraction advances gradually towards the centre of the field from every side, until it finally engulfs the fixation point.

Occasionally the affection begins as a central scotoma, accompanied by eccentric defects of the field. Colour-blindness is an almost constant symptom. As a rule absolute blindness is brought about in the course of a year or two, or it may come on more rapidly.

As a Purely Local Disease Primary Optic Atrophy of the progressive form just described may occur, without any other defect in the system. The prognosis for the sight in such cases is as serious as in spinal cases.

As the result of Poisoning with Organic Preparations of Arsenic.—These preparations have come much into use for the treatment of sleeping sickness and of many other diseases caused by protozoa, but unfortunately they are liable to give rise to optic atrophy and complete blindness. Many cases of blindness have been recorded from the use of atoxyl, and arsacetin has also caused it. No case of blindness from the use of salvarsan has been recorded. The accident cannot be avoided, for it depends not so much on the size of the dose as upon individual predisposition. But it seems to be less dangerous to give one large dose (the *dosis magna sterilisans* of Ehrlich) than small repeated doses. It may be that the blindness caused by atoxyl has been due to the methyl alcohol used in its preparation, rather than to the arsenic; and we understand that for this reason Professor Ehrlich now no longer uses methyl alcohol for this purpose. When atrophy of the optic nerve once sets in, discontinuance of the use of the preparation does not avail to arrest

the progress of the blindness. The features of this optic atrophy are :—Onset with haziness and scintillation, and progressive contraction of the field of vision, especially on the nasal side. Central vision remains good until the field has become very small, and in the course of a few months complete loss of sight ensues. The optic nerve is pale and sharply defined. The vessels are much reduced in size.

Poisoning by the inorganic arsenic preparations does not cause optic atrophy and amaurosis. The impairment of vision is only slight, there is no contraction of the field, but a central colour-scotoma is present. The ophthalmoscope may show some pallor of the temporal half of the optic disc. Discontinuance of the drug is followed by recovery of sight, and no case of total blindness has been recorded. The inorganic arsenic preparations cause conjunctivitis and œdema of the eyelids, while the organic preparations do not do so.

Treatment.—In neuritic atrophy, so long as there are signs of active inflammation, antiphlogistic measures—Heurteloup's leech to the temple, hot foot-baths, rest of body and mind, dark room, iodide of potassium, and, especially, mercury internally, when otherwise admissible—are to be adopted. At a later period, hypodermic injections of strychnia ($\frac{1}{30}$ gr., increased gradually to $\frac{1}{20}$ or $\frac{1}{18}$ gr. once a day) and galvanism may be tried. Hypodermic injections of antipyrin (about $7\frac{1}{2}$ grains every second day) have been given with some benefit in these cases.

In spinal amaurosis, and in optic atrophy occurring as a local disease, strychnia hypodermically and the galvanic current sometimes improve vision for a time. Phosphorus internally may be given.

The treatment for optic atrophy, due to other causes, is to be directed to the primary disease.

The Prognosis is very serious ; for, although every therapeutic measure may have been employed, amaurosis is the ultimate result as a rule. Cases of primary atrophy due to poisoning by organic arsenic preparations are hopeless from the beginning.

Tumours of the Optic Nerve will be treated of in chap. xix.

* **Hyaline Outgrowths** from the optic papilla, at its edge or centre, are occasionally met with. Seen with the ophthalmoscope, they present the appearances of small bluish-grey semi-translucent

nodules. In many instances retinitis pigmentosa is also present. These outgrowths do not always of themselves cause a defect of sight, and rarely cause serious blindness.

Treatment is of no avail.

* **Injuries of the Optic Nerve.**—In addition to those injuries which result from direct violence with sharp instruments, etc., entering the orbit, the optic nerve may be injured by falls on the head. Fractures of the base of the skull frequently involve injury to the optic nerve. But even where no fracture occurs, blindness with atrophy of the optic nerve, usually only in one eye, may follow a blow, or fall, on the head; and in these cases concussion of the nerve at its passage through the optic foramen, or fracture of the optic foramen, or an extravasation of blood in the sheath of the nerve, is probably the immediate cause of the atrophy.

* **Hæmorrhages from the Stomach, Bowels, or Uterus** are capable of giving rise to serious and incurable blindness.

Blindness during or immediately after a severe hæmorrhage is probably due to insufficient blood-supply to the nerve-centres and retina, accompanying general exhaustion of the system. For such cases the prognosis is favourable.

But there is another class of cases of very much more serious import. Fortunately, they are rare. In these the defect of vision does not come on until from two to fourteen days after the hæmorrhage, when the general system is recovering. Even comparatively slight hæmorrhages, which caused no marked anæmia, are said to have been followed by blindness. The pathogenesis of these cases is not yet clearly made out. Leber inclines to the belief that the blindness here is due to an extravasation of blood at the base of the skull, and into the sheath of the optic nerve; but, even then, the relationship between this and the stomachic or uterine hæmorrhage is not rendered clearer. Papillitis has been several times noted with the ophthalmoscope; and this circumstance makes it probable that neuritis is the immediate cause of blindness—even in those cases which show no ophthalmoscopic sign of it—and hydræmia may possibly be the influence which calls forth the neuritis.

The Defect of Vision may be but slight, or it may amount to absolute amaurosis. Both eyes are usually affected in equal degree. But cases have been observed in which one eye was completely amaurotic, while the vision of the other eye was quite normal;

and such cases prove that the lesion is peripheral—in fact, that it lies on the distal side of the optic commissure. The field of vision is frequently contracted, either concentrically or segmentally; and, even when central vision recovers, the field may remain contracted. The presence of central scotoma has also been observed in some cases.

The Ophthalmoscopic Appearances which are present immediately on the occurrence of the blindness have not as yet been observed. A few weeks later they are different in different cases. They have been found at this period normal; or presenting slight paleness of the papilla and contraction of the arteries; or there was marked paleness of the papilla, and the arteries were extremely contracted, with slight distension of the veins; or paleness of the papilla was present, but its margins were indistinct, and the surrounding retina somewhat swollen, while the retinal vessels were normal. Small hæmorrhages have repeatedly been seen in the neighbourhood of the papilla. At later periods well-marked optic atrophy is frequently observed.

Prognosis.—If in the beginning the defect of vision be merely amblyopia, and not complete blindness, hopes may be entertained of marked improvement, or of complete recovery. But Mooren saw slight amblyopia pass into permanent amaurosis.

Hæmorrhages from the stomach are those which are followed by the most complete and permanent blindness, while uterine hæmorrhages are more commonly followed by less serious degrees of blindness.

The Treatment must consist of internal remedies calculated to correct the general anæmia, such as iron, beef-tea, and meat extracts, wine, etc. Strychnine hypodermically, to stimulate the nerve, may be employed.

Glycosuric Amblyopia.—In addition to the retinal affections dependent upon diabetes (p. 316), we recognise the occasional occurrence in that disease of defects of vision which are referred to disorder of the optic nerve, and which are not always accompanied by ophthalmoscopic changes. These defects of vision are found in the form of (1) Central Toxic Amblyopia (p. 345), or, in slighter cases, as amblyopia without central scotoma. Occasionally, higher degrees of amblyopia with concentric contraction of the field of vision, and yet negative ophthalmoscopic appearances, are present.

(2) Atrophy of the optic nerve. This may appear in the usual form as progressive blindness, with concentric contraction of the field of vision; or it may come on after the slighter form of amblyopia has existed for some time. (3) Hemianopsia and colour-blindness.

It is probable that these apparently different kinds of blindness depend upon similar pathological processes, and merely indicate degrees of the latter. In what these processes consist is still unknown; but the tendency to hæmorrhages in the retina in diabetes makes it likely, that hæmorrhages in the optic nerve are sometimes the source of the amblyopia in question; while the cases with central scotoma are no doubt due to axial neuritis, similarly as in alcohol and tobacco amblyopia.

Amblyopia is sometimes the earliest symptom of diabetes; and, consequently, it is of the utmost importance to examine the urine for sugar in every case of amblyopia where the ophthalmoscopic appearances are negative, or where the only abnormality is atrophy of the optic papilla.

The Treatment indicated is solely that for the general disease, and the prognosis for vision depends upon the amenability of the latter to treatment, and upon the extent to which organic changes in the optic nerve have advanced.

CHAPTER XIII.

Part I.—Ocular Diseases and Symptoms liable to accompany Focal Disease of the Brain.
Part II.—Ocular Diseases and Symptoms liable to accompany Diffuse Organic Diseases of the Brain.
Part III.—Ocular Diseases and Symptoms liable to accompany Diseases and Injuries of the Spinal Cord.
Part IV.—Nervous Amblyopia, or Asthenopia.
Part V.—Various Forms of Amblyopia.

Part I.

OCULAR DISEASES AND SYMPTOMS LIABLE TO ACCOMPANY FOCAL DISEASE OF THE BRAIN.

Hemianopsia (*ἥμισυς, half; ἀ, priv.; ὤψ, the eye*).—This symptom consists in a loss of sight in one-half of the field of vision—usually of each eye—consequent upon a lesion either at the cortical centre for vision, or at the optic commissure (chiasma), or at some point in the course of the visual path in the brain between these two places. The term is not used for cases in which one-half of the field is lost, owing to disease (detachment of the retinal, etc.) within the eye itself.

In hemianopsia the line dividing the seeing from the blind half of the field passes vertically down the centre of the latter; or, it lies a little to one side of the centre of the field, so as to admit of the centre being included in the seeing part; or—although in other respects the dividing line lies in the centre of the field—the fixation point is circumvented by it, so as to leave that point free, as in Fig. 95; and this latter is the most common arrangement. All these varieties are termed complete hemianopsia.

Furthermore, cases occur which are properly regarded as hemianopsia, and yet in which only the upper or the lower half of one side of the field is wanting. This is termed incomplete or partial hemian-

opsia. If all three visual perceptions be lost, the hemianopsia is called absolute (Fig. 95); but if only one (colour) (Fig. 96) or two (colour and form) be wanting in the defective part of the field, it is termed relative hemianopsia. Relative hemianopsia is the result of a lesion of less intensity than that which causes absolute hemianopsia. The vast majority of cases of hemianopsia are absolute.

Homonymous Hemianopsia is the most frequent form. In it the corresponding half—the right half or the left half—of the field of each eye is wanting, as in Figs. 95 and 96.

Bi-Temporal Hemianopsia is much less common. In it there is

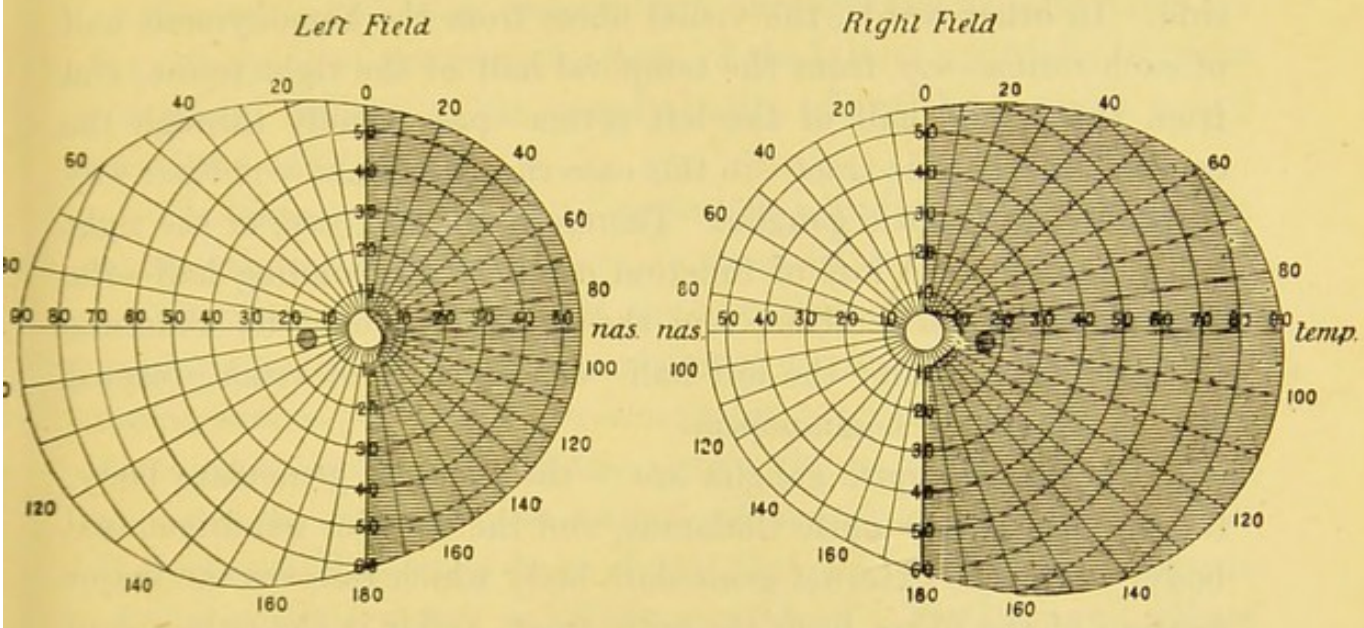


FIG. 95.—*Case of Right Homonymous Hemianopsia*, with word-blindness. Line of demarcation passing round fixation point.

loss of vision in the outer side of each field, in consequence of loss of function in the mesial half of each retina.

Superior or Inferior Hemianopsia, also called Altitudinal Hemianopsia, in which the upper or lower half of the field is blind, is exceedingly rare; and it is doubtful whether Nasal Hemianopsia has really been observed, although it has been described. In the latter form the inner side of the field of one eye only is lost.

Cases of Double Hemianopsia are those in which, owing to a cerebral lesion on each side of the brain, both sides of each field are lost. Usually in these cases the functions of the yellow spot are spared with a corresponding small central field. Or, the whole

of one side of each field, and only half of the other side of each field may be lost.

As hemianopsia can be caused by a lesion in the optic commissure, or in the cortical cerebral centre for vision, or by one anywhere in the long visual path between those two points, it will be convenient here to sketch

The Course of the Visual Path from the Retina to the Visual Centre in the Cortex of the Brain.

Having passed along the optic nerve, the visual fibres coming from the mesial half of each retina, when they reach the optic commissure, cross to the opposite optic tract, while those from the temporal side of each retina are continued in the tract of the same side. In other words, the visual fibres from the homonymous half of each retina—*e.g.* from the temporal half of the right retina, and from the mesial half of the left retina—pass wholly through the corresponding optic tract—in this case the right tract—on their way to the primary optic ganglia. Therefore a lesion, say, of the right tract, would cause loss of function of the corresponding half—the right half—of each retina, and the symptom would be blindness of the opposite half—the left half—of each field of vision, termed left homonymous hemianopsia.

The primary optic ganglia are :—the external geniculate body, the pulvinar of the optic thalamus, and the anterior quadrigeminal body. It is the external geniculate body which receives the major portion of the fibres from the optic tract, and it is the only one of the primary optic ganglia, which undoubtedly is connected with the act of vision, for a lesion of it invariably gives rise to homonymous hemianopsia. The fibres, which enter the external geniculate body, end there in fine branching terminals which are in relation with ganglion cells, the axis cylinders of which form the further centripetal path to the cortical centre for vision. But the main portion of these axis-cylinders, or fibres, passes into the pulvinar of the optic thalamus, which also receives direct fibres from the optic tract. Notwithstanding this anatomical fact, lesions confined to the pulvinar do not cause hemianopsia, and hemianopsia occurring with lesions of the pulvinar is due to interference with the functions of the external geniculate body, or other portion of the visual path outside the pulvinar. The anterior quadrigeminal body receives a small portion of the optic tract fibres, but these are not visual

fibres, and lesion of this body is never attended by hemianopsia. From the external geniculate body fibres pass, by way of the retro-lenticular portion of the posterior limb of the internal capsule, to the optic radiation, a large strand of fibres which run in the central white matter of the hinder part of the cerebral hemisphere, and terminate in the cortex of the occipital lobe. Lesions of the optic radiation cause homonymous hemianopsia. Although fibres can be anatomically traced, passing from the pulvinar to the optic radiations through the retro-lenticular portion of the internal capsule, yet lesions confined to the latter place do not cause hemianopsia, and it is evident that the true visual fibres pass directly into the optic radiation.

The optic radiation sweeps back through the parietal lobe, on the outer side of the posterior horn of the lateral ventricle, to reach the mesial surface of the occipital lobe, where the cortical centre for vision is situated.

The visual path thus is :—optic nerve, optic commissure, optic tract, external geniculate body, optic radiation.

Henschen, as a result of his clinico-pathological researches, would confine the cortical centre for vision to the middle part of the calcarine fissure—the upper, or cuneic lip, representing the homonymous dorsal retinal quadrants ; while the lower or lingual lip represents the homonymous ventral quadrants of the retina ; and Bolton and Brodmann have shown that the histological structure of this cortical region is highly specialised. Flechzig and others give a wider area to the visual centre, which may extend they say to the whole of the cuneus, and to the posterior part of the lingual gyrus.

Lesions of the cortical centre for vision cause homonymous hemianopsia. In cases of hemianopsia due to lesions of the optic radiations or cortical centre, there is often a peripheral contraction in the seeing side of the field due to diminished functional activity in the opposite side of the brain from that in which the disease is situated.

That, in hemianopsia, the functions of the macula lutea are so often spared (Fig. 95), indicates the existence of some special arrangement of the visual path and cortical centre for this portion of the retina. Henschen's investigations point to the maculo-cortical centre as being situated in the anterior part of the floor of the

calcarine fissure, and to the whole of each macula as being represented in each maculo-cortical centre, causing an overlapping of nervous supply in those regions ; so that in a lesion of one cortico-macular centre the macular functions of each eye would continue to be supplied by the cortico-macular centre of the healthy side of the brain. Occasionally the double innervation is not present, and then, in a cortical lesion, the dividing line in hemianopsia due to a cortical lesion would pass through the fixation point. A sparing of the macular functions is also usual in lesions of the most central portions of the visual path. But in lesions of the peripheral portions of the optic radiation, of the primary optical centres, of the optic tracts, and of the optic commissure, the dividing line almost invariably passes through this fixation point. It is therefore probable, that the point of decussation of the maculo-cortical fibres lies somewhere in the middle third of the parietal lobe.

The Localisation of the Lesion in Cases of Hemianopsia is a subject of interest, and, in cases of cerebral surgery, it may be of great practical importance.

Lesions of the centre of the *Optic Commissure*, injuring the crossed fibres, produce as their characteristic symptom bi-temporal hemianopsia, which may be relative at first, beginning, for instance, as a hemiachromatopsia, but later on becoming absolute. In some cases (basal meningitis, periostitis, hyperostosis) the diseased process comes to a standstill, and the bi-temporal hemianopsia remains. But the disease usually extends to the uncrossed fibres, and ultimately causes complete blindness. Optic atrophy, often commencing on the inner side of the papilla, is nearly always present at some period of the disease. Other symptoms which may be present in lesions of the chiasma are anosmia, paralysis of orbital nerves, and anæsthesia of the conjunctiva and cornea. The causes are : fractures of the body of the sphenoid, cysts, tubercle, tumours, exostoses, distension of the floor of the third ventricle in cases of internal hydrocephalus, and, most frequently of all, tumours of the pituitary body. In the latter case proptosis, discharge of fluid from the nostril, and diabetes may be present. Syphilitic gummata may cause transient recurrent attacks of bi-temporal hemianopsia.

In Altitudinal Hemianopsia the lesion must also, as a rule, be at the chiasma, encroaching on it from above or below. Sym-

metrical cortical lesions might, and optic neuritis sometimes does, produce it.

In Nasal Hemianopsia, too, the lesion must be at the chiasma, and must be so situated in its outer angle as to involve only the fasciculus lateralis or uncrossed fibres of the affected eye. The occurrence of binocular nasal hemianopsia is evidently almost impossible, implying, as it does, symmetrical lesion of the fasciculus lateralis of each tract. According to Henschen, a tumour in the external angle of the chiasma is apt to affect the crossed fibres as well as the uncrossed, and to produce a form of bilateral homonymous hemianopsia.

Bi-temporal hemianopsia is a common and early symptom in *Acromegaly*, a disease associated with enlargement of the pituitary body. This form of hemianopsia, and general adiposis of the body, form the main symptoms in some cases of tumour of the pituitary body.

In Homonymous Hemianopsia—which is the commonest form of the symptom—localisation of the lesion is a more difficult matter than in any of the other forms; for here the disease cannot be situated at the optic commissure, but may be in the optic tract, or in the visual centre, or anywhere in the lengthened course of the visual path which connects these two parts.

Can we distinguish a complete and absolute hemianopsia, due to a lesion confined to the cortical centre for vision, from a similar defect in the field, due to a lesion in the optic radiation, external geniculate body, or optic tract? We may conclude that the hemianopsia depends upon cortical lesion, if it be unaccompanied by hemiplegia, motor aphasia, or paralysis of cerebral nerves, as direct symptoms; any or all of these are liable to accompany lesions of the occipital lobe as distant[1] symptoms. Pressure of a cerebellar

[1] The term 'distant symptom' is suggested in preference to those in common use—namely, 'indirect symptom' and 'pressure symptom.' We cannot assume that these symptoms are less the direct result of the lesion than any of the others which are present; and, in many instances at least, it is certain that they cannot be due to pressure. In short, we do not know what produces these symptoms—they may be caused by inhibition—we only know that they are the result of interference with functions of parts of the brain not involved in the lesion; and the term 'distant symptom' conveys this idea sufficiently well without committing us to any theory. The corresponding German term is 'Fernwirkung.'

tumour may interfere with the functions of the healthy cortical centre for vision.

Aphasia, too, occasionally accompanies right cortical hemianopsia (*i.e.* due to a lesion in the left occipital lobe), although it is not easy to offer a satisfactory explanation of the fact.

Cortical hemianopsia may be a distant symptom. Gowers has observed that, at the onset of many attacks of cerebral hæmorrhage, hemianopsia is present as a distant symptom of a transitory character—so transitory, indeed, that it does not complicate attempts at localisation. Except under this condition, distant hemianopsia

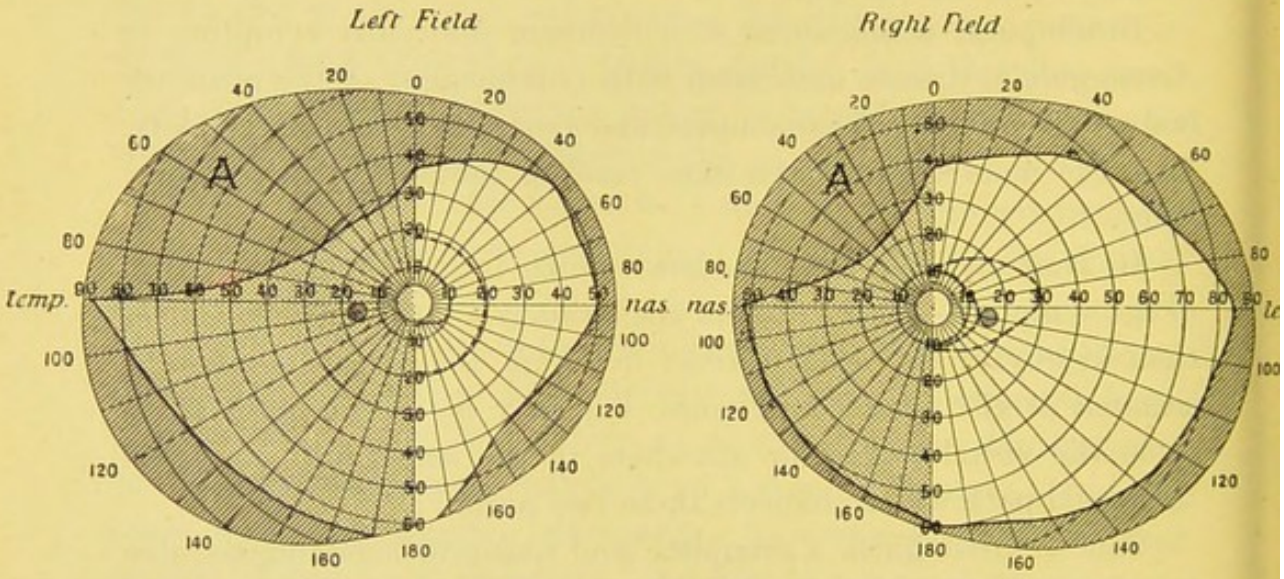


FIG. 96.—*Case of Left Homonymous Hemiachromatopsia* (colour vision only was lost in the dotted portion of left half of each field), with absolute homonymous defects at A. Line of demarcation passing through fixation point. Associated with partial mind-blindness. Outer boundaries for colours in the right half of each field contracted and reversed. Outer boundary for red – · – · – · for blue – – – – – for green . . . . . Slight apoplectic attack. Lesion almost certainly in cortical centre.

seems to be rare—a fact which enhances the localising value of the symptom.

Cortical hemianopsia may be incomplete, the homonymous quadrant only of each field being wanting, if the lesion be confined to the upper or to the lower lips of the calcarine fissure (p. 359).

In cortical lesions the hemianopsia is usually absolute. But the lesion may be such as to destroy only the colour-sense (Fig. 96), without affecting the form- or light-sense. Again, the form-sense

may be lost in the half field along with the colour-sense, while only the light-sense is retained. Furthermore, cases of hemianopsia are on record in which, in part of the defect, both the colour- and form-senses were absent, but the light-sense present, while in the remainder of the defect all three visual perceptions were lost.

It seems to be now proved that only a small portion of the *Optic Radiation* can be regarded as consisting of visual fibres. A lesion of the visual fibres of the optic radiation might be distinguished from one in the cortical centre by hallucinations of vision occurring in the former and not in the latter.

The symptoms, in addition to hemianopsia, due to disease of the *External Geniculate Body*, which might serve to distinguish the hemianopsia as being caused by a lesion there, have not as yet been ascertained, the clinical evidence being indefinite. In these cases the dividing line almost always passes through the fixation point.

With hemianopsia from lesions of the *Optic Tract*, the defect in the fields may be relative (hemiachromatopsia) or incomplete (only homonymous quadrants being lost), or complete and absolute, and the dividing line almost always passes through the fixation point. Lesions of the optic tract are, of course, apt to implicate the crus cerebri, and in that case hemiplegia of the opposite side of the body would be associated with the hemianopsia—*e.g.* lesion of the right optic tract implicating the crus would be followed by left homonymous hemianopsia and left hemiplegia. Symptoms may also be caused by implication of cranial nerves, especially of those which supply the orbital muscles (chap. xvi.).

Atrophy of the optic nerve, or neuritis, according to the nature of the lesion, are frequently present.

A sign which has been held to be of localising value in lesions of the optic tract, is the Hemianopic Pupil (Wernicke's pupil-symptom). Illumination of the amaurotic halves of the retinæ produces a more sluggish pupil-reaction than when the light is thrown on the seeing halves, because the lesion being on the distal side of the corpora quadrigemina, the impulse cannot pass on to the centre for the third nerve. The difficulty of concentrating light on the blind side of the retina, without allowing the good side to be exposed either to diffused or to diascleral light is great; and, unless it be obviated, the experiment is vitiated. Many authorities deny the possibility of overcoming this difficulty. Moreover, the experiments

of Hess which would show that the pupillo-motor area of the retina is confined to a region 4 mm. in diameter at the centre of the retina, and that the pupil-reflex cannot be excited by illumination of the periphery of the retina, throw further doubt on the practical value of this symptom, although it has occasionally been found, and we have observed it extremely well marked in a case of bi-temporal hemianopsia from tumour of the pituitary body.

Wilbrand has proposed an aid in deciding whether the seat of the lesion in a case of homonymous hemianopsia be above the primary optic centres (*i.e.* in the optic radiation or cortex), or in the optic tract, which he terms the Hemianopic Prism Phenomenon, and states he has found to be of practical clinical value. The patient faces a black wall on which a small white mark is made. One eye is closed, and the patient is directed to look at the mark with the other eye. A prism of about 12° or 14° is brought suddenly before the eye, its base being so directed that the retinal image of the white spot may be thrown on that half of the retina which does not see (*e.g.* if the experiment be performed with the right eye, in a case of right homonymous hemianopsia, the inner half of the retina being blind, the prism must be placed opposite the eye with its base inwards). At the same moment the surgeon has to observe whether or not the eye makes such a movement as would tend to bring the retinal image again on the macula lutea (*e.g.* in the case above chosen the motion would be outwards) ; and, again, whether or not at the moment of rapid removal of the prism the eye returns to its former position. The prism must be brought rapidly before the eye, in order that the patient may not be able to observe the path of the moving retinal image from the macula lutea towards the boundary line between the seeing and blind halves of the retina. Those cases in which the boundary line is at or close to the macula lutea are the most favourable for the experiment. If a compensatory movement of the eye take place when the prism is held before it, then the path through the optic tract to the nuclear oculo-motor centres is free, and the lesion must be situated above these centres—*i.e.* in the optic radiations or cortex. On the other hand, if there be no compensatory motion, the path for the movements of the eye from the retina to the nuclear centres must be interrupted. The explanation of this phenomenon is as follows : although the motions of the eye for the purpose of fixing visual objects are not, strictly

speaking, reflex motions, yet, in each individual they to a great extent become so by long usage, and are controlled mainly by the lower, rather than by the cortical centres. Hence, so long as the path for these motions to the nuclear centre is uninterrupted, if the retinal image of the visual object be thrown by a prism on a non-seeing part of the retina, the necessary compensatory motion of the eye will be made by reflex action as it were, to bring the image again on the macula lutea.

The Diseased Processes which cause a Lesion of the Optic Tract are: syphilitic gummata and syphilitic meningitis; new growths, including tubercle; while softening and hæmorrhage are rare. Tumours of the optic thalamus, lenticular nucleus, or temporo-sphenoidal lobe may also injure the tract by extension or pressure.

In hemianopsia the *Prognosis* for recovery of vision in the defective halves of the fields depends, of course, upon the nature of the lesion. But recovery is rare, especially in the most common class of cases—those, namely, which are due to cerebral apoplexy.

In Right Homonymous Hemianopsia, wherever the position of the lesion may be, a greater difficulty in reading is experienced than in left hemianopsia. This is due to the fact that we read from left to right; and that, owing to the defect being on the right side, the word immediately following that at which the patient is looking cannot be seen at the same moment. A lesser difficulty in reading occurs in cases of left homonymous hemianopsia—namely, when the commencement of the line following that which is being read has to be picked up.

Word-Blindness is the term given to an inability to understand written or printed characters, although they and other small objects can be distinctly seen. Other visual objects are named with ease (no visual aphasia). The patient can express his ideas in writing, or write from dictation, yet cannot understand what he has just written, nor can he copy written or printed words. He understands the meaning of spoken words, and the use of all objects around him (no mind-blindness). He can generally recognise individual letters with some difficulty. This is 'pure word-blindness,' or 'sub-cortical alexia.' When combined with inability to write spontaneously or from dictation, it is known as 'cortical alexia.' The condition has been occasionally complicated with right homonymous hemianopsia (Fig. 95). In those cases where an autopsy was obtained

the lesion was found in the left occipital lobe. Word-blindness with agraphia or cortical alexia is due, according to Dejerine and Wernicke, to a lesion in the centre for visual memory for words, which, in right-handed people, is the left angular gyrus and inferior parietal lobule.

Congenital Word-Blindness is probably not a rare condition, although liable to be overlooked. It is shown to be present when it is found exceedingly difficult, or, in severe cases, impossible, to teach a child with healthy eyes, normal acuity of vision, and good general intelligence to read, sometimes even common words of one syllable, although he can learn to recognise them if permitted to spell them aloud. The defect is probably due to imperfect development of the cortical centre for the visual memory for words in the left cerebral hemisphere, while the centre for the auditory memory of words is unimpaired. As a rule, except in the severest cases, numerals and music can be read. Hemianopsia is never associated with this state. The condition sometimes runs in families. When the word-blindness is not very marked, and when it is recognised in childhood, a great deal can be done by careful, long-continued, and individual tuition to effect a cure. These children should not be sent to school. Cures are probably brought about by stimulation of the defective word-memory centre, or by development of the corresponding centre in the opposite side of the brain.

Visual Aphasia consists in inability to name objects seen, the use of which is known. The objects can be named, if the patient be allowed to feel them even with his eyes closed. A few cases of this affection have been recorded, and in all there was right homonymous hemianopsia. Alexia and agraphia sometimes coexisted.

Dyslexia.—This symptom was first described by Berlin. In a wide sense it belongs to the aphasic group. It consists in want of power on the patient's part to read more than a very few—four or five—words consecutively, either aloud or to himself. The difficulty is not caused by dimness of sight, nor by pain in the eye or head, but simply by an unconquerable feeling of dislike or disgust, due to the mental effort. After a few words which can be well understood have been read, the book is pushed away, and the head drawn backwards and turned aside; and then in a moment or two the patient may be tempted to repeat the effort, but with the same result after a very few words have been read. The symptom comes

on suddenly, and has been usually the first sign of the presence of cerebral disease. Although in most of the cases the dyslexia disappeared in the course of a few weeks, either permanently or to recur later on, yet other symptoms soon followed its first onset, such as headache, giddiness, aphasia, hemianopsia, paralysis of the tongue, hemianæsthesia, hemiplegia, twitching of the facial muscles, etc. All the recorded cases had a fatal termination. The lesion was situated, in all but one of those cases where an autopsy was obtained, in the neighbourhood of Broca's lobe. In one case the left hemisphere was normal, while the right hemisphere was extensively diseased.

Amnesic Colour-Blindness is a symptom which is most probably due to a lesion in the occipital lobe, interrupting the paths between the centre for vision and the speech centre. It has always been accompanied by right homonymous hemianopsia. In this condition the patient sees colours and can recognise them, and he can perform the colour tests, but he is unable to name each colour.

Visual Hallucinations may occur in cases of homonymous hemianopsia in the blind side of the field only, and are due to irritation of the visual-memory centre. Homonymous hemianopic hallucinations, persisting for years without hemianopsia, have also been observed. Visual hallucinations also occur very occasionally in connection with glaucoma.

Mind-Blindness, also called **Optic Amnesia,** is a symptom first observed by Munk in his experiments upon dogs. It consists in the loss of power of recognising objects, while the power of seeing them remains. A whip is seen by the animal, but inspires no terror; a tempting morsel is seen, but excites no desire. The symptom was caused by destruction of a region situated chiefly in the posterior division of the second external convolution of the dog's brain.

It has also been observed in man. The patient fails to recognise the most familiar objects by sight. In one case the patient could not recognise his wife until he heard her voice. There are two forms of mind-blindness—the cortical and the transcortical. In the former, the lesion is in the centre for memory; and the patient has lost the power of visual imagination, and cannot describe visual objects from memory. In the latter, the connecting path between the centre for vision and the visual memory centre is interrupted, and the patient, though he can describe an object from memory, is

unable to recognise it when looking at it. Loss of the faculty of orientation is a form of mind-blindness. Hemianopsia is present in the majority of cases of mind-blindness; and colour-blindness, complete or hemianopic, is not unusual. The lesion has been found in the occipital lobe, usually on the left side, involving sometimes the parietal convolutions. It usually consists in hæmorrhage or softening, and the symptom is consequently sudden in its onset; but it also occurs from tumours. Exhausting illnesses, by reducing the mental energy, may produce a condition of mind-blindness.

Some authors localise the centre for visual memory in the angular gyrus, whilst others take for it the whole of the occipital lobe, except the cuneus and its neighbourhood.

PART II.

OCULAR DISEASES AND SYMPTOMS LIABLE TO ACCOMPANY CERTAIN DIFFUSE ORGANIC DISEASES OF THE BRAIN.

There are organic diseases of the brain which are not focal, and which, as they attack extensive regions of the brain substance, may be called diffuse. Under the same heading may be placed some diseased cerebral states which we cannot doubt are organic, although their pathology is as yet unascertained. It is proposed here to describe the points of ophthalmological interest which belong to some of these diffuse brain diseases.

Disseminated Sclerosis of the Brain and Spinal Cord.—Central Colour Scotoma is the most usual defect of sight in this disease (Fig. 97), and in a few cases absolute central scotoma is present. It is due to retro-bulbar neuritis (p. 343), which is now recognised to occur most commonly as a symptom of disseminated sclerosis. Irregular defects in the periphery of the fields—sometimes only for colour—or regular concentric contraction may be found. These defects may be in one or in both eyes; they most commonly come on very rapidly, and they often get better, or may, after a time, get quite well. Even complete blindness, lasting as long as several months, occasionally occurs; but permanent complete blindness is rare. The ophthalmoscopic appearances do not always coincide with the state of the vision; for with marked defect of sight the

fundus oculi may be normal, or the vision may be normal, while the optic papilla looks diseased, or both sight and ophthalmoscopic appearances may be abnormal. The most common ophthalmoscopic change is a not very intense atrophic appearance of the whole surface of the papilla, or its temporal third alone may be affected in this way. But in these latter cases, where the temporal third alone shows atrophy, a central scotoma is not necessarily present, nor are the papillo-macular fasciculi in the nerve diseased. In a very few cases optic neuritis becomes apparent at the papilla. The ophthalmoscopic changes may be present in both eyes or in only

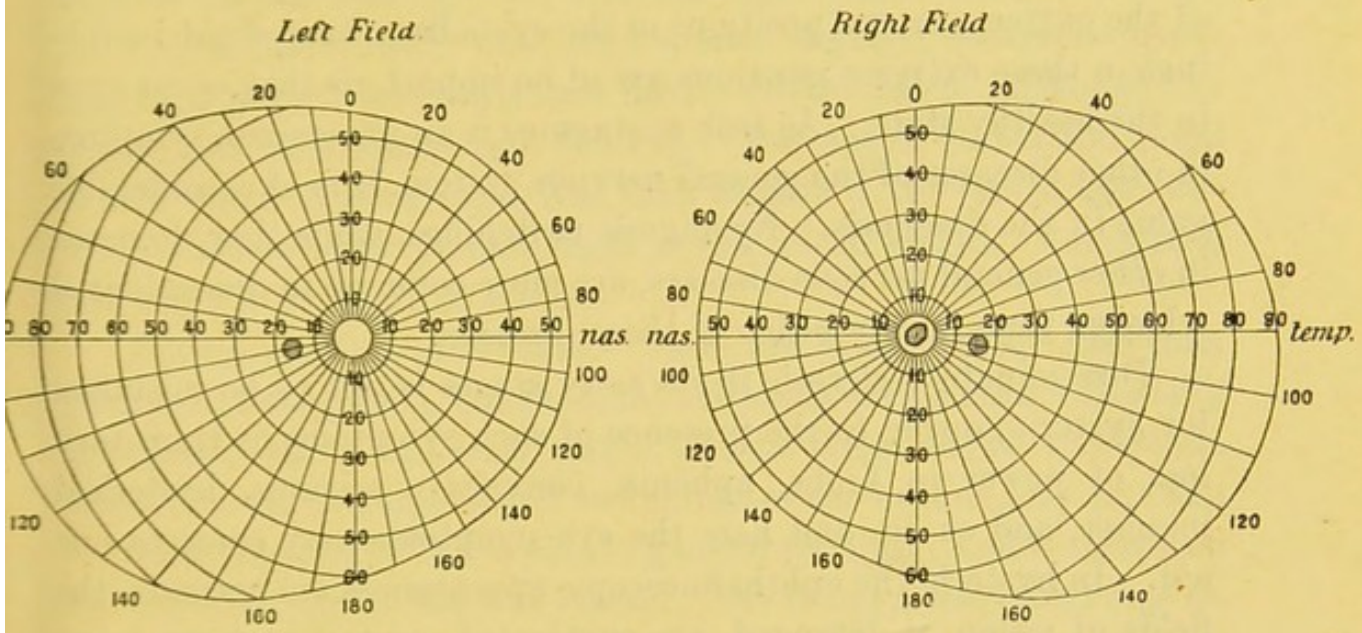


FIG. 97.—*Case of Disseminated Sclerosis.* In right field a very small central scotoma for pale green, and relative for white. A mist before the R.E. for fourteen days, otherwise strong and healthy. Fundus normal. V= 6/18. Exaggerated knee-reflex. No nystagmus, nor nystagmic twitchings. A week later nystagmic twitchings in extreme lateral positions. L.E. healthy.

one. Uhthoff has shown by pathological investigations that, in disseminated sclerosis, disease can exist in the trunk of the optic nerve, without any abnormal ophthalmoscopic appearances, or defect of sight. Sometimes defects of vision and ophthalmoscopic changes precede all other symptoms by long periods, or they appear in the very early stages of the disease; but more commonly they do not come on until other symptoms have been present for some time. In all cases of retro-bulbar neuritis exaggerated tendon reflexes, and other well-known signs of disseminated sclerosis should be looked for. At the commencement of the attack of defective vision, the

patient complains of some pain on movement of the eyeball, and gentle pressure backwards of the globe causes pain in the back of the orbit.

Nystagmus, isolated paralyses of orbital muscles, and nuclear paralysis, are derangements of the oculo-motor apparatus, which are liable to be present in disseminated sclerosis. Marked exterior ophthalmoplegia is rare; but the paralyses of nuclear origin of which there can be no doubt, are loss of conjugate motion to one or other side, and defective power of convergence. Nystagmus is present in about 50 per cent. of the cases, and is either of the ordinary kind or consists merely in nystagmic twitchings, more particularly at the extreme lateral positions of the eyeballs. Very slight twitchings in these extreme positions are of no import, as they occur even in the healthy state. As true nystagmus is an uncommon symptom in other diseases of the general nervous system, it is of considerable value in the diagnosis. Nystagmic twitchings, while they do occur in other general nervous diseases, are more common in disseminated sclerosis than in any other of these diseases.

Disseminated sclerosis in its early stages is apt to be mistaken for hysteria, owing to the presence of such symptoms as transitory loss of power in limbs, aphonia, convulsive seizures, hysterical manner, and so on, and here the eye-symptoms may come to our aid. In hysteria the ophthalmoscopic appearances are normal; the fields of vision, if deranged, are contracted, central scotoma being rare, and when the fields are contracted the colour boundaries often do not recede in their regular order—the field for red, for example, may be wider than that for the other colours. In hysteria, again, it may be found impossible to examine the colour fields at all, all colours being named dark or black; and finally oculo-motor disturbances rarely occur.

Diffuse Sclerosis of the Brain.—In some rare cases of this disease, headache, vomiting, and double optic neuritis may lead to the diagnosis of cerebral tumour, an error in diagnosis which, with our present knowledge, it is impossible to avoid, unless there be also focal symptoms that would point with certainty to a tumour. The mistake will not often occur, as diffuse sclerosis of the brain is exceedingly rare.

General Paralysis of the Insane.—Derangements of the intrinsic muscles of the eyeball, orbital paralyses, atrophy of the optic disc,

and mind-blindness are the eye-symptoms which may be found in this disease.

The Pupil, etc.—The pupils are usually contracted in the early stages, and dilated at later periods. An early symptom is slight inequality in the pupils, with somewhat sluggish reaction of the wider one, and, also at an early period, there is apt to be loss of the pupil-reflex to sensory stimuli. Later on the larger pupil does not react to light at all, while its fellow does so normally, and sight is good. The so-called paradoxical pupil-symptom is an early augury of coming paralysis, and consists in this, that when a strong beam of light is thrown into the eye with the focal illumination, the pupil at first contracts fairly well, then dilates slightly, contracts again, and after a few such oscillations finally dilates widely, although the strong light still shines into the eye. The Argyll Robertson pupil is only found in some cases, and then usually in the late stages, but it does occasionally present itself in the initial stages. Sometimes the pupil is irregular in shape.

Paralyses of Orbital Muscles.—These are of rarer occurrence than paralysis of the pupil ; but the third and sixth nerves are occasionally paralysed even in the early stages, and in these stages, too, ptosis and transient nystagmus and twitchings of the eyelids may be seen.

Optic Atrophy.—This is rare in general paralysis, and is then seen for the most part in the late stages. But it has sometimes come on in a very early period, and has even preceded every other symptom by several years.

Mind-blindness occurs in cases of general paralysis, usually in the advanced stages.

Amaurotic Family Idiocy.—This disease occurs in children during the first year of life, and most, if not all, of the cases recorded occurred in Jewish families. Family predisposition is strongly marked, as many as five children in a family of seven having been attacked. The causes which have been assigned are neurotic taint, blood relationship between the parents, and traumatism of the mother during pregnancy. Syphilis does not seem to play any part in the etiology.

The children are born sound and healthy, and continue to be so for some months. They then cease to develop mentally, and idiocy is gradually established. At the same time paresis or paralysis, either flaccid or spastic, of the greater part of the body appears.

while the reflexes may be deficient or increased. Hyperacusis is often present. A chief and very early symptom of the disease is loss of sight, ending in absolute blindness, with certain characteristic ophthalmoscopic appearances, and nystagmus and strabismus are sometimes present. A slowly increasing marasmus leads to a fatal termination before the end of the second year, as a rule. Waren Tay first observed the peculiar ophthalmoscopic appearances, and Sachs described the clinical history, general symptoms, and morbid changes in the brain.

The ophthalmoscopic appearances are as follows :—There is at first no change in the optic discs. At the macula lutea in each eye there is a large white spot, rather diffuse, with softened edges, and about twice the size of the optic papilla. In its centre there is a brownish-red, fairly circular spot, which contrasts strongly with the white around it. This central spot, as Tay says, has not the appearance of a hæmorrhage, nor of pigment, but suggests a gap in the white patch through which the healthy structures are seen. In short, the appearance reminds one of that seen in cases of embolism of the central artery of the retina (p. 322 and Plate VII. Fig. 1). At a later period, with complete amaurosis, atrophy of the optic nerve is found.

In the brain the pathological changes consist in degeneration of the pyramidal cells of the cerebral cortex. In the pons and medulla oblongata, degeneration of the pyramidal fibres and of the fillet has been found ; and in the spinal cord, degeneration of both the crossed and direct pyramidal tracts was seen. Treacher Collins found œdema of the retina around the yellow spot, and Holden discovered disease of the ganglion cells of the retina similar to that in the cerebral cortex. The normal absence of the ganglion cell layer at the macula lutea, and the fact that it is thickest just around the latter, go far to explain the ophthalmoscopic appearances.

Meningitis.—Inflammation of the cerebral meninges, of whatever form, and whether at the base or on the convexity of the brain, is liable to be accompanied by optic neuritis. When the meningitis is at the base, ocular paralyses, pain, or anæsthesia of regions supplied by the fifth nerve, and defects in the fields of vision from pressure on the optic tracts or commissure, may be found.

Acute Tubercular Meningitis.—In a small percentage of the cases of this form of meningitis miliary tubercles in the chorioid are present

(p. 226). Optic neuritis is more common than in any other form of meningitis, as are also orbital paralyses, in consequence of the tendency of this form to attack the base of the brain.

Cerebro-Spinal Meningitis.—Eye-symptoms are often present both in the epidemic and sporadic forms of this disease. Swelling of the eyelids, conjunctivitis, and photophobia are frequent, even in the early stages. The pupils may be unequal, contracted, or dilated. There may be ulceration of the cornea, parenchymatous keratitis, or deep purulent infiltrations. Retinitis and plastic irido-chorioiditis, followed by retinal detachment, may be found, or there may be purulent irido-chorioiditis, with purulent infiltration of the vitreous humour, going on to panophthalmitis. If the fundus can be examined, optic neuritis or neuro-retinitis will often be seen, or thrombosis of the central vein, with retinal hæmorrhages. Each epidemic of cerebro-spinal meningitis is apt to be associated with some one of these conditions as its special type of eye-affection. The eye-affections in cerebro-spinal meningitis then are very grave; but some of the cases of irido-chorioiditis do recover, with retention of good sight.

Traumatic Meningitis.—Falls and blows on the head which do not fracture the skull are held by many to be capable of causing meningitis, and occasionally, the inflammatory process, reaching the optic nerve, creeps down it to the optic papilla, where it may be diagnosed with the ophthalmoscope.

Hydrocephalus.—Well-marked papillitis, or neuritic atrophy, is sometimes found in congenital hydrocephalus, or in the hydrocephalus which makes its appearance in infancy; and it would probably be more common, but for the compensation for the increased intra-cranial pressure, which distension of the sutures and fontanelles must provide. In the acquired hydrocephalus of later life, optic neuritis passing over to optic atrophy is the rule; and such cases may closely simulate an intra-cranial tumour in all their other symptoms as well. Bi-temporal hemianopsia is apt to be present, owing to pressure on the optic commissure by the distended floor of the third ventricle.

Infantile Paralysis.—Hemianopsia has been noted in a very few cases of this affection; and papillitis, with some orbital paralysis, has also been seen, but usually there are no eye-symptoms.

Paralysis Agitans.—In some cases a fine vibratory tremor may

be noticed along the margin of the upper lid, especially when the eyes are closed, and the lids will be found to be unusually rigid on an attempt being made at passive opening of them. The slowness of muscular action in other parts does not affect the motions of the eyeballs. If a patient be called on to look in any direction, the eyes are instantly turned, while the head slowly follows them.

Epilepsy.—A visual aura is more common than any other special sense aura in idiopathic epilepsy. It may take the form of subjective sensations of lights, colour, flames, megalopsia or micropsia, etc.; or visual hallucinations may occur; or there may be simple homonymous hemianopsia. Where epilepsy is due to organic brain disease, a visual aura, occurring always in homonymous sides of the fields, is important, as indicating the occipital lobe as the region of the brain in which the discharge originates. At the onset of an epileptic fit, there is often conjugate lateral deviation of the eyes to the opposite side of the body from that on which the convulsions commence, with rotation of the head in the same direction, while subsequently the eyes may suddenly be turned in the opposite direction. The condition of the pupils varies, often even in one and the same fit. At the onset they are usually normal or contracted; but during the tonic spasm they become dilated, and remain so until consciousness returns. The pupillary light-reflex is lost—a point of importance in the diagnosis of a true epileptic fit from an hysterical attack, in which latter it is retained. After a fit, rapid changes in the size of the pupil may sometimes be seen, and these are valuable as evidence of the fit having been a genuine one. The ophthalmoscopic appearances during a fit vary in different cases. In some they are normal, in others there is marked pallor of the disc and contraction of the blood-vessels, and, again, in others the papilla is hyperæmic and the retinal veins enlarged. Optic neuritis and optic atrophy do not belong to epilepsy; and if found they can be regarded only as complications. Between attacks the fundus may be normal; but it is not unusual to find a high degree of hyperæmia of the retina and papilla, which may continue for some days or hours, or may even become chronic. The fields of vision after a fit, and sometimes as a permanent state, are concentrically contracted; or there may be colour-blindness, and the central acuteness of vision may be reduced. The state of the fields is a valuable aid in the detection of simulation. Transitory amblyopia

(migraine, scotoma, etc.) is more frequent in connection with epilepsy than under any other condition. It may precede the true attack by years, or it may occur with, or for an hour or so before, the fits, or it may be substituted for them. Inasmuch as this transitory amblyopia is often attended by disturbances in speech, or in the intelligence, or by passing paralysis, and as both eyes are usually attacked by it, frequently in the form of homonymous hemianopsia, it is obvious that its cause resides in the visual cortex. Occasionally the blindness is monocular, and must then be referred to disturbance in the circulation of the retina or optic nerve. It is held by some authorities that, given a predisposition to epilepsy, irregularities in refraction may at times prove the exciting cause of the disease; and that cases of epilepsy occur, in which the attack is induced by the undue strain put upon the muscular apparatus of the eye by reason of an abnormality of refraction. They also hold that, if correcting glasses be worn by these patients at a sufficiently early period, the fits will cease, or at least in a considerable proportion of the cases. Further investigations on this subject are required, especially as concerns the permanence of cures.

Chorea.—It is probable, that in some cases, at least, of this affection, cerebral embolism may be taken as the cause. Several instances of embolism of retinal vessels have been seen in immediate connection with the onset of chorea.

In chorea the eyes participate in the irregular jerky motions, and the spasm may be so unequal in the two eyes as to cause brief diplopia; although, not being constant, it is little heeded by the patients, and is rarely mentioned by them.

PART III.

OCULAR DISEASES AND SYMPTOMS LIABLE TO ACCOMPANY CERTAIN DISEASES AND INJURIES OF THE SPINAL CORD.

Tabes Dorsalis.—Amongst the ocular complications to be found in this disease, *Atrophy of the Optic Nerve* (p. 350) is the most serious. It occurs in about 20 per cent. of the cases, and commences more frequently in the pre-ataxic period than subsequently. Rarely it is the first symptom, preceding all spinal symptoms by from two to

twenty years, and it does sometimes commence in the later stages of locomotor ataxy. Coming on in the pre-ataxic stage, optic atrophy seems very often to have, as it were, a favourable influence on the spinal disease, the spinal symptoms already existing becoming ameliorated or disappearing, while the further progress of the disease is retarded or averted. It is indeed rare for tabetic patients who go blind at an early stage of the disease to become ataxic later; but if the ataxy be once well marked, it does not improve with a subsequent development of optic atrophy. It sometimes occurs that the onset of optic atrophy in one eye precedes that in the other by a long interval, even by many years; but usually the eyes are affected simultaneously, or at a short interval. The relation between the optic atrophy and the spinal disease is not as yet well understood. The atrophy is probably merely a manifestation of a diseased process in the optic nerve, similar to that which attacks the posterior columns of the cord.

Paralysis and Ataxy of the Orbital Muscles.—Paralyses of orbital muscles in locomotor ataxy occur in about 30 per cent. of the cases. They usually appear in the pre-ataxic stage, and even as an initial symptom, and are of two kinds—namely, the transient paralysis, which lasts a few days or weeks, and may recur; and the permanent paralysis of one or two muscles. Diplopia is produced by these paralyses, and is often the symptom which first induces the patient to see his doctor. The sixth nerve is the one most commonly paralysed; but the third nerve is also often paralysed, including the branch to the levator palpebræ, with resulting ptosis. Loss of power of convergence is often present in commencing tabes, and double exterior ophthalmoplegia, as well as double sixth-nerve paralysis, is sometimes seen; and there can be no doubt but that all these three conditions, and probably also some of the other oculo-motor disturbances in tabes, are often of nuclear origin. But the orbital nerves may, it is found, undergo atrophy without their nuclei being altered, and probably, therefore, some of the ocular paralyses here are due to peripheral neuritis.

Ocular ataxy is another not infrequent symptom in tabes. It is sometimes erroneously called nystagmus; but nystagmus is a constant oscillatory motion of the eyeballs, both while the eyes are at rest, and when they are looking at an object, and is extremely rare in tabes. In ocular ataxy, so long as the eyes are at rest, there

is no oscillation or twitching; but as soon as an object is carefully looked at, and especially if followed when in motion, and more particularly at the end of the latter, a slight twitching of the eyeballs is seen. It may be found in any stage of tabes.

Pupillary Alterations.—Myosis is the usual state of the pupil in tabes, and is held to be due to paralysis of the pupil-dilating fibres from disease in the front part of the aqueduct of Sylvius. The myosis is often extreme, or 'pin-hole,' as it is then termed; yet the pupil may react to light and on convergence. The pupil may be of normal size in tabes; but mydriasis, except as part of a third-nerve paralysis, is rare. Again, both in the early and later stages, the pupils may be of different sizes.

The Argyll Robertson pupil is an important symptom of tabes. It consists in this, that, even with normal or fairly good vision, the pupil, although as a rule contracted, does not respond to the stimulus of light by further contraction, or but slightly, yet does become more contracted on convergence of the visual axes (or on accommodation). Myosis need not necessarily be present with the Argyll Robertson pupil; the pupil may be of normal size or dilated. The symptom is one of those most regularly found in tabes. It is often an early or initial symptom, and it continues through all the stages of the disease. It is occasionally present in one eye only, and is sometimes quite wanting. The pupillary reaction on convergence alone in advanced optic atrophy must not be mistaken for an Argyll Robertson pupil.

Neither the Argyll Robertson pupil nor primary optic atrophy occurs in peripheral neuritis, a disease which is liable to be sometimes mistaken for tabes.

Paralysis of Accommodation without paralysis of the sphincter iridis is a rare symptom in tabes. It is more common in the late than in the early stages.

Narrowing of the Palpebral Fissure, due to a slight drooping of the eyelids, hardly to be called ptosis, sometimes occurs in tabes along with the myosis. It is held to be due to paralysis of the sympathetic (sympathetic ptosis), is usually binocular, and the frequency of its occurrence increases as the disease advances.

Twitchings in the Orbicularis Muscle for some Moments after Closure of the Eyelids may sometimes be observed in tabes. Similar twitchings may occasionally be seen in some other nervous diseases,

and even in health, but less well marked. Probably their marked character in tabes is due to very slight facial paralysis, and the consequent imperfect power of closing the eyelids.

Hereditary Ataxy (Friedrich's Disease) presents few eye-symptoms, a fact of some diagnostic importance. Ocular ataxy (p. 376) is the only one which occurs with any constancy. Optic atrophy is of such rare occurrence in the disease, that it can hardly be reckoned as one of its symptoms. Paralyses of orbital muscles do not occur, nor does any pupil-symptom.

Myelitis.—Apart from the inflammation of its meninges (cerebro-spinal meningitis), of which mention has already been made (p. 373), acute inflammation of the cord may be associated with optic neuritis. The optic nerve seems usually to become inflamed before the spinal cord, but the myelitis may precede the optic neuritis, or optic nerve and spinal cord may be simultaneously attacked. The relation of the optic neuritis and myelitis to each other is, doubtless, nothing more than that each is a manifestation of the presence in the system of one and the same toxic influence. Rheumatism, epidemic influenza, and syphilis are amongst the causes assigned in some cases, while in others no cause could be assigned. If the cervical portion of the cord is inflamed, pupillary symptoms—irritation mydriasis or paralytic myosis—are apt to be present.

Syringomyelia.—Concentric contraction of the field of vision without ophthalmoscopic changes, is the one eye-symptom sometimes present in this disease. It is not quite certain whether this abnormality of the field is due, at least sometimes, to attendant hysteria, or is always a symptom of the organic disease as such. Inequality of the pupils has sometimes been noted.

Myotonia Congenita (Thomson's Disease).—In some cases of this rare disease the external musculature of the eyes affords symptoms, although the intrinsic muscles are never disordered. The opening and closing of the eyelids may be difficult—they cannot be closed or opened at one stroke, successive jerky motions being required to effect closure or opening. As in Graves' disease, when the eyes are open the upper lid is apt to be retracted, and the upper lid does not readily follow the downward motions of the eyeball. Transitory amblyopia, or even amaurosis, has been noted in some cases.

Acute Ascending Paralysis (Landry's Disease).—Eye-symptoms are rare in this disease, but there may be paralysis of some of the

orbital muscles, paralysis of accommodation, mydriasis, or loss of the light-reflex.

Injuries of the Spinal Cord.—The condition which used to be known as railway spine, but which is now better styled traumatic neurosis, and is due to mental shock rather than to organic lesions of the brain and spinal cord, is accompanied frequently by certain functional eye-symptoms, of which the chief one is a contraction of the field of vision similar to that found in some cases of hysteria. In those much rarer cases of organic injury to the cord, or of myelitis, or of hæmorrhage in, or inflammation of, its membranes, following on railway and other accidents, organic eye-disease seldom results, although optic neuritis and optic atrophy were at one time held to be frequent consequences of these injuries. If the lesion be in the lower cervical region of the cord, the pupils are apt to be contracted from sympathetic paralysis.

PART IV.

NERVOUS AMBLYOPIA, OR NERVOUS ASTHENOPIA.

We find Nervous Amblyopia, or Nervous Asthenopia, for the most part in connection with three functional disorders of the nervous system—namely, Neurasthenia, Hysteria, and Traumatic Neurosis. Many observers, it is true, hold that these three conditions ought to be regarded and treated of as hysteria, that the term neurasthenia is quite superfluous, while traumatic neurosis is merely hysteria caused by shock. This is not the place to enter into a discussion on this question; and it need only be said that while these various states of the nervous system are admitted on all hands to have much in common, and also to merge insensibly into each other, yet typical cases of each are sufficiently differentiated to make it justifiable and convenient to retain all three in our minds, as separate clinical entities.

Neurasthenia may be described as abnormal susceptibility of the nervous system to fatigue from mental or bodily exertion; while in hysteria the symptoms depend upon idea, the essence of hysterical conditions being that ideas too easily excite abnormal changes in the organism.

The defects of vision which accompany these disorders are, like all their other symptoms, purely functional—*i.e.* they do not depend on any organic disease in the retina, or other portions of the visual apparatus, but merely upon derangement of the functions of these parts. Consequently, there are no ophthalmoscopic changes in the fundus oculi.

In the following, the derangements of vision most liable to be found in each condition will be pointed out, but here it is desirable in the first instance to state them in a general way. Complete blindness of one or both eyes may be found, but is rare; a diminished, but fluctuating, acuteness of vision is more common, the effort or desire to see well being often the signal for the acuteness of vision to fall, and objects disappear from sight if looked at long. Attacks of defective sight, too, may come on suddenly without any provocation, accompanied by positive scotomata, and may last for some minutes. But the most remarkable, important, and characteristic symptom is concentric contraction of the fields of vision. It is almost always necessary, in order to ascertain the presence of this symptom, to examine the fields with the perimeter—no rougher method will answer—and it is important to use a test-object of not more than 5 mm. square. Concentric contraction of the fields is, we know, a symptom in optic atrophy and in glaucoma; but, while in those diseases the contraction usually advances with more or less deep re-entering angles directed towards the fixation point, in nervous amblyopia the contraction is about equal in degree in each meridian, and hence the seeing portion of the field which is left presents a somewhat circular shape (Fig. 98). This shape of the field with normal ophthalmoscopic appearances is pathognomonic of the condition. The contraction may be but slight, or it may approach to within 10° or 5° of the fixation point. It is almost invariably present in both eyes, but it is often more marked in one eye than in the other.

Associated sometimes with this concentric contraction, and sometimes without it, is a phenomenon known as the fatigue field. It consists in this, that if the test-object be brought from the periphery towards the fixation point in each meridian successively, the outside limit of the field comes nearer to the fixation point on each successive meridian examined, without regard to the part of the field in which the examination is commenced. Or, if the test-

object be brought in the horizontal meridian from the periphery on, say, the temporal side across the field until it disappears on the nasal side, and the points of entrance and of exit noted, and the object be immediately carried back on the same meridian until it disappears on the nasal side, and the entrance and exit again noted, and this manœuvre repeated five or six times; should fatigue be present, it will be shown by the points of entrance and exit coming nearer and nearer to the fixation point on each journey —in short, the field is becoming more and more contracted. This method of taking the field in these cases is useful, too, as showing whether at the beginning there is any concentric contraction of the field. These two modes of examination are practically the same; and the reason for the form of fields they are intended to bring out is, that the longer in each case the examination is continued, the more fatigued does the nervous visual apparatus (be it cerebral centre, or retina, or both) become, and this exhaustion is most marked in the periphery of the field. In the normal state, the boundary of the field is not much affected by the length of the examination.

In addition to contraction of the visual field, inversion of the colour fields is often present, the field for red becoming the largest (Fig. 12). This sign may also sometimes be found in cases of cerebral tumour.

Ring-form and island-like defects in various parts of the field, which come and go, are recognised as functional defects, and cannot be confused with the continuing central scotoma of toxic amblyopia due to disease in the papillo-macular fibres. In addition to the defective sight, or contraction of the fields, or fleeting scotomata, there are often other eye-symptoms present, such as weakness of accommodation, or of the internal recti, or some derangement of the fifth or facial nerves.

While functional derangements of vision, as distinguished from those due to organic disease, are what are here under consideration, yet it is very necessary to state that visual defects due to organic disease may sometimes be aggravated by functional blindness. In tabes with optic atrophy, for instance, the contraction of the field may become suddenly increased with the occurrence of some mental worry or intercurrent general illness, and become restored again to its former dimensions with the return to a calmer state of mind or to

improved health. In homonymous hemianopsia, as already mentioned, there is often a peripheral contraction in the seeing side of the field, which can only be due to diminished functional activity in the opposite side of the brain from that in which the disease is situated.

In the three disorders of the nervous system mentioned, the symptoms may, in a given case, remain confined to the nerves which are associated with the various functions of the eye; but this is rare. It is more common to find also symptoms provided by the derangement of functions in other parts of the nervous system.

Nervous Amblyopia in Neurasthenia.—School-children and those of that age are very liable to become neurasthenic. They are brought to the physician with the complaints that the sight is confused, that print disappears as they look at it, that reading causes the eyes to smart and run over water, and that it brings on headache. If the patient be required to read aloud he soon stops, complaining that the words are running into each other, and the book is then brought closer to the eyes; then a few more words are read, and the book is brought still closer, until, finally, it is nearly in contact with the nose; and then further attempts to see are made by twisting the head about, turning the book towards the light, frowning, and so on. Obviously what causes this difficulty in reading is a rapid exhaustion of the accommodation. Insufficiency of the internal recti is also often present, and would contribute to the difficulty of use for near work. The eyes are often emmetropic, and the amplitude of accommodation is normal. Examination of the fields may discover them to be concentrically contracted, and the fatigue field, too, is frequently present. With these asthenic symptoms there are often symptoms of exalted sensibility of the visual apparatus, such as photopsiæ (bright spots, coloured balls, glittering surfaces, etc., before the eyes), a prolonged continuance of the after-images of objects, increased sensitiveness to daylight, and still more so to artificial light, and visual hallucinations (heads, animals, passing shadows, etc.). In the neurasthenia of school-children eye-symptoms often predominate, but other nervous symptoms are nearly always present, such as hallucinations of hearing, states of uncalled-for joyous excitement, or of mental depression, or of irritability of temper. Vertigo, a tendency to weep, some loss of memory, and insomnia may all, or any, of them be present. The patellar reflex is usually increased. Patches of diminished sensation may be found

here and there over the surface of the body, although completely anæsthetic patches, or hemianæsthesia, are rare.

In school-children complaints of difficulty in reading suggest malingering in many instances, but it is not wise to adopt this view without good grounds for it. An examination of the fields may set the question at rest, for neither the concentrically contracted field nor the fatigue field can be malingered.

The neurasthenia of adults manifests itself, so far as eye-symptoms are concerned, less in the use for near work than is the case with school-children. In them, moreover, the contraction of the fields is usually slight, while the fatigue field is well marked. These patients complain of unpleasant and painful sensations in and around the eye, such as creeping sensations and boring pains in the orbit, stabbings in the eyeball, a sensation as if the eye were turned round in the head, and uneasy feelings attending the motions of the globe. The eye may be very painful on pressure at some one spot without apparent cause; and there are often uncomfortable sensations of cold, burning, or dryness under the lids. If there be an error of refraction it is difficult to find glasses with which the patients will be content, the bridge and wings of the frames annoy them with their slight pressure, while the reflection of light from the margins of the eye-pieces causes dazzling. The patients are very sensitive to any bright light. The central acuteness of vision is usually normal, but use of the eyes for near work causes headache, often in the form of a hammering in the temples, or a sensation of pressure on the vertex.

Treatment.—Tinted protection spectacles. Abstinence from use of the eyes for near work. A general tonic treatment, including cold sponge baths when they can be borne, bracing air, plenty of exercise in the open air short of fatigue, early hours, and easily digested diet. As regards drugs, strychnine and iron are those from which most can be expected.

Nervous Amblyopia in Hysteria.—Nervous amblyopia, or nervous asthenopia, in hysteria is often very similar to that in the neurasthenia of school-children, except that the difficulty for near work is even greater. Tonic blepharospasm and partial paralysis of orbital muscles may accompany it. The field of vision is commonly more contracted in one eye than in the other, or the contraction may be very marked in one field, while the other field

is normal or nearly so. In neurasthenia the contraction is usually about equal in each eye. Inversion of the colour fields is often present in hysterical amblyopia, so that the field for red is wider than that for blue. Orientation is rendered more difficult by the hysterical than by the neurasthenic field. A high degree of blindness or even complete amaurosis may attack a neurasthenic schoolchild for a few minutes; but in hysteria such attacks, which may occur in both eyes, but are usually confined to one eye, are likely to last for weeks, or months, or longer. In the amblyopia of hysteria, we may find, that an eye, which cannot see moderately

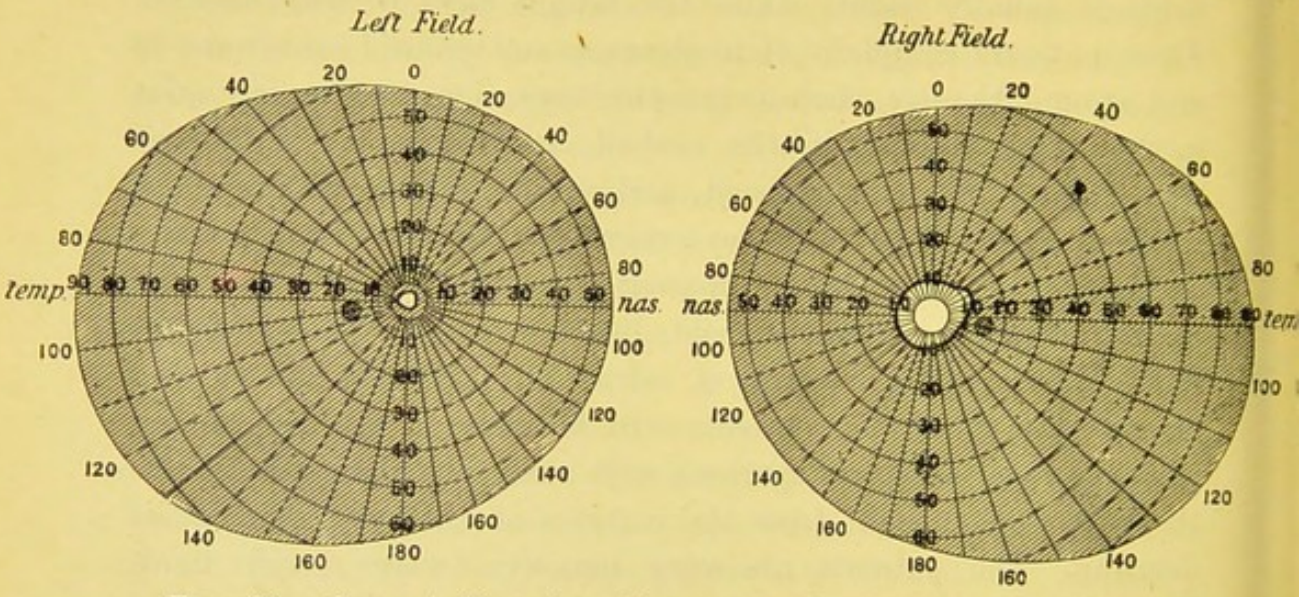


FIG. 98.—*Case of Hysteria.* Extreme and absolute contraction of each field—the left more so than the right—for white. Owing to the small dimensions of the fields the colour boundaries could not be ascertained.

sized type, is enabled to do so by placing any plane glass as spectacles before the eye. Such an occurrence does not mean that the patient is malingering; it shows, rather, that the psychical inhibition to the function of sight in the eye has been withdrawn by the suggestion provided by the spectacles.

With monocular amblyopia, or amaurosis, there is usually hemianæsthesia of the same side of the body as the blind eye; or, if there be merely contraction of the fields, there is often hemianæsthesia on the side of the most contracted field.

The pupils vary much in these cases, and even in one and the same case from time to time. They may be normal, or wide and immovable, contracted, or of different size in each eye.

Nervous Amblyopia in Traumatic Neurosis. One of the most important and most constant of the symptoms of traumatic neurosis is concentric contraction of the field of vision. Yet it is often absent, and, when present, is not always sufficiently typical in form to enable it to be utilised in the diagnosis. It is rarely so pronounced as to interfere with orientation, and must be sought for with the perimeter to determine its presence. The boundaries for the colour-fields are affected even more than that for white, and consequently the tests for these boundaries may discover the contraction more readily than examination of the boundary for white. The colour boundaries are often inverted, but colour-blindness is seldom present. The defect in the field is usually to be found in both eyes, and if there be hemianæsthesia it is on the side of the most contracted field. It is an important fact that the contraction of the field may be the only derangement of sensation, either special or general. The contraction is liable to continue for months or years, and to become more marked for a time, as the result of any passing mental disturbance. The fatigue field, too, is present in some cases of traumatic neurosis.

As regards other ocular symptoms in traumatic neurosis: the pupil-reflex is usually normal, but is occasionally wanting, and a difference in size of the pupils may sometimes be noted; paralyses of orbital muscles are rare, but insufficiency of the internal recti is not uncommon; sensations of sparks, colours, and waviness before the eyes are sometimes complained of; photophobia, and sensations of dazzling with their resulting blepharospasm, may be present.

It is not desirable to rest content with one examination of the field of vision which may prove negative in its result, for it is only shown thereby that on that particular occasion the field was normal. At a later period a defect may be discovered.

PART V.

VARIOUS FORMS OF AMBLYOPIA.

Transitory Hemianopsia, or **Scintillating Scotoma.**—This affection is characterised by (1) symmetrical defects in the fields of vision, usually of the hemianopic type, and (2) vibrating or scintillating

luminous sensations, which after a short time disappear, and are followed by an attack of (3) migraine. In fact, the visual troubles belong to the symptoms of migraine.

The scintillations and defects in the fields, either of which may occur first, commence over a small area, generally near the centre of the field, and gradually widen out; the flashing increases in intensity, and often assumes a zigzag shape, like fortifications, at the periphery of the defect in the field. This defect may exist as symmetrical scotomata, complete or partial homonymous hemianopsia, or even altitudinal hemianopsia. In some cases the scintillation may be absent, while in others the attack of migraine does not follow. The ocular symptoms, which last for a period varying from a few minutes to half an hour, are not accompanied by any changes in the fundus oculi, and nearly always end in complete recovery, but a few cases have been recorded in which the hemianopsia persisted. Vertigo, nausea, or sickness, and even slight aphasia sometimes accompany the headache.

This affection occurs most frequently in intellectually active individuals; fatigue, long reading, and hunger have been known to bring on attacks. The symptoms are probably due to disturbances of the circulation in the occipital lobe.

Treatment should be directed to the cause of the migraine. Lying with the head low, or stimulation of the circulation by wine or nitro-glycerine sometimes cuts short an attack.

Congenital Amblyopia.—This condition is not very uncommon. Ophthalmologists, in the course of their practice, meet with persons in whom the vision of each eye is below the normal standard, even with perfect correction of any error in refraction, and who declare that they never have seen better, and that their sight is not getting worse. Still more common is congenital amblyopia in one eye. As a rule the field of vision and the colour-vision are normal, but cases occur in which there is contraction of the field, with defective colour-sight.

The *Ophthalmoscopic Appearances* are normal.

Amblyopia during Pregnancy.—The disturbances of vision which occur during pregnancy are seldom functional, with the exception of occasional hysterical cases. They are for the most part due to uræmia (p. 388). But there does seem to be a small class of cases in which a functional amblyopia special to the period of pregnancy

occurs. Whether this is due to toxic effects, or to disturbances of nutrition, or to disturbances of circulation has not been determined. Recovery takes place after the birth, and sometimes even before it.

Reflex Amblyopia is said to have been observed, and chiefly in connection with irritation of the fifth pair, especially of its dental branches. Carious molar teeth are reputed to be its frequent cause, usually with severe toothache, but sometimes without it. The defect of vision may be confined to the side of the carious tooth, and is nearly always most marked on that side. It is said that it may be of extreme degree, vision being reduced even to the merest perception of light.

More generally recognised than amblyopia, as the result of toothache, are: hyperæsthesia of the retina, photophobia, subjective sensations of light, and diminution in the amplitude of accommodation.

All these symptoms, even amblyopia of the severest type, disappear when the dental affection is relieved.

Many cases are on record in which wounds of the supra-orbital nerve were looked on as the cause of amblyopia or of amaurosis; but it is by no means certain that an ophthalmoscopic examination would not have afforded another explanation in many of these cases. Yet, even nowadays, many hold that wounds of the supra-orbital region can produce amblyopia, as cases are said to have been cured by division of the nerve involved in a cicatrix that was tender on pressure.

The *Ophthalmoscopic Appearances* in reflex amblyopia are normal.

Night-Blindness.—This is a well-recognised symptom of the disease known as Retinitis Pigmentosa (p. 318). An instance of congenital night-blindness in five members of a family of ten children without ophthalmoscopic signs, has come under the notice of one of us; and Richter, quoted by Lawrence, observed a similar instance.

But the condition to be considered here is Acute, or Idiopathic, Night-blindness.

The patients can see well in good daylight; but on a very dull day, or in the dusk of evening, or by indifferent artificial light, their vision sinks very much more than that of persons with normal eyes. They are then unable to see small objects, which are quite plain to other people, and in a still worse light they fail even to recognise large objects visible to every one else. This peculiar visual defect

is due to imperfect adaptation power of the retina, and not to defective light-sense, as is sometimes stated.

Conjunctivitis and xerosis of the conjunctiva (p. 90) are often present in acute night-blindness. Some observers have found micrococci and bacilli in the conjunctiva in these cases, and have regarded these organisms as the cause of the conjunctival affection. It seems now more probable that they are merely secondary to the xerosis.

The connection between night-blindness and xerosis conjunctivæ remains to be explained; but it is likely that they are both results of one cause.

Acute night-blindness is often the result of long-continued dazzling by very bright sunlight, or of lengthened exposure to bright firelight (*e.g.* in foundries), and it is probable that in many, if not in most, instances of this affection, defective nutrition of the system plays the chief *rôle* in rendering the patients liable to it. Thus, in scorbutus, acute night-blindness has been frequently seen, when the patients have been exposed to strong glares of sunlight. It is common in an epidemic form in Russia during Lent.

Treatment consists in protection from light—in short, in complete darkness for a time—and then gradual return to ordinary daylight; while the system is to be strengthened by careful dietary and suitable tonic medicines, especially cod-liver oil.

Uræmic Amblyopia.—This is most commonly seen in connection with the nephritis of pregnancy and scarlatina, but may occur in any case of uræmic poisoning. It is met with in the acute forms of nephritis, in which albuminuric retinitis is not so liable to occur. The blindness is usually absolute, and may come on suddenly, or with a short previous stage of dimness of vision. It lasts from twelve hours to two or three days, and may recover completely, but in some cases a central scotoma remains.

The *Ophthalmoscopic Appearances* are negative.

Treatment can only be directed to the general condition.

The Prognosis for vision is good, as it always recovers if the patient's life be spared.

Pretended Amaurosis.—Malingerers rarely pretend total blindness of both eyes, and such cases can often only be detected by constant observation of their actions.

The presence of pupillary reflex is not a complete proof that the

patient sees, for it would be compatible with a cortical lesion causing total loss of sight.

The crossed diplopia test (*vide infra*) may be employed to detect malingerers of this class; for if both eyes see, the one armed with the prism will rotate inwards for the sake of single vision, while if both eyes be blind, no such motion will take place. Again, if the malingerer's own hand be placed in various positions, and he be asked to look at it, he will in all probability look in some other direction; whereas a truly blind man usually makes a fair attempt at directing his eyes towards his own hand.

Pretended monocular amaurosis can generally be detected by the Diplopia Test. If the malingerer be made to look, with both eyes open, at a lighted candle placed some feet off, while a prism with its base downwards is held before the admittedly good eye, he will say he sees two images of the light one over the other. Were he blind of one eye he would not see two images.

Another method—the Crossed Diplopia Test—consists in holding a prism of some 10° or 12° with its base outwards before the pretended blind eye, when, if it sees, it will make a rotation inwards for the sake of single vision, an effort which a blind eye would not make.

Alfred Græfe's Method.—In this test the pretended blind eye is covered with the surgeon's hand from behind the patient, while with the other hand a prism (about 10°) is held base down before the good eye, so that its edge may pass horizontally across the centre of the pupil. Monocular double vision results, as the rays pass through the upper part of the pupil normally, while through the lower part of it they are refracted downwards by the prism. The double images stand over each other. If now the hand which excludes the pretended blind eye be rapidly removed, while at the same moment the prism is moved upwards, so that the entire pupil is covered by it, a malingerer will still see double images standing one over the other; but now the diplopia must be binocular.

Harlan's Test consists in placing a trial frame on the patient's nose with a very high + lens—say + 14 D—opposite the good eye, by which means it is excluded from distant vision, and a plane glass—or a 0·25 D convex or concave lens, which of course would not materially interfere with its distant vision—opposite the pretended blind eye. The patient then, believing there is much the same kind of glass before each eye, will read the test-types; and if it be now

desired to expose the deception, the pretended blind eye is excluded from sight, and the malingerer will then be unable to read the test-types.

Snellen's Coloured Types may also be used for this purpose. These types are printed in green and red. If a person be really blind of one eye, he will, of course, see both the green and the red letters with the good eye. But if a green glass be held before the good eye, the rays from the red letters will be excluded, and he will now only see the green letters; or with a red glass the red letters alone will be seen. A malingerer may be detected by holding before his admittedly good eye a green glass; and if he now still see the red letters, it must be that he does so with the so-called blind eye. A good modification of this test is Haselbury's test types, of which the letters are composed of black and white portions. The diploscope and diaphragm tests (chap. XVI.) are also useful.

It is well to have this variety of tests, in order that they may be used to corroborate each other.

Erythropsia (*ἐρυθρός, red*)—**Red Vision.** A large number of cases of this remarkable affection are on record; indeed, it will have come under the notice of nearly every ophthalmic surgeon of any experience. The majority of the cases have been subjects of successful cataract operations, whilst the remainder have possessed normal eyes. In some cases the red vision remains only a few minutes, and does not again return; whilst in others it appears every day for a short time, for weeks or months; and, again, in others it continues for several days, and then disappears for good or recurs at intervals. In the aphakic cases it does not usually appear for weeks or months after the removal of the cataract, and in one case the interval was two years. During the attacks the patients see all objects of a deep red colour, and occasionally of a purple or violet hue. In no instance is the acuteness of vision affected either during or after the attacks.

A quite satisfactory explanation for the affection has not yet been offered. Possibly it is due to over-excitation of the visual nervous apparatus—it may be of the visual centre, or of the retina—set a-going by exposure of the eye to light which is rich in ultra-violet rays, as in high mountain altitudes, along with other favouring circumstances, especially general over-excitement of the body or mind. The normal crystalline lens absorbs the greater part of

the ultra-violet rays which are present in the daylight at ordinary altitudes. Consequently the retina of an eye which has been operated on for cataract is deprived of this protection, and is liable to the irritation caused by these rays.

Treatment seems to have but little effect. Protection of the eyes from light has not been of use. Bromide of potassium internally seems to have done some good in those cases where it was tried.

CHAPTER XIV.

ELEMENTARY OPTICS.

§ 1. The light from a luminous point travels in all directions in diverging straight lines which are called rays. The angle between the outermost rays which pass through an aperture (A B, Fig. 99), or fall on a given surface, is the measure of the divergence of the rays. This divergence diminishes as the distance of the luminous point, from the surface on which the light falls, increases until it finally becomes so small that the rays may be considered to be parallel. In a strict mathematical sense, rays can only be parallel when the luminous point from which they come is at an infinite distance ; but, in ophthalmological practice, rays proceeding from any point at a distance of 6 metres, or more, from the eye may be regarded as parallel when they reach the pupil. Under natural conditions, rays entering the eye are either divergent (objects nearer the pupil than 6 m.) or parallel ; but they are never convergent, unless rendered so by artificial means (lenses, mirrors).

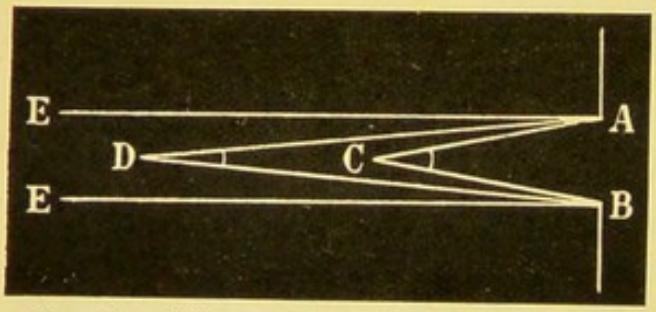


Fig. 99. The rays from D, which is further from A B than C, have a smaller angle of divergence. The parallel rays, E E, are supposed to come from a point infinitely distant.

§ 2. When light falls on an opaque object, some of the rays are absorbed, some are reflected in an irregular or diffuse manner, rendering the object visible, while others are regularly reflected according to the amount of polish on the surface of the object, but none pass through it. When the object is transparent, the majority of the rays pass through, but are bent or *refracted* if the velocity of the light be diminished in its passage through the object—that is to say, if the optical density of the latter be greater than that of the surrounding medium.

§ 3. **Refraction,** then, is the deviation which a ray of light undergoes when it passes from one homogeneous transparent medium into another of different density. The only rays which are not refracted are those perpendicular to the surface (A B, Fig. 100). All others are deviated towards the perpendicular when passing from a rarer into a denser medium, and away from the perpendicular when travelling in the opposite directien.

In Fig. 100 the incident ray, I H, travelling from the rarer medium (air) into the denser medium (glass), is bent towards the perpendicular, P, in the direction H R, and would continue in this path as long as it remained in the denser medium; i is the angle of incidence and r the angle of refraction. If the ray R H were to pass back in the opposite direction from the glass into air, it would be deviated away from the perpendicular, in the direction H I. The path of the ray, therefore, is the same in either direction.

§ 4. **Index of Refraction.**—The more optically dense a medium is, the greater is its refractive power. The relative refractive power of a given substance is called the index of refraction of the substance, air being generally taken as the unit. A medium, therefore, having a greater density than air will have, as index, a number greater than unity; the index of crown glass, for instance, is 1·5. The cornea and the vitreous humour have the same index as water, namely 1·33, while that of the crystalline lens, as a whole, is 1·43. The refractive power depends on the difference between the indices of the two media; for example, in the eye the cornea has a greater effect than the lens, although it has a lower refractive index than the latter, because the difference between air and the cornea is greater than that between the media (aqueous and vitreous) and the lens which lies in them.

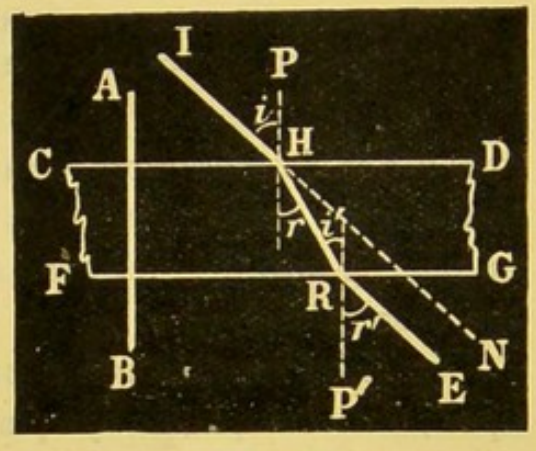


FIG. 100.—Refraction at a plane surface. The surfaces C D and F G being parallel, the emergent R E is parallel to the incident ray I H.

§ 5. **Plane Parallel Surfaces (Plane Glass)** bounding a transparent medium cause merely a lateral displacement of the rays without changing their direction, if the first and last media are the same. In Fig. 100, C D F G may be taken to represent a piece of glass with parallel sides C D and F G, with air on each side. When the emergent ray, R E, passes out again into the air it is refracted away from the perpendicular, P′, and as the angles i and r' are equal, and the perpendiculars P and P′ are parallel, the ray E R is parallel to its original path I H, and suffers only a lateral displacement, which increases with the thickness of the plate. But the relative direction of the rays is not changed; they retain the parallelism, divergence, or convergence, which they possessed before their passage through the plate; hence no images are formed by plane glass, and objects seen through it are unaltered in size and shape.

PRISMS.

§ 6. **Prisms** are refracting media limited by plane surfaces which are inclined at an angle, as in Fig. 101. The thin edge is called the

Apex, *a* is the Refracting Angle, while the thick part opposite the apex is the Base. In passing through a prism a ray of light under-

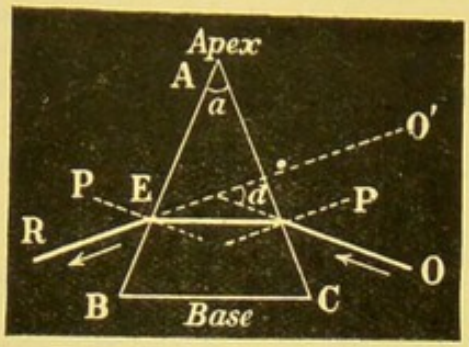


FIG. 101.—Refraction by a prism. The rays from O are displaced towards the base, but O appears to an observer at R to be displaced towards the apex.

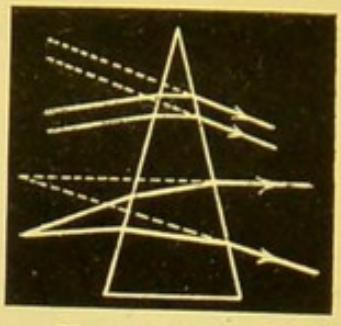


FIG. 102.—Showing parallelism or divergence of rays unaltered by their passage through a prism.

goes a double refraction towards the base. The ray O is deflected towards the perpendicular on entering the prism, and away from it on passing into the air at the side B A, the deviation being towards the base in each case.

An object seen through a prism seems to be displaced towards the apex; for example, an eye placed at R receives the ray E R coming from O, and imagines it to be at O′ in the prolongation of R E. The deviation which the ray O has undergone is shown by the angle *d* (angle of deviation). In prisms made of crown glass, with an index of refraction of 1·5, the angle of deviation is equal to half the angle of the prisms. Fig. 102 shows that, as in plane glass, the relation of the rays to each other is unaltered in their passage through a prism.

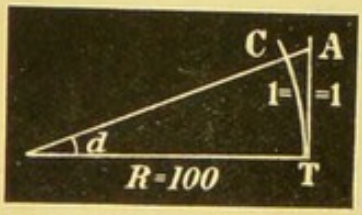


FIG. 103.—One centrad $= \frac{CT}{R}$.

One prism dioptre $\frac{AT}{R} = \frac{1 \text{ c.m.}}{100 \text{ c.m.}}$.

§ 7. **Numbering of Prisms.**—Prisms are numbered according to the size of the refracting angle (*a*, Fig. 101), which is expressed in degrees; we speak of prisms of 1°, 2°, etc.

This method of numeration is not quite accurate, because the deviation depends, not only on the angle of the prisms, but also on the refractive index of the glass composing it; hence, two prisms having the same number will not produce the same amount of deviation, or be of the same strength, if the kinds of

glass of which they are made have different refractive powers. It has, therefore, been proposed to number them according to the angle of deviation (*d*, Fig. 101), expressed either in Centrads or in Prism-Dioptres, a centrad being a deviation (*d*, Fig. 103), the arc (C T) of which is $\frac{1}{100}$ of the radius, while in the prism-dioptre it is the tangent (A T) which is the $\frac{1}{100}$ of the radius (Fig. 103). The three methods are, however, equivalent for all practical purposes. The simplest plan would be to indicate the deviation, and not the angle of the prism, in degrees.

§ 8. **Recognition of a Prism and the Base-apex Line.**—Prisms used in ophthalmic practice are usually cut round for convenience of placing in trial frames, but the thick base and thin apex are

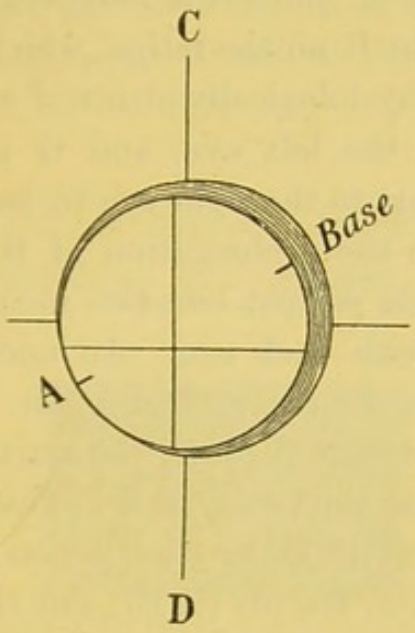


FIG. 104.—Prism horizontal, vertical line only displaced.

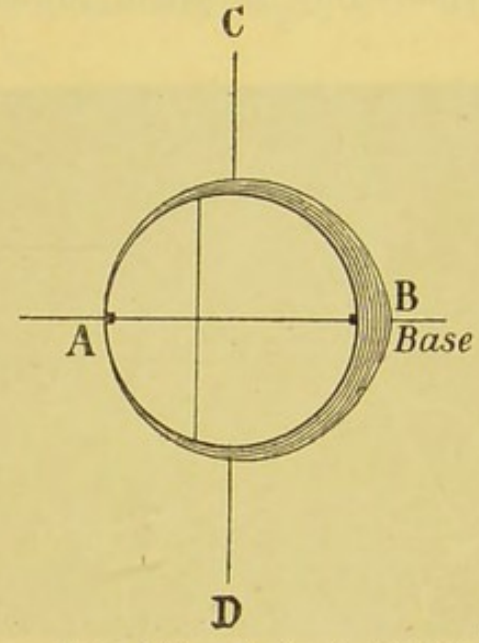


FIG. 105.—Prism held obliquely, both vertical and horizontal lines displaced.

sufficient to distinguish them from lenses or plane glass. In weak prisms this is not so evident, but they can always be recognised by the displacement which they cause when an object is seen through them, by quickly putting the prism up before one eye, the other being closed, or if the prism be rotated before the eye, an object seen through it will be observed to move in a circle, following the displacement of the apex. Figs. 104 and 105 show a simple method of detecting the displacement, and at the same time of ascertaining the exact position of the apex and base. The prism is held at a short distance from the eye opposite two crossed lines, vertical and horizontal (the bars of a window-sash, say), so that they can be seen

outside the edge of the glass as well as through it. If, as in Fig. 105, the apex and base, A, and B, are exactly horizontal, then the portion of the vertical line C D seen through the glass will alone be displaced towards the apex; but if the prism be oblique both lines will be displaced as in Fig. 104.

§ 9. **Effect of a Prism on Binocular Vision.**—When a prism is placed before one eye, both eyes being open, the immediate effect is to cause double vision or diplopia, which either persists, or is overcome by an effort of one of the orbital muscles. In Fig. 106, the image of the object, O, falls on the macula lutea, M, in the left eye (L), but instead of falling on the macula, M, in the right eye (R) it is displaced by the prism, towards the base of which it is refracted, to a point B on the retina, which is not physiologically identical with M in the left eye, and O now appears to the right eye to be at O′, in the prolongation of B P, and the patient sees two images, one with each eye. An unconscious effort is then made by the patient to bring the macula, M, into the position B. This is accomplished by the action of the Ext. Rectus (R E), and thus single vision is again obtained. If desired, by increasing the strength of the prism until the diplopia can no longer be overcome, the strength of the muscle, in this instance the Ext. Rectus, can be estimated. It will be observed also, that when, in order to correct the diplopia, the axis of the eye has moved into the position P B, the convergence of the eyes is diminished, and therefore the effort of the internal rectus muscle must to a certain extent be relieved. From this it follows, that the muscle towards the apex of the prism is brought into action, while the muscle towards the base is relieved. The rotatory prism, composed of two prisms of equal strength, in contact, and rotating in opposite directions, is a useful instrument for measuring purposes, as by its aid values of from 0° up to the strength of both prisms combined can be obtained gradually. Maddox's double

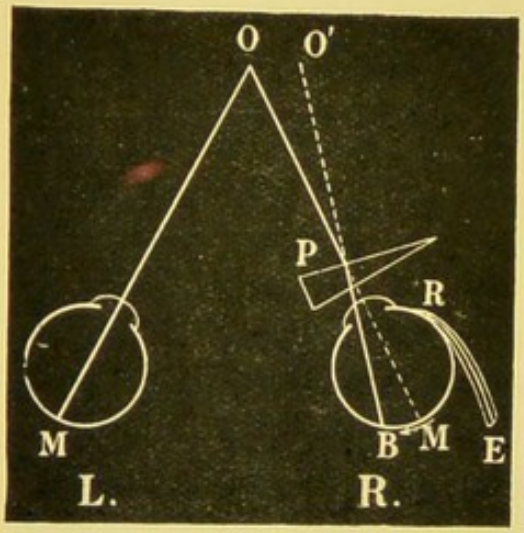


FIG. 106.—Binocular diplopia produced by a prism.

prism is also very convenient for producing diplopia (see Latent Deviations, chap. xvi.).

§ 10. **Uses of Prisms.**—1. By the production of diplopia, prisms can be used, (*a*) to test the strength of muscles, (*b*) to detect latent deviations or insufficiencies of muscles, (*c*) to strengthen weak muscles by exercise, (*d*) to test binocular vision, (*e*) to detect feigned blindness of one eye. 2. For the purpose of correcting or measuring the diplopia in paralysis, or insufficiencies of orbital muscles.

§ 11. **Prescribing of Prisms.**—In practice prisms of more than four degrees can rarely be worn by patients, owing chiefly to the weight and colour effects of higher numbers. The position of a prism placed before an eye is indicated by reference to its base, *e.g.* Pr. 3° base up, down, in, or out, as the case may be.

Lenses.

§ 12. A lens is a portion of a transparent refracting medium bounded by two surfaces, one or both of which are curved. It

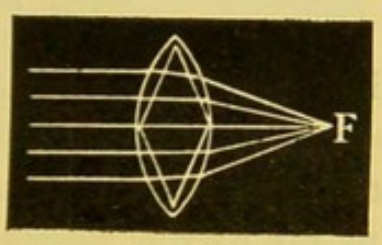


Fig. 107.—Convergent effect of a convex or + lens. F, principal focus.

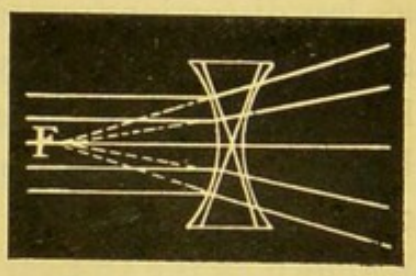


Fig. 108.—Divergent effect of a concave or − lens. F, principal focus.

may be spherical, or cylindrical, or it may be compound—that is to say, spherical on one surface and cylindrical on the other.

§ 13. **Spherical Lenses** are bounded by spherical surfaces, and therefore their action is the same in all meridians; they are either convex or concave. Convex spherical lenses may be regarded as composed of prisms with their bases together (Fig. 107) and are thickest in the centre. They converge parallel rays of light, and bring them to a point or focus. Concave lenses, on the other hand, are like prisms with their apices together (Fig. 108), and are thinnest in the centre. They cause parallel rays of light to diverge. Convex lenses are positive, and are indicated by the sign + (plus). Concave lenses are negative, and marked with the sign − (minus). The

former placed in front of the eye add to its refractive power, the latter diminish it. Fig. 109 shows the different kinds of spherical

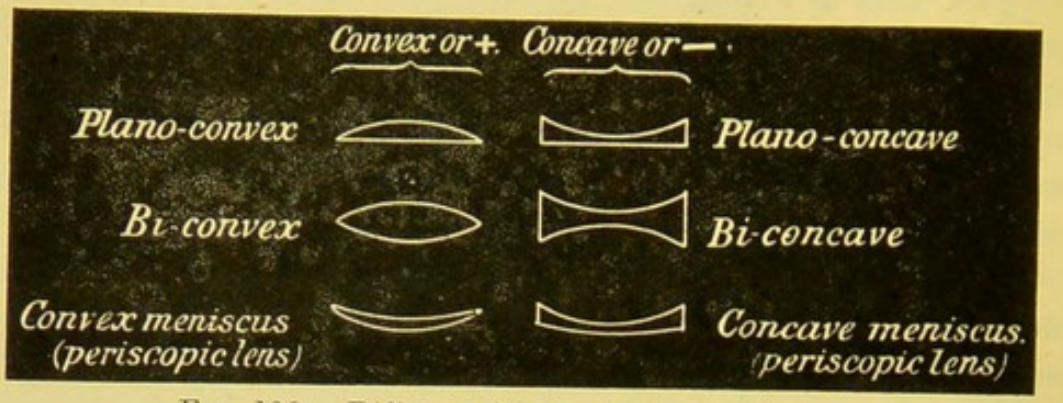


FIG. 109.—Different forms of spherical lenses.

lenses in use. In the convex meniscus, the convex surface has a shorter radius of curvature than the concave; whereas in the concave meniscus, the concave surface has the smaller curve. Meniscus lenses are also called periscopic (*περί, around*; *σκοπεῖν, to look*), because (with the concave surface towards the eye) they produce less distortion towards their edges, and consequently permit a greater excursion of the eye.

§ 14. **Axes of Spherical Lenses.**—The Principal Axis of a spherical lens (P A, Fig. 110) is the line joining the centres of curvature of the surfaces, and the point O in the centre of the lens on the principal axis is known as the Optical Centre. Any ray passing through the optical centre, except along the principal axis, is called a Secondary Axis, and it emerges parallel to its original direction (N E is parallel to S S′). In thin lenses the slight displacement may be neglected, and the secondary axes may be considered to pass through the optical centre without any deviation. These statements apply to both convex and concave lenses.

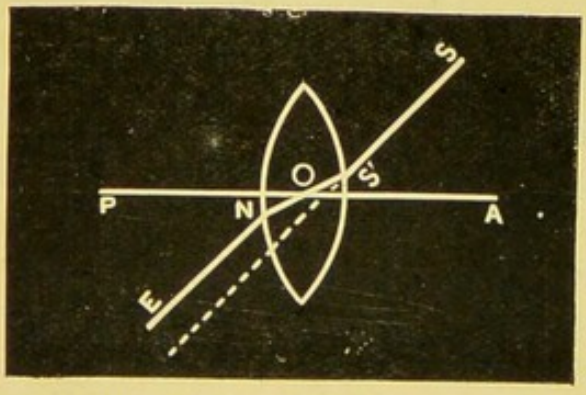


FIG. 110.—Primary and secondary axes of a lens.

§ 15. **Principal Focus of Convex Spherical Lenses.**—The point to which parallel rays of light converge after passage through a convex

lens is called the Principal Focus of the lens, and the distance of this point from the lens is its focal length (Fig. 111). Rays of light diverging from the principal focus pass out parallel on the other side of the lens. Rays (*a c*, Fig. 111), parallel to the principal axis, have their focus on this axis, while those which are parallel to a secondary axis (A S, Fig. 112) are brought to a focus on the secondary axis at a point (S), where it cuts the perpendicular line passing through the principal focus (principal focal plane). The stronger the lens the more the rays are refracted, and therefore the shorter is the focal length (Fig. 113).

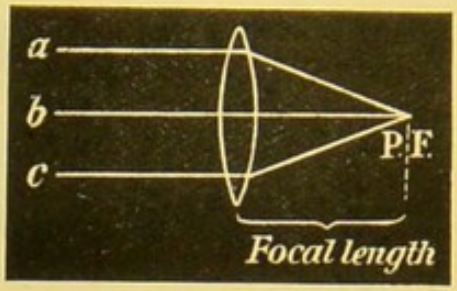


FIG. 111.—Principal focus (P F) and focal length of a lens.

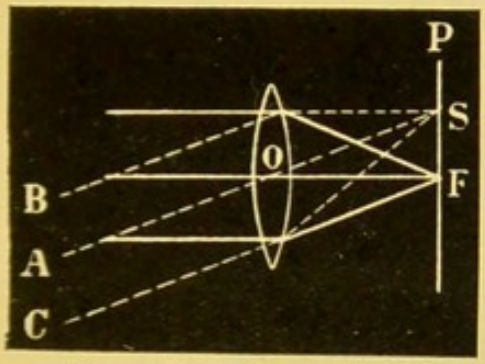


FIG. 112.—Rays A and B, parallel to the secondary axis A S, unite in the focal plane F P at S.

§ 16. **Conjugate Foci** are foci which are so related that rays from one of them pass to the other and vice versa. For instance, the conjugate focus of parallel rays (or infinity) is the principal focus, and the latter is again the conjugate focus of infinity.

§ 17. **Real, or Positive, Conjugate Focus of a Convex Lens.**—We have now to consider what happens to rays which diverge from points on either side of the principal focus; namely, points farther from, or nearer to, the lens than the principal focus. In Fig. 114 the rays from the point 1 farther from the lens than the principal focus F, converge to 1′, beyond F, on the other side of the lens, and form an image there, which is real and can be received on a screen. When the point from which the rays diverge approaches nearer to F, say at 2, then the conjugate focus moves farther away to 2′, until, when the point reaches the principal focus F, the conjugate focus has moved away to infinity, and the rays are parallel. It will be

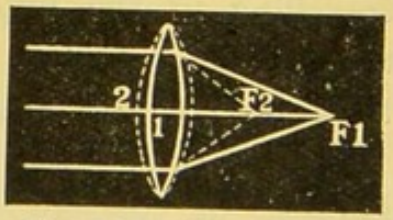


FIG. 113.—The stronger lens (2) has a shorter focus, F 2.

noticed that in this case the conjugate foci are on opposite sides of the lens, but that they move in the same direction.

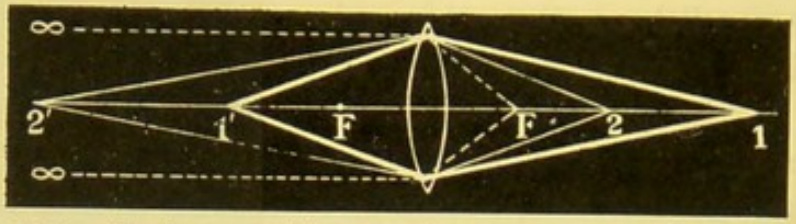


FIG. 114.—Real, or positive, conjugate foci of a convex lens.

§ 18. **Virtual, or Negative, Focus of a Convex Lens.**—When rays proceed from a point nearer to the lens than the principal focus F, the angle of divergence being greater than at F, the lens is not sufficiently strong even to render them parallel, and they therefore continue to diverge after their passage through the lens, but not so much as before. In Fig. 115, the rays coming from P, internal to the principal focus, F, are rendered by their passage through the lens, L, less divergent than before; but, being divergent, they cannot come to a focus. To an observer at C, however, looking through the lens, the rays A and B would seem to come from a point P′, in the direction of their prolongation. P′ is the conjugate focus of P, but it is virtual as opposed to real, and is negative, or on the same side of the lens as P. If we consider the rays as travelling in the opposite direction, A and B with a convergence towards P′ will be focussed at P.

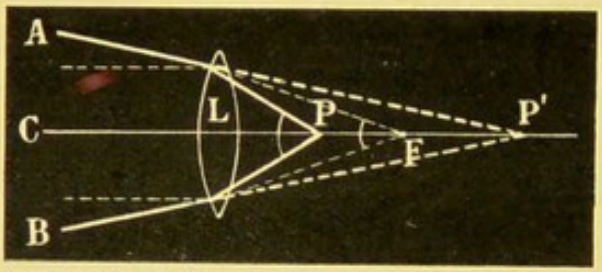


FIG. 115.—Virtual, or negative, conjugate foci of a convex lens.

§ 19. **Foci of Concave Spherical Lenses.**—A concave lens renders parallel rays divergent. In Fig. 116, rays A and B, parallel to the principal axis P X, diverge as if they came from F, which is the principal focus of the lens. Rays from a near point will be rendered still more divergent, and will appear to proceed from a point still

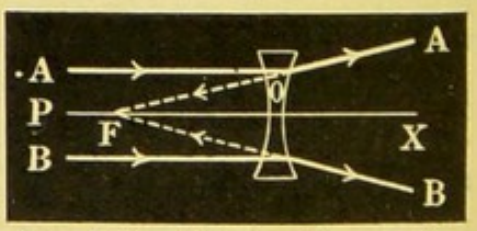


FIG. 116.—Principal focus of a concave lens.

closer to the lens than the principal focus, F; but, in all cases, the conjugate focus will be apparent or virtual, and also negative, or on the same side of the lens as the point of light. Convergent rays are rendered parallel by a concave lens, if they converge towards the principal focus on the other side of the lens, and divergent if the point towards which they converge is farther from the lens than the principal focus. They still remain convergent, but less so than before, if the point towards which they converge is closer to the lens than the principal focus.

§ 20. **Images formed by Spherical Lenses** consist of foci, each of which corresponds with a point in the object, and of which it is the conjugate focus. The image is real when the rays forming it actually meet and can be received on a screen; it is virtual when it does not in reality exist, but is formed by the imaginary backward prolongation of the rays, and can only be seen by looking through the lens.

§ 21. **Method of finding the Position and Size of an Image formed by a Spherical Lens.**—In order to find the position of the image of a point, say of O, Fig. 117, formed by a lens, first draw the secondary axis O I, which passes through the optical centre without deviation. The image will be formed on this axis at a point where the other rays proceeding from O intersect it. Two other rays (the paths of which are known) can be utilised: O A parallel to the principal axis will pass through the principal focus F_2, and the image of O will be at I, where A I meets O I, or I can be found by means of the ray O C, which passes through the principal focus, F_1, and therefore becomes parallel to the principal axis, taking the direction C I. In the following examples, the ray O A only will be used.

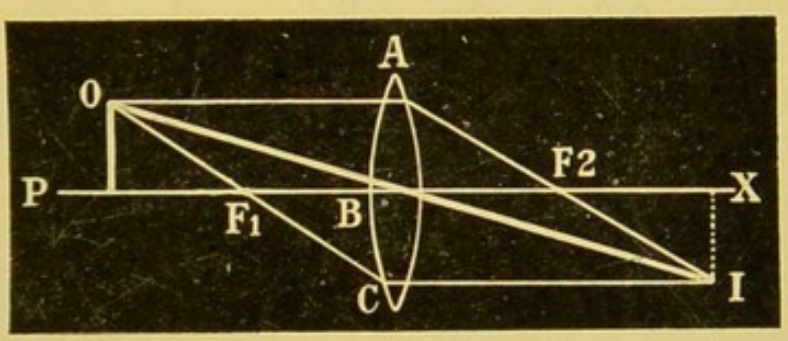


FIG. 117.—Image of a given point O formed by a convex lens.

§ 22. **Real Inverted Image formed by a Convex Lens.**—When an object is farther from the lens than the principal focus, an inverted image is formed on the opposite side of the lens, as in Fig. 118, and the image is equal to the object A C, and at the same distance from the lens, if the object be at twice the focal distance from the lens. The image is larger if the

object be closer than 2F (*e d* is the image of D E), and smaller if it be farther than 2F (D E is the image if *e d* be the object). The closer the

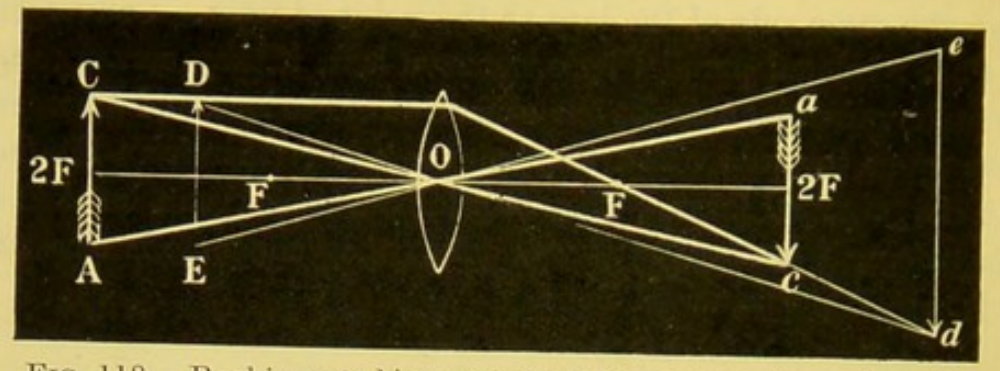


FIG. 118.—Real inverted image formed by a convex lens when the object is farther from the lens than the principal focus.

object is to the principal focus, the larger the image. It is in this way that the image is produced in the indirect method of ophthalmoscopy.

§ 23. **Virtual, Erect, and Magnified Image formed by a Convex Lens.**—When the object, C D (Fig. 119) is closer to the lens than the principal focus F_1, an erect, magnified virtual image, *c d*, can be seen on looking at the object through the lens. As the object approaches the lens, say to N P, the image, *n p*, becomes smaller; in other words, the virtual,

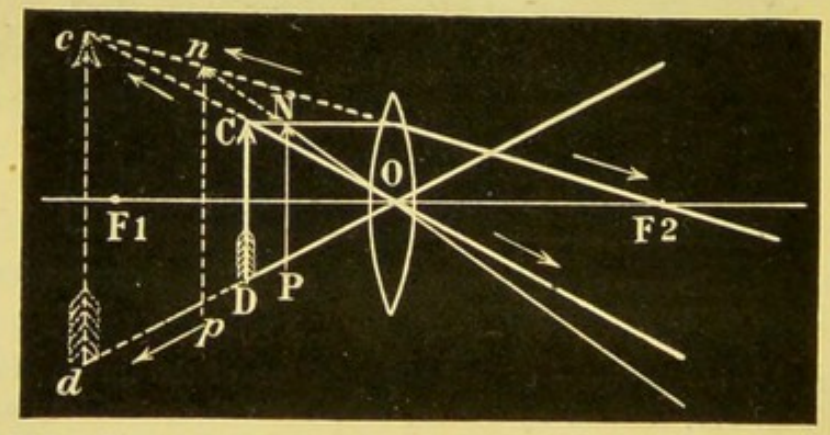


FIG. 119.—Virtual erect and magnified image formed by a convex lens, when the object is closer to the lens than the principal focus.

like the real inverted image, increases in size the nearer the object is to F_1. It is in this way that a convex lens is used as a magnifying glass.

§ 24. **Images formed by Concave Lenses** are always erect, virtual and diminished. The nearer the object is to the lens the larger the image. In Fig. 120 the point *c* or image of C is found at the intersection of S R (prolonged back to the principal focus, F) with the secondary axis C O N, and *d e* is the image of D E.

§ 25. **Optical Defects of Lenses.**—1. *Spherical Aberration.* In § 15 it is stated that parallel rays after passing through a lens unite in one point at the principal focus. Now this is practically the case,

if only a small area of the lens, near the axis, be utilised, say, by means of a 'stop' or diaphragm, but as more of the periphery of

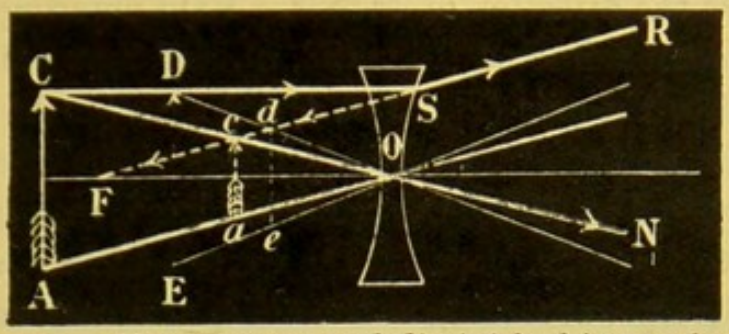


FIG. 120.—Virtual erect and diminished image formed by a concave lens.

the lens is taken in, the rays become increasingly refracted, and cut the axis correspondingly nearer to the lens (Fig. 121). Hence when a larger portion of the lens is used, the image is rendered indistinct. Spherical aberration is present in the eye, although to a certain extent corrected by contraction of the pupil.

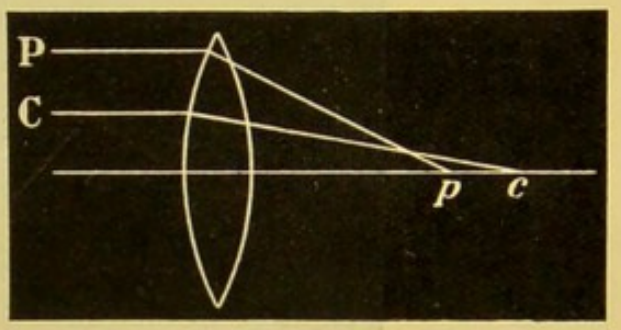


FIG. 121.

2. *Chromatic Aberration.*—The spectral colours, of which white light is composed, are refracted in different degrees by a lens, the red rays being the least and the violet the most refrangible. This tends to give a coloured border to the images formed by the lens. This phenomenon is known as chromatic aberration. It can be corrected by making a compound lens of two kinds of glass having different colour dispersing powers. Such a correction is necessary in many optical instruments, but it is not required for spectacles in which the chromatic aberration is not noticeable. Its presence in the eye, however, can be easily demonstrated.

§ 26. **Cylindrical Lenses.**—A lead pencil is a good example of a cylinder, the lead running down the centre being its axis. Any lines on the surface, parallel to the axis, are straight lines, whereas sections at right angles to the axis are always curved. If a slice were taken off the surface of the pencil, in the direction of its length or axis, and a round piece cut out of it, it would represent a convex cylindrical lens. A cast of the surface of the pencil would form a

concave cylinder. Cylinders only act in the direction of their curvature—that is to say, at right angles to the axis. A cylinder has no effect in the direction of its axis. Rays entering in the plane of the axis are not refracted (Fig. 122, *a*), and rays entering in any plane parallel to the axis (Fig. 122, *b*) are merely bent towards the axis, but suffer no deviation in the direction of the axis—that is to say, vertically in Fig. 122. On the other hand, rays in a plane at right angles to the axis, meeting the curved surface, are made to converge or diverge, according as the cylinder is convex or concave. (Horizontal plane in Figs. 122 and 123.) The focus of a cylinder therefore is a line parallel to the axis, and no image is formed.

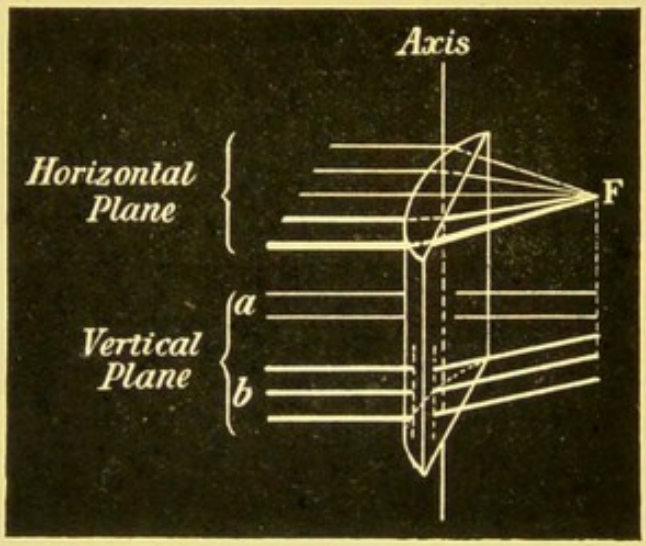


FIG. 122.—Refraction through a convex cylinder. F the principal focus, is really a line parallel to the axis.

The position of a cylinder placed before the eye, is indicated by the degree of inclination of its axis to the vertical or horizontal. The axis of the cylindrical lenses used in trial-cases is shown by two slight scratches at the edge, or by two muffed portions parallel to the axis.

§ 27. **Sphero-Cylindrical and Toric Lenses.**—When it is necessary to combine a spherical with a cylindrical lens, the segment of the sphere is usually ground on one surface of the glass and the cylinder on the other, but in toric lenses the spherical and cylindrical effect is produced on one surface. The nature of the surface then resembles that of a bicycle tyre, the length of the tyre having a flatter curve than the breadth.

§ 28. **Numbering of Lenses.**—The lenses in trial-cases and in spectacles are numbered according to the metric system.

A lens of one metre focal length is adopted as the Dioptric Unit or unit of refractive power, and is called a Dioptre (1 D). The greater

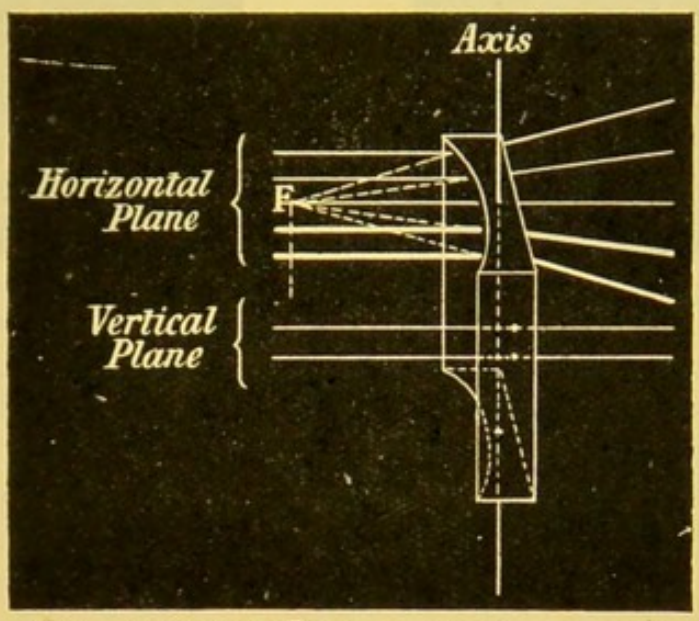


FIG. 123.—Refraction through a concave cylinder.

the strength or refractive power of a lens, the higher will be its number, and the shorter will be its focal length (Fig. 113). Lenses of 2 D and 4 D are twice and four times as strong, respectively, as a lens of 1 D, and their focal length will be inversely, $\frac{1}{2}$ and $\frac{1}{4}$ of the focal length of the 1 D lens, that is to say $\frac{1\text{m}}{2}$ and $\frac{1\text{m}}{4}$, or expressed in centimetres (1 metre = 100 centimetres), $\frac{100}{2}$ = 50 cm., and $\frac{100}{4}$ = 25 cm.

If, therefore, it be required to ascertain the focal length of a given lens, 100 must be divided by the dioptric number of the lens, and the answer will give the focal length in centimetres. For example, the focal length of a lens of 5 D is $\frac{100}{5}$ = 20 cm.

If the focal length of the lens be known, and it be desired to ascertain its dioptric number, we find it by dividing 100 cm. by the focal length. For example, if the focal length be 33 cm., then $\frac{100}{33}$ = 3 D.

Lenses of less than 1 D have of course decimal fractions for their numbers—*e.g.* 0·75, 0·5, and 0·25. The focal length of 0·5 D is $\frac{100}{0{\cdot}5}$ = 200 cm. = 2 metres. Cylindrical lenses are numbered in the same way as sphericals. The strength of two lenses in contact is practically equal to the sum of their numbers, if of the same kind, and to

the difference of their numbers if of the opposite kind—*e.g.* + 4 D lens combined with — 1 D lens equals a + lens of 3 D.

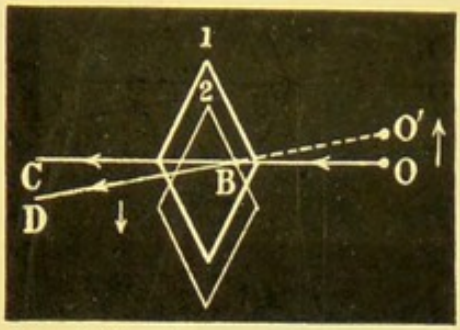


FIG. 124.—Apparent movement, in the opposite direction, produced by displacement of a convex lens. In position 2, O B is deviated towards the base of the prism to D, and O is seen at O′ (chap xiv. § 6).

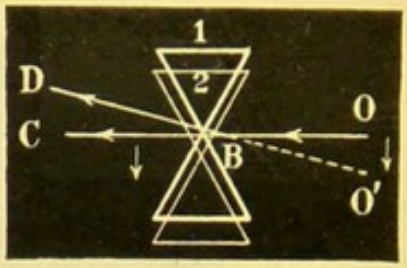


FIG. 125.—Apparent movement, in same direction, produced by displacement of a concave lens. In position 2 the prism is base up, O B is deviated to D, and O seems to be at O′.

§ 29. **Recognition of Spherical Lenses.**—If a spherical lens be moved before the eye, when looking at an object through it, the object will seem to move in the opposite direction in the case of a convex lens, and in the same direction, if the lens be concave. This is due to the prismatic action of the lenses (Figs. 124 and 125), and occurs equally in all diameters.

* § 30. **Recognition of Cylindrical Lenses and of the Position of the Axis.**—Cylinders act in the manner described above for spherical lenses, but only in the direction at right angles to the axis. Further, if a cylinder be rotated while an object is viewed through it, it produces a distortion, when the axis is oblique with regard to the chief lines of the object. The effect is best seen if a rectangular object be selected, the angles of which are then no longer right or equal. This is noticeable even when the cylinder is combined with a spherical lens.

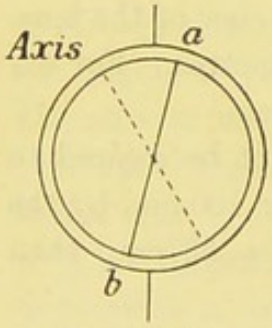


FIG. 126.

The simplest plan is to look at a vertical line through the glass, and if the axis of the cylinder be either vertical or horizontal, the portion of the line seen through the glass appears to be continuous with that outside it, whereas if the axis be oblique, as in Fig. 126, the portion

seen through the lens becomes twisted into the position *a b*. Maddox's axis-finder, Fig. 127, is based on this principle. The spectacle frame is placed in a groove on the top of the instrument, and is held there, while both are tilted round until the line appears continuous as at A, Fig. 127; the pendulum, P, then indicates on the graduated arc the position of the axis, or the direction at right angles to it. The axis can also be found by the lens measurer.

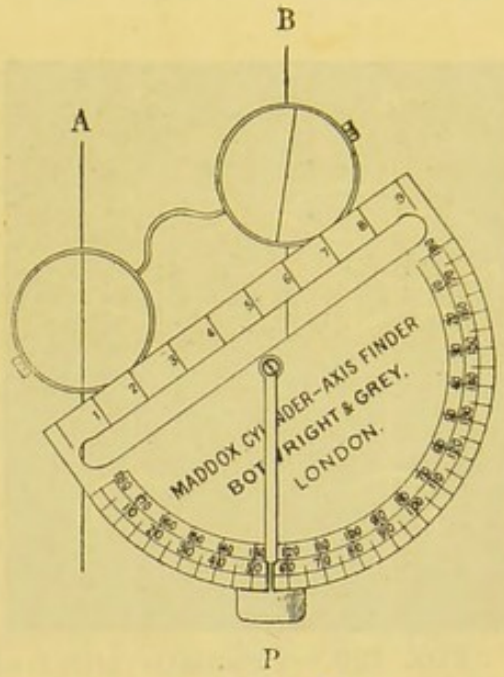


FIG. 127.

* § 31. **To find the Number of a Lens** it is only necessary to neutralise it with a lens of the opposite kind taken from the trial-case. The two lenses are held in contact and moved together, while the apparent motion of an object (§ 29) as seen through them is noted, the lens which stops all movement giving the required number. Or it can be ascertained more rapidly by the Geneva lens measurer, Fig. 128. The three points, *a*, *b*, *c*, the central one, *b*, of which is movable, are applied to the surface of the lens, and the corresponding number is indicated by the pointer on the dial. Both surfaces of the lens must of course be measured. The position of the axis of a cylinder is also easily found by this instrument. When the points are placed parallel to the axis the index stands at 0 (zero), showing that the surface is plane in that direction.

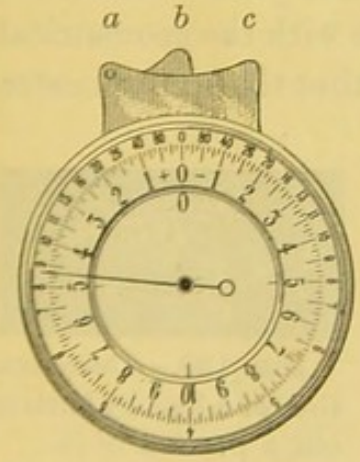


FIG. 128.—Lens measurer.

* § 32. **To find the Optical Centre of a Lens** is often a matter of practical importance. It can be found in the same way as is the base-apex line of a prism (Fig. 104). When both the crossed lines seen through the lens are continuous with the portions outside the lens, the optical centre is opposite the point of intersection of the lines.

* § 33. **Decentration of Lenses.**—Normally, the distance between the optical centres of the lenses in spectacles should be the same as that between the optic axes of the eyes of the patient, otherwise a prismatic effect would be produced. Sometimes, however, such an effect is desirable, and then it can be brought about by decentration of the lenses. This may be done in one or other of two ways, namely, by altering the distance between the glasses by means of the frames, or by decentring the glass in its rim. The effect of the first method is shown in Fig. 129, from which figure, too, it is evident that, in order to produce the same effect, convex and concave lenses must be displaced in opposite directions.

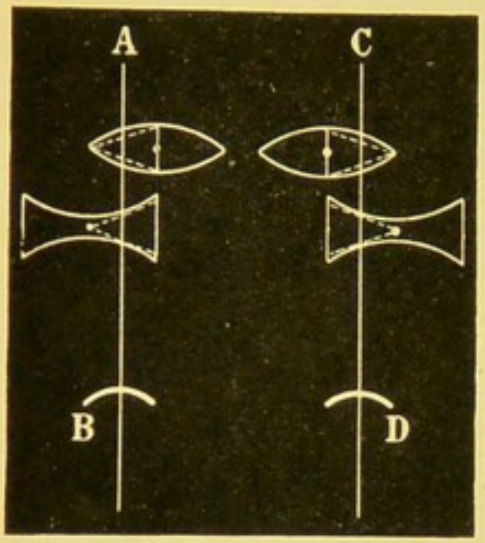


FIG. 129.—Prismatic effect of decentration of lenses. A B and C D represent the visual axes.

The second method consists in cutting out the lens so that the optical centre is displaced with reference to the geometrical centre. By the geometrical centre we mean the central point of the piece of glass constituting the lens. In round glasses it is of course equally distant from all parts of the circumference, and in oval glasses it is at the centre of the horizontal diameter of the glass. In lenses, as commonly made, the optical centre coincides with the geometrical centre. Fig. 130 shows how a lens can be cut so that the optical centre will be decentred. A B is the lens as originally ground, and B C D is the portion which is cut out and fitted in the spectacle rim. If the whole of A B were used, the optical centre, O, would be the geometrical centre, but in the portion C B D the point G, midway between C D and B, would be the geometrical centre, while the optical centre, O, would be decentred. To obtain a prismatic effect of 1° a lens of 1 D requires to be decentred $1\frac{3}{4}$ cm. The stronger the lens the greater is the prismatic effect produced by a given amount of decentration, so that a lens of 2 D need only be decentred half

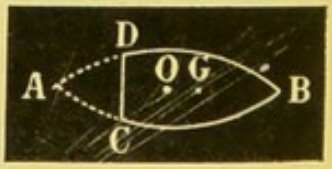


FIG. 130.—Decentration of a lens by cutting out a portion of it.

the distance of a lens of 1 D, in order to produce the same prismatic effect. Tables have been constructed giving the prismatic effect of lenses of different strength corresponding with the extent of the decentration in millimetres.[1]

§ 34. **Protective Glasses.**—Glasses are chiefly used for the correction of optical errors (lenses), or for the relief of muscular insufficiencies (prisms), but they are sometimes worn solely for the protection of the eyes from injury by solid particles (stone-breakers, mineral-water operatives, motorists), by heat (smelters, glass blowers), by excessive light (snow, electric light), or as a protection from ordinary daylight in acute inflammation of the eyes accompanied by photophobia, and during the period immediately after operations such as cataract extractions. For mechanical protection, plate glass, celluloid, or wire gauze spectacles are employed. The injurious effects of light, which are most probably due to the ultra-violet rays, are best prevented by a special glass, such as amber-coloured glass, or a specially made glass of a greenish-yellow tint known as 'euphos' glass. For ordinary clinical purposes smoked or neutral tint glasses are preferable to blue.

[1] See Maddox's work *Ophthalmological Prisms*.

CHAPTER XV.

ABNORMAL REFRACTION AND ACCOMMODATION.

Ametropia.—It has been explained (p. 4) that, in Emmetropia or Normal Refraction, the retina is at the principal focus of the dioptric system. When the retina does not coincide with the principal focus, parallel rays no longer meet on it, if the accommodation be at rest; this condition is called Ametropia (*ἀ, priv.; μέτρον, standard; ὤψ*), or an error of refraction. There are three varieties of Ametropia. 1. Myopia (*μύειν, to close; ὤψ*), or Short-sight; in which the principal focus lies in front of the retina. 2. Hypermetropia (*ὕπερ, over; μέτρον, standard; ὤψ*), in which the principal focus lies behind the retina. 3. Astigmatism (*ἀ, priv.; στίγμα, a point*), in which the refraction of the eye in its different meridians is different.

Myopia, or Short-Sight.

Definition and Optical Causes.—Myopia is an error of refraction in which the retina lies behind the principal focus of the dioptric system, and in which therefore parallel rays of light (*a b*, Fig. 131) are brought to a focus, not on the retina, but in front of it (at *f*), and form on it circles of diffusion (*c d*).

Compared with emmetropia, therefore, the refraction of the myopic eye is increased. This may be due to shortening of the focal length by an absolute increase in the refractive power of the eye, brought about by increase of the curvature of the cornea, as in conical cornea, or of the crystalline lens, as in spasm of accommodation (Curvature M.), or by alteration in the refractive index of the crystalline lens (Index M.), as in some cases of commencing cataract, or by forward displacement of the lens, but in all of these the myopia is of secondary importance.

The most common cause of myopia is an elongation of the antero-posterior axis of the eyeball (Axial M.), and in this case the increase of the refraction is therefore only relative.

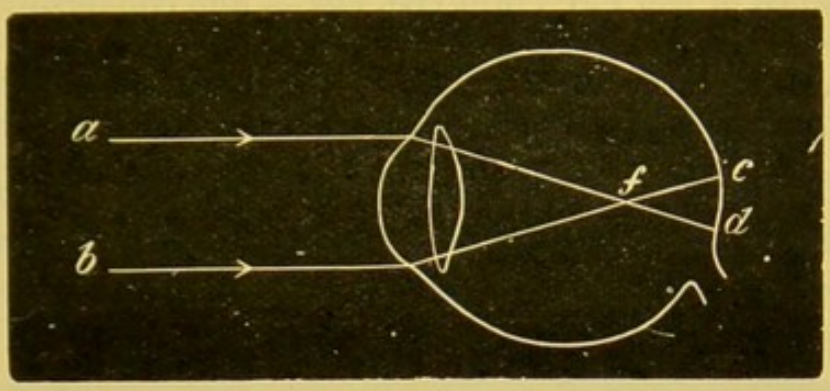


FIG. 131.

Far Point (Punctum Remotum, R.) of the Myopic Eye.—The myopic eye cannot see distant objects (at six metres or more) distinctly, because of the circles of diffusion (*c d*, Fig. 131), but if the object be brought closer, its conjugate focus (§ 16, chap. xiv.) will lie farther back than *f*, Fig. 131, and when the object reaches a certain point nearer to the eye, say R, Fig. 132, its conjugate focus will meet the retina (at *c*) and it will be distinctly seen. This point—which is the farthest point of distinct vision—is the Far Point or Punctum Remotum (R.). The myopic eye is therefore adapted for seeing near objects. Conversely rays emerging from *c* will unite at R, which is the conjugate focus of the retina. It will be observed that,

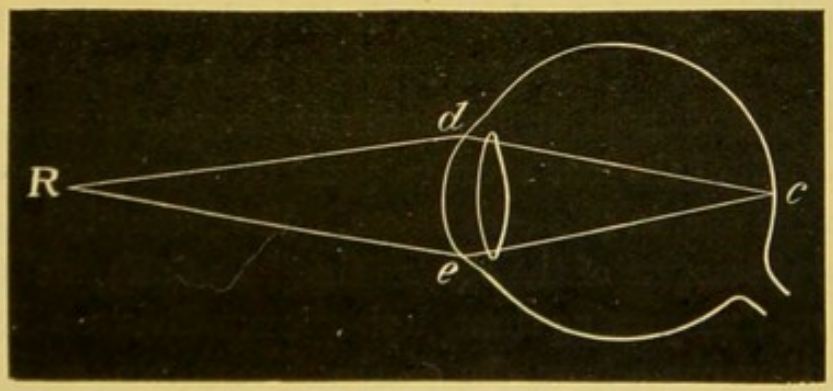


FIG. 132.—Far point of a myopic eye.

in myopia, R is real and can actually be measured, that it lies in front of the eye and is a positive quantity. As the *position* of R in front of the eye determines the *nature* of the error of refraction,

so the *degree* of error depends on the *distance* of R from the eye; the longer the eyeball the closer is R, and the greater is the error of refraction. In other words the error of refraction (r) is the inverse of the distance of the Far Point (R), $r = \frac{1}{R}$, and conversely of course $R = \frac{1}{r}$. These are general equations for all errors of refraction.

Optical Correction of Myopia.—The optical correction of an error of refraction is accomplished by placing in front of the eye a lens which renders it emmetropic, or enables it to bring parallel rays

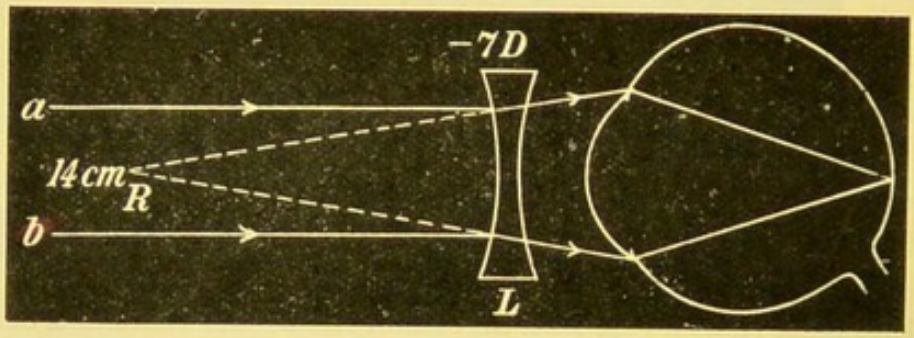


FIG. 133.—Correction of myopia.

(a, b, Fig. 133) to a focus on the retina, without any effort of accommodation, and thus renders the vision of distant objects distinct. Since rays diverging from the punctum remotum (R, Fig. 133) are brought to a focus on the retina in the myopic eye, the correcting lens, L, must evidently give to parallel rays such a degree of divergence before they pass into the eye, as though they came from this punctum remotum. This lens must therefore be a concave or diverging lens, and its principal focus must be at R; that is to say, the focal length of the lens must be equal to the distance of the far point from the eye, in this case 14 cm. The focus of the glass and the punctum remotum of the eye are then identical; and therefore, parallel rays, after passing through the glass, will have a divergence, as though they came from the punctum remotum, and will form an exact image of the distant object on the retina. It is evident that the glass will also make the rays emerging from the eye parallel. The number of the glass, in this case,—7 D ($=\frac{100}{14}$), will indicate the degree of the myopia—*i.e.* by how many dioptres the refracting power of the eye is in excess of that of an emmetropic eye. The

longer the eyeball the shorter is the distance of the far point from it; and therefore the shorter must be the focal length of the correcting lens, and the higher must be its number. The degree of myopia therefore increases with the elongation of the eyeball.

In the explanation of the correction of myopia given above, the correcting glass was assumed to be in contact with the cornea. In practice, however, the glass is placed a short distance in front of the cornea, and consequently, must be stronger than the theoretical correction. For example: if the punctum remotum (Fig. 134) be situated at 20 cm. from the eye, then the number of the correcting lens in contact with the eye, and the real measure of the myopia, will be — 5 D, because the focal distance of this lens is 20 cm. ($\frac{100}{20} = 5$). But if, in the above case, the distance from cornea to glass be 2 cm., the required lens in practice will be — 5·5 D ($\frac{100}{18} = 5{\cdot}5$). Evi-

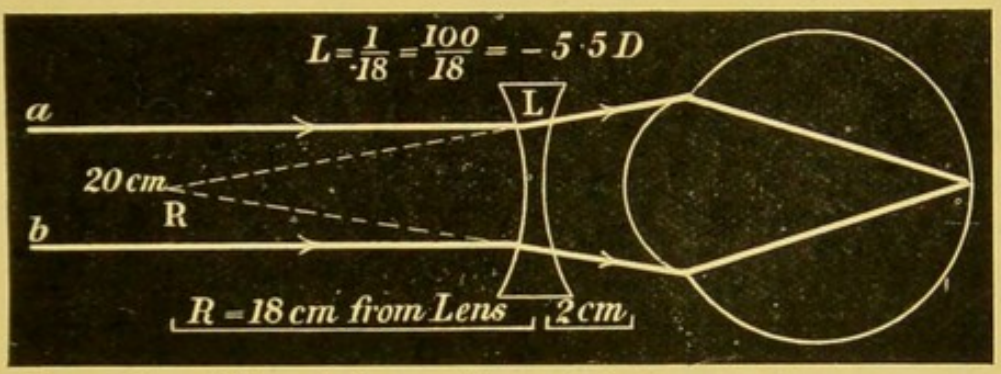


FIG. 134.—Effect of the position of the lens in the correction of myopia.

dently, the farther the lens is from the eye the stronger must it be; and it is therefore advisable that correcting lenses should be worn at the same distance from the eye as are the trial lenses when used to estimate the degree of ametropia. In the example just given the difference between the theoretical and practical amount of myopia is very slight, but it becomes greater the higher the myopia. In a theoretical M. of 20 D, the lens required if placed at 2 cm. from the eye would be — 33 D.

Diagnosis and Determination of the Degree of Myopia.—The degree, or amount, of myopia may be determined either objectively by the ophthalmoscope, or subjectively by means of the trial-lenses and test-types.

SUBJECTIVE METHOD.—Examining each eye separately, we find the correcting glass by placing our patient as directed in the section

on Acuteness of Vision (p. 16). Having first tested V. without a glass, a weak concave trial-glass is then placed before the eye under examination, and higher numbers are gradually proceeded to, until that glass is reached which gives the eye the best distinguishing power for the types. In order to save time, the distance of the far point can be found approximately with small print, and the degree of M. deduced. A lens a little lower than this may be taken to commence with. We often find that there are several glasses, with each of which the patient can see equally well. *The weakest of these is the measure of his myopia.* When a higher glass than this is used the patient may still see well, but he does so only by an effort of accommodation (*i.e.* the crystalline lens has to be made more convex, in order to compensate for the excessive concavity of the glass placed in front of the eye), and the glass employed represents then, not merely the myopia present, but also this accommodative effort. It is therefore a serious mistake to prescribe too strong concave glasses for a myopic individual.

The Ophthalmoscopic Methods will be explained in detail further on (p. 443), and need only to be mentioned here.

Direct method at a distance.—The retinal vessels are visible and appear to move in the opposite direction to the motion of the observer's head.

Indirect method.—The optic disc appears to increase in size when the object lens is drawn away from the patient's eye.

Direct method.—The fundus and vessels are indistinct, and the lowest concave glass which makes them distinct is the measure of the myopia.

Retinoscopy.—With a *plane* mirror the shadow moves *against* the direction in which the mirror is rotated, provided the observer is farther from the patient's eye than the far point of the latter (p. 451).

The Amplitude of Accommodation in Myopia.—The myopic eye has an excess of refractive power (r) as compared with the emmetropic eye; therefore, in calculating its amplitude of accommodation, this excess must be subtracted from the positive refractive power (p), which would be required to adapt the emmetropic eye to the same punctum proximum; or, in other words, the myopic eye has need of less accommodative power than the emmetropic eye, because, even at rest, it is adapted for a distance (R., its punctum remotum) for which the emmetropic eye has to accommodate; hence in myopia

$$a = p - r.$$

For example: a myope of 4 D who can accommodate up to 11 cm. ($p = \frac{100}{11} = 9$ D) has an amplitude of accommodation of 9 − 4 = 5 D.

Range of Accommodation in Myopia.—In myopia both R. and P., and therefore the range of accommodation, are brought closer to the eye. The

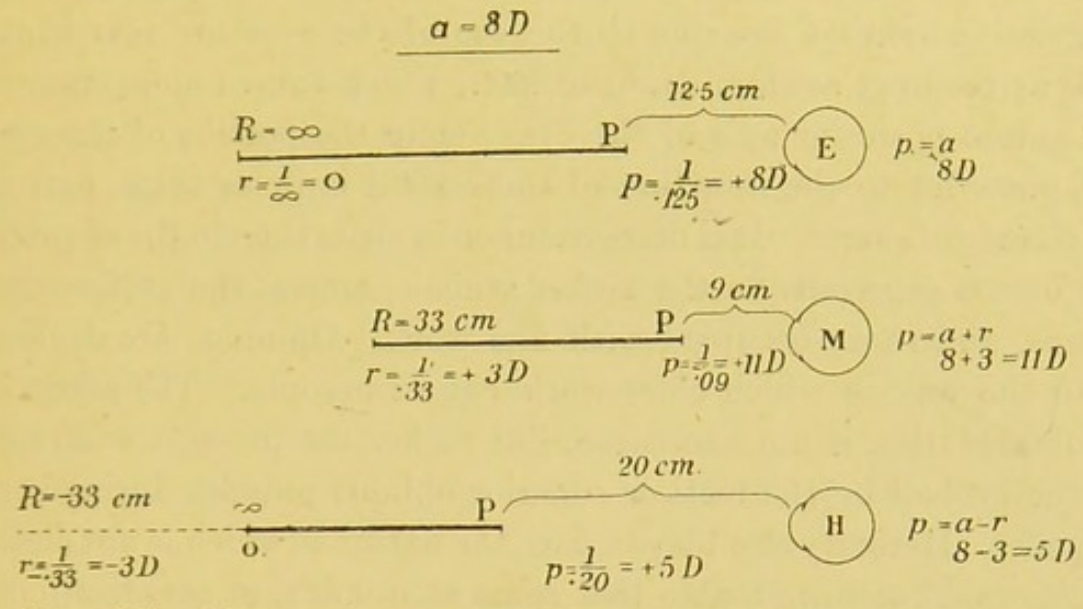


FIG. 135.—Range of accommodation in emmetropia (E.), in myopia (M.), and hypermetropia (H) of 3 D. each, the amplitude of accommodation in all cases being 8 D.

range is also shortened as can be seen from Fig. 135, which shows the range of Acc. with an amplitude of 8 D, in cm., and in M. and H. of 3 D respectively. In this case, R is known from the refraction ($R = \frac{1}{r} = \frac{1}{3} = 33$ cm.); it remains therefore only to determine P. We saw above that in M. $a = p - r$, therefore $p = a + r = 8 + 3 = 11$ D, and P. $= \frac{1}{p} = \frac{1}{11} = 9$ cm.

The Angle γ in Myopia.—In myopia, owing to the length of the eyeball, the cornea is cut closer to its centre by the visual line (M.V_I., Fig. 136) than in emmetropia; or, by displacement of the macular region the

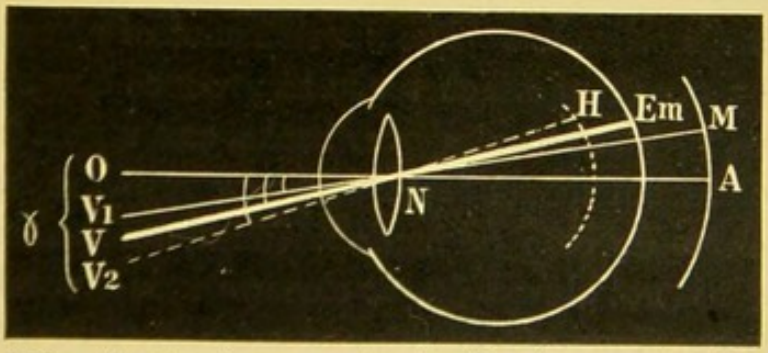


FIG. 136.—Angle γ in emmetropia (Em.), myopia (M.), and hypermetropia (H.).

visual line and the optic axis (A O) may coincide; or, the cornea may even be cut to the outside of its centre by the visual line. In any of these cases, but especially in the latter, the effect will be that of an apparent convergent strabismus.

Etiology.—Myopia is rarely congenital. Infants are hypermetropic, but as they grow older the eye tends to become less hypermetropic, or emmetropic, or even in some cases myopic. Myopia is almost wholly a result of civilisation, and its development and progressive increase are due to the use of the eyes for near work, such as reading, sewing, drawing, etc., which causes elongation of the antero-posterior axis of the eye. Only the portion of the eyeball posterior to the insertion of the orbital muscles takes part in the change of shape. It is more common in cities than in the country, and occurs especially in the higher schools, among the professional classes, and those occupied with fine work. Opinions are divided as to the way in which close work causes myopia. The effort of accommodation is not the cause, but rather the pressure exercised on the eyeball by the recti or superior oblique muscles during convergence. Heredity also plays a part, the nature of which is not clear; but it would seem probable that some anatomical or constitutional predisposition is transmitted from parent to offspring. Finally, the higher degrees of myopia are very constantly complicated with pathological changes at the posterior pole of the eye, called by some posterior sclero-chorioiditis, and regarded by them as inflammatory, while others attribute them to the mechanical distension of the coats of the eye, consequent on its elongation. How far this disease is either the consequence, or the cause, of the elongation of the globe has yet to be decided.

It should also be stated that anything which encourages approximation of objects to the eye such as defective print, bad light, or indistinctness of vision, *e.g.* astigmatism, and nebulæ of the cornea, may act as indirect causes. The development of myopia may also be assisted by anything which tends to produce congestion of the head and eyes, such as stooping over books, as a result, for instance, of badly constructed school desks. In rare instances, myopia has been observed to develop or increase considerably after a severe illness. That it is not always due to close work, is shown by the facts that high degrees of myopia are very occasionally met with in young children before they have begun to use their eyes much for near objects; and that the worst cases may sometimes be met with in agricultural labourers, who have done little or no close work.

Myopia, as a rule, first shows itself from the eighth to the fifteenth year, and is apt to increase, especially during the early years of

puberty. After this the majority of cases remain stationary, but others continue to increase during the whole lifetime, either periodically or continuously, and may reach 30 D or more.

Simple, or Non-Progressive Myopia.—In this variety the M. ceases to increase when the body has reached its full development, and does not, as a rule, go beyond three or four dioptres. The eye is perfectly sound and presents no disease of the fundus, except occasionally a slight crescent at the outer side of the optic disc (Plate IX. Fig. 1). This form of myopia is sometimes regarded as a harmless adaptation of the eye to the requirement of civilisation, and as being different in its etiology from the progressive form which is a true disease. Unfortunately it is not possible to distinguish with certainty one form from the other in the earliest stage. But if a patient of sixteen years of age or more, have a low degree of M., say only of 2 D or 3 D, and especially if there be no crescent, one may feel fairly confident that the M. will become stationary when the patient is fully grown. The points which guide one in the prognosis are the age of the patient compared with the amount of the M., and the appearance of the fundus.

Spasmodic Myopia—that is to say, M. due to spasm of accommodation—is a condition which is not uncommon, and one which is frequently seen, during the transition of H. or Em. into M. The M. disappears under atropine, only to return when the use of the latter is discontinued.

Symptoms of Myopia.—The symptoms of M., apart from the complications which occur in the high degrees, and which will be considered later on, are dependent on the optical error of the eye, and are very few. Distant vision is impaired according to the degree of M. present, but many short-sighted people half close their eyes in order to diminish the size of the diffusion circles on the retina, and they are thus enabled to see a little better. It is this habit which has given rise to the term myopia (p. 410). The smallest print can be distinguished with great facility, at or within the near point; and as the retinal images are larger than in emmetropia and consequently require less illumination for their perception, short-sighted persons are much given to reading in bad light. If the patient reads at his far point no accommodation is necessary, and for a nearer point the accommodation being less than in emmetropia,

one of the stimuli to convergence is deficient, and in some cases this leads to latent, or even to absolute divergence (see Insufficiency of Convergence, chap. xvi.).

The particles which normally float in the vitreous humour are rendered more noticeable by the larger shadows which they cast on the retina ; and this is one of the reasons why myopic people are so frequently troubled by black spots (muscæ volitantes) before their eyes. That short sight improves with age, or is the strongest kind of eye, is a fallacy which owes its origin to the absence or delayed onset of presbyopia in myopic people ; and also to the fact that, in low degrees of myopia, the vision may improve a little at a distance owing to the small size of the pupils in old people, or to the slight diminution in the refractive power of the lens which occurs at about sixty years of age (cf. Presbyopia).

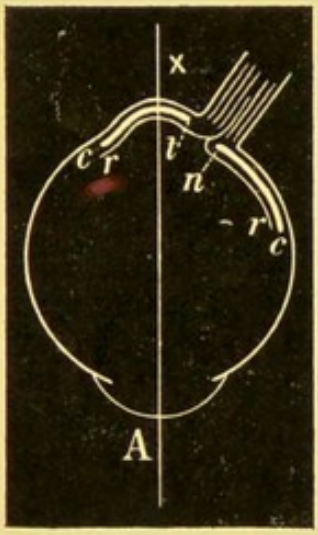


FIG. 137.—Explains formation of myopic crescent.

Progressive Myopia frequently becomes complicated with Organic Disease, and to the more serious cases the term **Pernicious Myopia** may be applied. The following are the forms of organic disease met with :

1. *Posterior Staphyloma, or Myopic Crescent.*—This condition is recognised by the ophthalmoscope as a more or less extensive white crescent at the outer circle of the optic papilla.

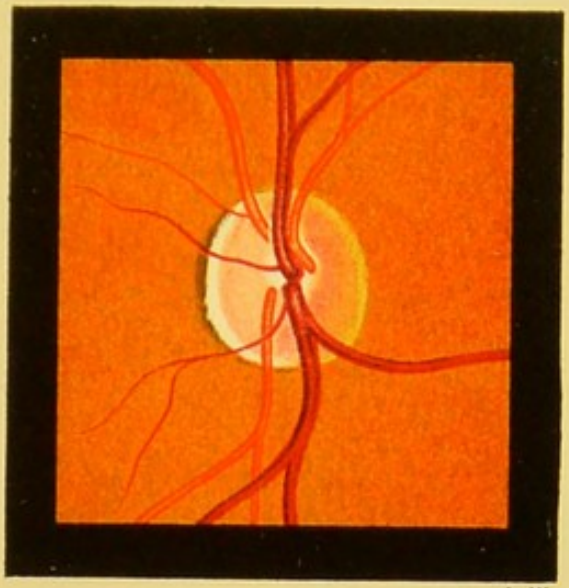
Fig. 137 explains the manner in which it arises. The bulging of the eyeball, at X, takes place at the posterior pole, in the direction of the axis A X. The chorioid *c* becomes drawn towards the temporal side, and the optic nerve appears to be displaced in the opposite direction. The chorioid is, consequently, drawn over the edge of the scleral opening at the nasal side at *n*, while it becomes detached and drawn away from it at the outer side at *t*, the portion of sclerotic thus exposed appearing as a white crescent at the temporal edge of the disc (Plate IX. Fig. 1). As the bulging increases, with increase of the myopia, it extends to the nasal side of the nerve as well, the chorioid also becoming atrophied ; and the posterior

PLATE IX

(*To face page* 418)

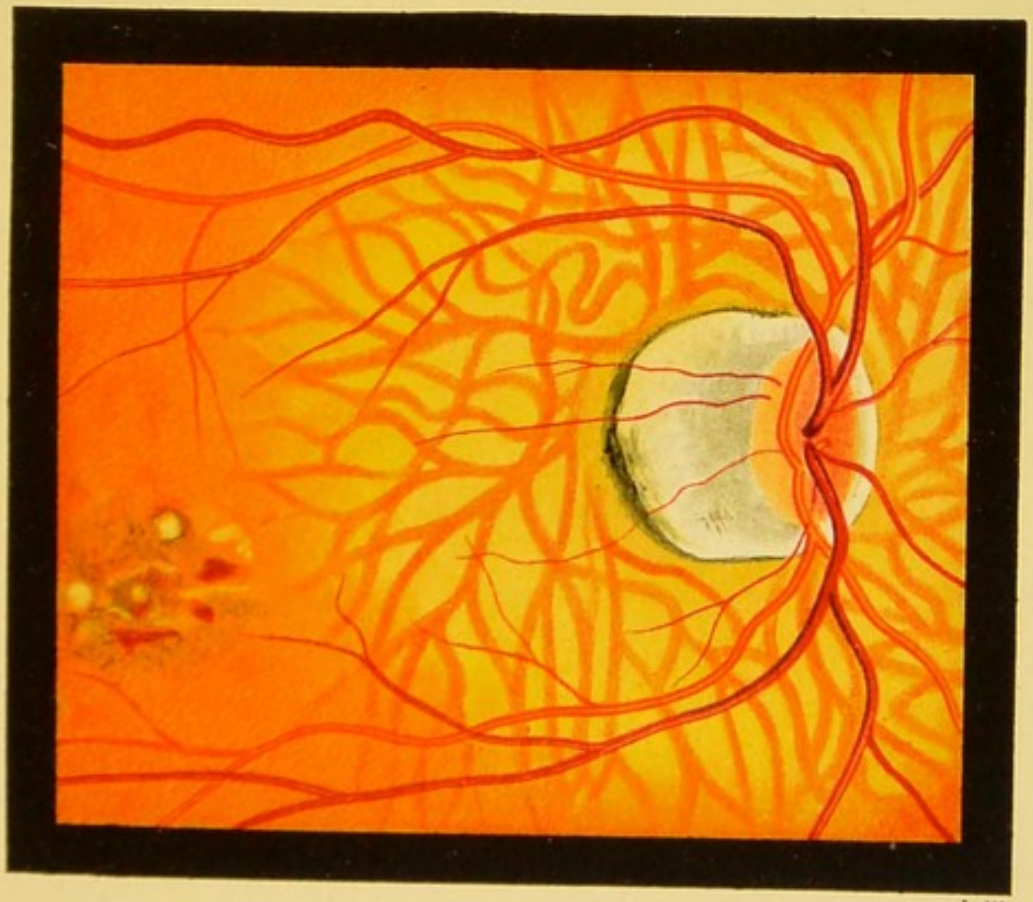
FIG. 1.—This represents a small myopic crescent in a case of myopia of 3·5 D. The crescent is white, and is situated on the temporal side of the disc.

FIG. 2.—Posterior staphyloma in myopia of high degree. The staphyloma surrounds the disc, but the larger portion of it is on the temporal side. The disc appears as a vertical oval. The chorioidal vessels have become visible in the neighbourhood of the disc, owing to atrophy of the pigment-epithelium. The macular region (to the left) shows evidences of disease, in the form of atrophic spots and lines, irregular pigmentation, and hæmorrhages.



L. W.

FIG. 1. Myopic Crescent.



L. W.

FIG. 2. Large Posterior Staphyloma.

staphyloma,[1] is then seen with the ophthalmoscope completely surrounding the disc, but always larger at the temporal side. The stretching of the retina may, in extreme cases, derange its functions and increase the size of the blind spot. The disc itself appears oval, owing to the oblique position, which the nerve head acquires (Plate IX. Fig. 2). The size of the staphyloma generally corresponds with the degree of M. although exceptions to this occur. Every case in which a small crescent is present is not to be regarded as serious; for much here depends on the age of the patient and the degree of the myopia. The younger the patient and the higher the myopia, the more serious is the outlook.

2. *Chorioidal Degeneration in the Neighbourhood of the Macula Lutea* (Plate IX. Fig. 2).—This should always be carefully looked for, as the region of the yellow spot is very liable to disease in the worst cases of progressive myopia. The disease seems to begin in the chorioid, giving the appearance of small cracks or fissures, which, at a later period, develop into a patch of chorioidal atrophy. The retina at the yellow spot becomes gradually disorganised, and very serious disturbance of vision, associated in the early stages with metamorphopsia, is the result, the patient being disabled from reading, although, as the periphery of the fundus is usually sound, he can find his way about freely. Treatment can do little here. Abstention from near work, and the wearing of dark glasses are to be recommended.

3. *Chorioidal Exudation in the Neighbourhood of the Macula Lutea.*—A small grey spot of exudation may appear in the chorioid at this place, accompanied by loss of sight for reading. These cases are often amenable to active mercurial treatment, when sight may be restored. Should the case be neglected or run a bad course, vision will be permanently damaged from secondary chorioidal degeneration.

4. *The Black Spot in Myopia.*—This disease also attacks the chorioid in the region of the yellow spot, and causes a loss of central

[1] Staphyloma in ophthalmology means a bulging of the coats of the eye (see anterior staphyloma, p. 175). In myopia the area of atrophy, called above posterior staphyloma, is smaller than the real area of distension of the back of the eye. This is apparent in Fig. 137. The edge of this true posterior staphyloma can sometimes be seen with the ophthalmoscope, the retinal vessels suddenly dipping in over it.

vision, as in the two previous forms of disease. The appearance shown by the ophthalmoscope is that of a black spot, usually quite circular and with a defined margin. In the early stages its size is much smaller than that of the papilla, but later it often attains a dimension of two papilla diameters, or more. The spot is rarely of an equal intensity of blackness all over, but towards its centre a faint reddish hue often shines through in places. At a later stage the black spot becomes surrounded by a narrow whitish border, while towards its centre it becomes less black, and finally greyish or even white, its margin remaining black. Although small hæmorrhages, which often occur in the neighbourhood of the black spot, gave rise to the opinion that the black spot itself was the result of hæmorrhage, yet this seems not to be so, as the investigations of E. Lehmus have shown. The disease consists in a proliferation of the pigment epithelium, combined with a gelatinous exudation, which in the case examined had attained a thickness, at the centre of the black spot, of two-thirds that of the chorioid. The chorioid was but very slightly altered, and the glass membrane was quite normal. At the margin of the proliferating region the pigment epithelium was found to be paler or even quite free from pigment. The black spot very gradually, in the course of years, attains its ultimate dimension, and then very slowly retrogresses, until finally its place is taken by a greyish or bluish-white scar. Treatment is of no avail, and central vision does not become restored.

5. *General Chorioidal Atrophy.*—In advanced cases of pernicious myopia, large patches of chorioidal atrophy, other than the crescent, are often present, chiefly in the region of the posterior pole, but often also towards the periphery of the fundus. The vitreous humour in these cases is more fluid than normal, and usually contains many opacities. Treatment by means of sub-conjunctival saline injections is occasionally of use in clearing up the vitreous humour, and thus effects some improvement of vision. The eyes should not be used for near work, and dark glasses should be worn.

6. *Hæmorrhage in the Retina at the Yellow Spot* may occur, and when the hæmorrhage becomes absorbed the macula lutea may not recover its function, owing to the delicate retinal tissue having been seriously damaged. Yet we often meet with cases of this kind which do regain their former vision. Rest of the eyes and dark glasses should be prescribed.

7. *Detachment of the Retina.*—This is a frequent, and most serious complication of progressive myopia, and sometimes leads to secondary cataract and even to shrinking of the eyeball (Phthisis Bulbi). It has been considered in the chapter on Diseases of the Retina.

In high degrees of M. the eyes are unduly prominent, and the sclerotic appears flatter at the sides; the pupils are usually large and the anterior chamber deep, owing to the slight development of the ciliary muscle in consequence of the non-use of accommodation.

Functional Anomalies attending Progressive Myopia.—

(*a*) *Insufficiency of Convergence* is almost always associated with progressive myopia, and is the result of two causes, namely the diminished impulse to convergence produced by the absence of accommodation, and the mechanical difficulty introduced by the elongation of the eyes. The insufficiency of convergence may be only latent, or it may lead passively to absolute divergent strabismus (chap. xvi.).

(*b*) *Cramp of Accommodation* is often present and causes an apparent increase in the Myopia (p. 417).

The Management of Myopia.—In view of the tendency to increase, to which, especially during adolescence, nearly every case of short-sight is liable, and of the fact that in a given case we cannot tell to what extent this increase may go, and, finally, as the high degrees almost invariably lead to disease of the eye, the management of myopia, including the prescribing of glasses for it, is one of the most important matters with which we have to deal.

The Prescribing of Glasses in Myopia.—It is not necessary to prescribe glasses for very slight degrees of myopia (up to 1·0 D or 1·5 D); yet, should the patient desire to wear correcting glasses for distant objects, there can be no objection to it. But for cases of myopia of 2·0 D or more, unless presbyopia be also present, it becomes very desirable to prescribe glasses which fully correct the myopia, to be worn constantly—*i.e.* for both distant and near objects; and, should the myopia increase, to accordingly increase from time to time the strength of the glasses.

We now know, on the one hand, that the action of the muscle of accommodation does not produce a pull on the chorioid farther back than the equator of the eyeball, while on the other hand it is at the posterior pole that the diseased processes in myopia commence. Nor does the ciliary muscle by raising the tension of the

eye, nor in any other way, cause an elongation of the eyeball. Hence, there is no reason to spare the healthy myopic eye any ordinary effort of accommodation. Indeed, it is reasonable to think that if normal efforts be required of the ciliary muscle, its more healthy tone will improve the general healthy nutrition of the uveal tract, and consequently will tend rather to avert morbid changes in it.

On the other hand, the diminution of the angle of convergence at near work is a truly important matter, for the reason above stated ; but it is more effectually provided for by full than by partial correction.

Practical experience is here even more valuable than theory, and it shows that in a large majority of those patients whose short-sight has been fully corrected in youth, and who have worn their spectacles constantly for a number of years, the myopia in many instances has not increased at all, while in a large proportion the increase will have been moderate, and in but a small proportion marked pernicious progress will be noted. In short, the tendency to increase of the myopia, and to organic disease, is less than in those myopes who have either worn no glasses, or but partially correcting glasses.

Well-fitting, properly centred spectacles are much to be preferred to folders, which are difficult to keep correctly centred before the eyes. Any astigmatism present should always be corrected. Patients whose eyes are healthy, and who wear constant full correction, may be permitted, and even encouraged, to use their eyes freely for near work, always keeping the work as far from the eyes as possible, to diminish the angle of convergence. With this latter object in view, too, well-printed books, ample light, and suitable reading- and writing-desks should be provided in all educational establishments, and for home studies.

But in prescribing the full correction for constant wear to young short-sighted persons, we meet with some difficulties. The first of these is due to the range of accommodation, which is imperfect in the myopic eye, and consequently the patients may complain of painful accommodative sensations when first using their fully correcting lenses for near work, and sometimes they decline to persist in the attempt. These complaints are more likely to be made by patients of about twenty years of age or more, whose habit of use of

their eyes (relative amplitude of accommodation, and degree of convergence) has become more or less confirmed, and in whom the power of accommodation has naturally diminished to an appreciable degree. Patients should be encouraged, in spite of discomfort, to continue for some time longer to read, etc., with the full correction, when, very often, the relative amplitude of accommodation will gradually improve, and the discomfort will cease. Or, a lower number than the full correction may be ordered, and the strength gradually increased, until, in the course of some weeks or more, the full correction can be worn for near work with ease.

Myopic persons of middle age and over, who have never worn the full correction, will rarely tolerate it.

Operative Cure of Myopia.—This consists in diminishing the refraction of the eye by the removal of the crystalline lens. Some surgeons simply extract the clear lens, while the majority now, including the authors, perform discission, followed, in a few days, by the evacuation of the swollen and cataractous lens, and in some cases by a subsequent capsulotomy. A larger number of operations than this is apt to be injurious; moreover, the swollen lens should be removed before the tension of the eye becomes increased. For both of these reasons, therefore, simple discission without extraction is inferior to the other method. There are grounds for suspecting that, in these highly myopic eyes, the tendency to retinal detachment is increased by the operation, although this has not been shown by statistics.

The operative cure of myopia is not to be recommended except for cases of 15 D and more; nor should it be performed where there is such serious disease of the fundus or vitreous humour as would render any improved use of the eye on conclusion of the treatment unlikely. Active chorioidal disease is regarded as a contra-indication, but small retinal hæmorrhages, even if they be near the macula lutea, need not be so regarded. The best time of life for the cure is in childhood or in early youth, but it can be successfully undertaken at a much later period. In the myopic eye the nucleus of the lens undergoes sclerosis to a less extent than in hypermetropia or in emmetropia, and hence in it discission is less apt to be followed by high tension or other complication, even when performed in middle age.

The advantages gained by the patients from the operative cure of their myopia are very great. Not merely do they become sometimes emmetropic, but the acuteness of vision is usually increased in a remarkable degree, being occasionally even double or treble that which previously existed with the correcting glasses. This improvement is chiefly due to the increased size of the retinal images. The reduction in the refraction is much greater in these cases, than after removal of the lens for cataract in an emmetropic eye. In the latter case a convex lens of 10 D is required to correct the eye for distance, whereas a myope of 20 D most commonly

requires no correction for distance after the removal of his lens. The explanation of this is simple. When the lens is removed, the only refracting surface then is the cornea, the focal length of which is approximately 31 mm. ; a myopic eye therefore which is 31 mm. long would, when deprived of its lens, bring parallel rays to a focus on the retina and would require no correction for distance. Since the average focal length of the emmetropic eye is 24 mm. this myopic eye would be 31 — 24 = 7 mm. longer than the emmetropic eye. Now it can be easily shown that, in the complete eye containing the lens, every millimetre of increase in length corresponds with an increase of 3 D of refraction, consequently in this case before operation, when the lens was present, the refraction would have been increased by 3 × 7 = 21 D, a result which agrees in most cases with practice.

In the absence of the lens an increase of 1 mm. in length of the eyeball only augments the refraction of about 1·5 D, that is to say, only half the amount which the same increase of length produces in the complete eye. A simple rule, therefore, for finding approximately what the refraction will be, after removal of the lens, in a given case of myopia, is to take half the number of dioptres of the myopia and subtract it from 10. If the result be positive a plus lens will be required after operation, and if negative a concave lens. For example, a myope of 10 D will require a + 5 D for correction after operation, $10-\frac{10}{2} = 5$, and a myope of 30 D will remain with 5 D of myopia, $10 - \frac{30}{2} = -5$. In practice cases sometimes occur which do not fall in with this theory, and for this there are reasons which cannot be fully entered into here, but amongst them is the difficulty of an exact estimation of the refraction in high M. and the possibility of the M. being not merely axial, but also caused by shortening of the focal length of the dioptric system.

The mere possibility that detachment of the retina may be caused, or hastened, by the operation is a sufficient reason for limiting the operation to one eye. It is wiser not to operate on the second eye, even though a successful result may have been obtained in the first, and though the patient, as often happens, may desire the operation. The eye which has been operated upon will serve for distant vision and its fellow for near work, and thus, where the eye after operation becomes emmetropic, the patient is rendered independent of glasses. It has not been proved that removal of the lens arrests the progress of myopia. Many ophthalmologists do not now regard this operation with favour, but we employ it for selected cases, in one eye only.

Hypermetropia.

Definition, and Optical Causes.—In Hypermetropia the retina lies in front of the principal focus of the dioptric system, and therefore parallel rays of light (*a*, *b*, Fig. 138), falling into the hypermetropic eye (*E*), do not meet on the retina but converge towards a point (*c*) situated behind it. As compared with emmetropia the refraction

of a hypermetropic eye is diminished. It may be caused by displacement of the retina forwards, from shortening of the eyeball (Axial H.), or by elongation of the focal length of the dioptric system

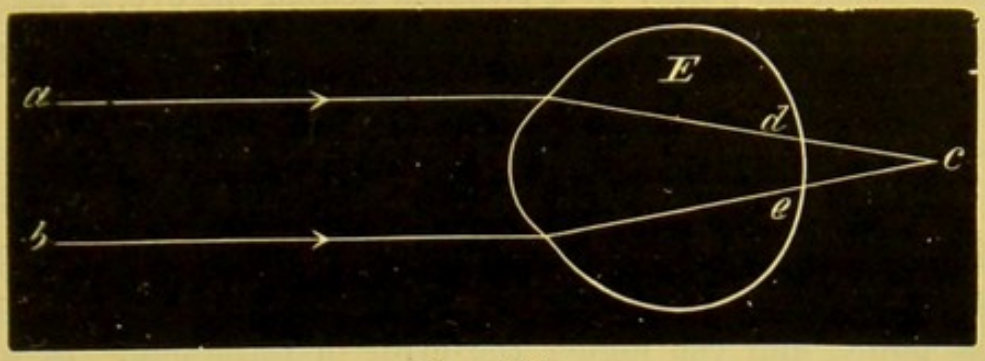


FIG. 138.

through flattening of the cornea (Curvature H.), absence of the lens (dislocation, cataract extraction), or diminution of the refractive index of the lens in old age (senile hypermetropia).

Far Point (R.) of the Hypermetropic Eye.—Since parallel rays do not unite on the retina, but produce there a circle of diffusion (*d*, *e*, Fig. 138), the hypermetropic eye cannot see distant objects distinctly, and if an object be brought closer, its focus will lie still farther behind the retina (§ 17, chap. xiv.). There is therefore no position between infinity and the cornea, from which rays of light would unite on the retina of the hypermetropic eye ; in other words, there is no real far point. What kind of rays then do come to a focus on the retina of a hypermetropic eye ? The answer will be found by considering the course of the rays emerging from the eye. Since

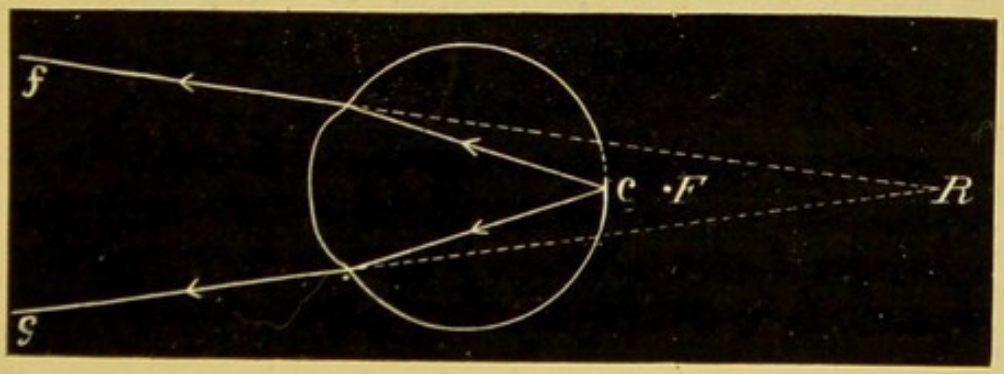


FIG. 139.

the refraction is deficient or, what is the same thing, since the retina lies in front of the principal focus F. Fig. 139 (§ 18, chap. xiv.), rays coming from any point (*c*), will not even be rendered parallel, but will pass out as divergent rays (*f*, *g*), and they can therefore never

meet to form a real conjugate focus, or far point. But they will diverge as if they came from a point R, situated behind the eye, which point is the virtual conjugate focus of the point *c* on the retina. R is the virtual far point. It is situated behind the eye, is negative, and cannot be measured directly as in myopia. Conversely, if the rays *f*, *g*, enter the eye with a convergence towards R, they will unite on the retina. The hypermetropic eye therefore is only adapted, when at rest, for convergent rays. The shorter the eyeball, the farther the retina is from F, and the greater the divergence of the emerging rays, and consequently the shorter will be the distance of the far point, and the higher the error of refraction. In hypermetropia, as in myopia, $r = \frac{1}{R}$, but here R is negative, and therefore *r*, the error of refraction, is also a negative quantity.

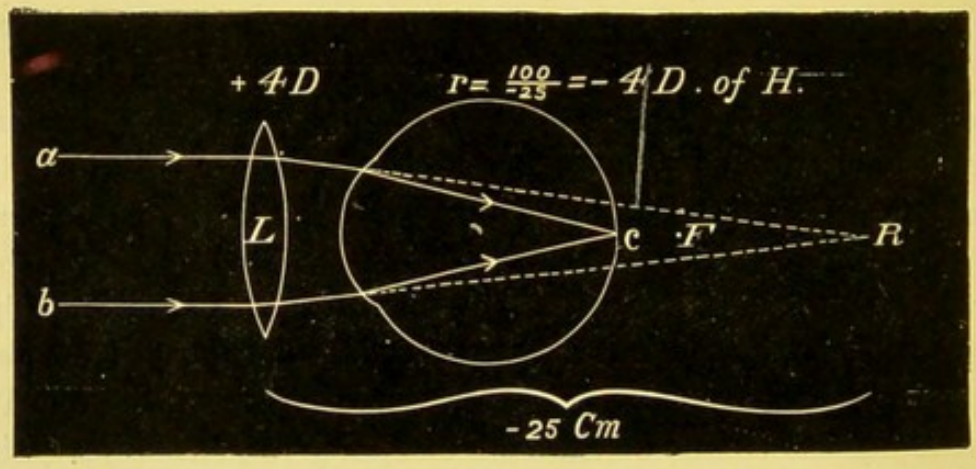


FIG. 140.—Correction of hypermetropia. R = far point, *r* = error of refraction.

Optical Correction of Hypermetropia.—In order to correct hypermetropia—that is, to render the eye emmetropic, so that parallel rays may be brought to a focus on the retina (*c*, Fig. 140)—a lens must be placed in front of the eye, which will give to the parallel rays (*a*, *b*) before they enter it a convergence towards its far point, R. This lens must therefore be a converging or + lens, and its focal length must be equal to the distance of R from the eye (in this case 25 cm.). The negative error, or deficiency in the refraction, is corrected by a + lens (L), which increases the refraction, and thereby shortens the focal length of the eye so as to bring the focus on to the retina. The shorter the antero-posterior axis

of the eyeball, the closer is R, and the shorter therefore must be the focal length of the correcting lens. That is to say, the correcting lens must be stronger, and the hypermetropia consequently greater, when the eye is shorter.

It is evident that the farther the lens (L) is from the cornea the greater is its distance from R, and therefore the weaker the lens which is required. This is the reverse of what takes place in myopia (p. 413).

Hypermetropia can also be corrected by an effort of accommodation, in which the increased convexity of the crystalline lens within the eye takes the place of the correcting glass. In the case represented by Fig. 140, an accommodation equivalent to 4 D would be required.

Determination of the Degree of H. SUBJECTIVE METHOD BY TRIAL-LENSES AND TEST-TYPES.—Since accommodation tends to correct hypermetropia, care must be taken in drawing conclusions from this method of examination. If the acuteness of vision be improved by a convex lens, H. is present, but it may be found that, with a lens of some dioptres less, the eye will see equally well; this means that an effort of accommodation supplements the weaker lens placed before the eye. As higher lenses are proceeded to, the effort of accommodation is relaxed, until, finally, the strongest lens with which vision is still at its best is reached, when, it may for the present be assumed, no further effort of accommodation is made, and this lens then represents the whole error of refraction.

In low degrees of hypermetropia, accommodation frequently corrects the whole of the H. When such an eye is found to have full vision without a glass, a beginner may fall into the error of regarding it as emmetropic; but if he take the precaution of placing a low convex lens in front of it, and then finds that the acuteness of vision remains as good as without the glass (because the effort of accommodation is now relaxed), he will avoid this mistake, unless there should be tonic cramp of accommodation, which might partially, or even completely, mask the hypermetropia.

If a glass a single number higher than the exact measure of the defect be placed before the eye, vision again becomes indistinct, because the rays are then brought to a focus in front of the retina, and a circle of diffusion is formed on the latter. The eye, in fact, is put by such a glass in a condition of myopia. Therefore *the*

strongest convex glass with which a hypermetropic eye can see distant objects (the test-types) most distinctly is the glass which corrects its hypermetropia, and is the measure of the latter. Very commonly it is only the manifest hypermetropia (*vide infra*) which is ascertained by this method, unless the accommodation has been previously paralysed by atropine.

OBJECTIVE, OR OPHTHALMOSCOPIC METHODS. *Direct Method at a Distance.*—The retinal vessels are visible, and appear to move in the same direction as the motion of the observer's head.

Indirect Method.—The optic disc appears to diminish in size as the lens is withdrawn from the patient's eye.

Direct Method.—The strongest convex glass with which the fundus and vessels can be seen distinctly is the measure of the H.

Retinoscopy.—With a *plane* mirror the shadow moves in the same direction as that in which the mirror is rotated, that is to say, *with* the mirror.

Amplitude of Accommodation in Hypermetropia.—When at rest the refraction of the hypermetropic eye is deficient, consequently r must be negative ($-r$), and the amplitude of accommodation must include the correction required to adapt the eye to infinity; therefore the formula for the amplitude of accommodation (p. 7) becomes

$$a = p - (-r) = p + r.$$

For example: if the punctum proximum of a hypermetropic eye of 5 D be at 30 cm., what is the amplitude of accommodation? 5 D ($= r$) is necessary in order to make the eye emmetropic, and to accommodate the emmetropic eye to 30 cm. 3·25 D ($\frac{100}{30} = 3{\cdot}25$) is required. Hence $a = 3{\cdot}25 + 5 = 8{\cdot}25$ D.

Range of Accommodation in H.—In hypermetropia a part of the patient's amplitude of accommodation is used to correct the error of refraction, the remainder only being available for the purpose of adapting the eye for a near point. It follows, therefore, that, with the same amplitude of accommodation as an emmetrope, the near point will be farther away from the eye in hypermetropia. This is shown in Fig. 135, which represents the ranges of accommodation in emmetropia (E.), myopia of 3 D (M.), and hypermetropia of 3 D (H.), the amplitude being 8 D.

The Angle γ in Hypermetropia.—In hypermetropia, as in emmetropia, the cornea is cut to the inside of its axis by the visual line; but in hypermetropia the angle which the visual line forms with the optic axis is greater, owing to the shortness of the eyeball, the effect of which is to increase the angular distance between the macula lutea and the optic axis (*O A*, Fig. 136). Consequently, in extreme cases, when the two visual lines of a hypermetropic individual are directed to an object, the axes of the corneæ may seem to diverge, and thus the appearance of a divergent strabismus will be given (see apparent strabismus, chap. xviii.).

Varieties of H. in Relation to Accommodation.—Hypermetropes endeavour to correct as much of the error of refraction as possible by accommodating, and the ciliary muscle is thus kept persistently contracted even though the visual axes remain parallel.

In young persons this spasm is not, or may be only partially, relaxed when the correcting convex glass is held before the eye, and consequently the whole or part of the hypermetropia may be masked by the cramp. That part of the hypermetropia which is thus masked is called latent (Hl.), while the part which is revealed by the convex glass with which the test-types are read is called manifest (Hm.). The entire hypermetropia is made up of the latent and manifest H. (H. = Hm. + Hl.).

If the Hm. cannot be corrected by accommodation it is called absolute H., if it can be so corrected it is known as facultative. For example, a patient without glasses has V = $\frac{6}{18}$, and with + 1·5 D, V = $\frac{6}{6}$; with 2·5 D also, V = $\frac{6}{6}$, but when accommodation is paralysed the H. is found to be 4 D. In this case the total H. is 4 D, the Hm. is 2·5 D, of which 1·5 D is absolute and 1 D facultative, while there is 1·5 D latent H. The relation between the Hm. and H. varies with the age and general health of the individual.

When the spasm persists so that the accommodation cannot be relaxed, the vision is then made worse, even by a weak convex glass, thus simulating emmetropia. We then say that the whole hypermetropia is latent. Or, in extreme cases of accommodative spasm, parallel rays may be united in front of the retina, and the eye made apparently myopic, distant vision being actually capable of improvement by concave glasses. Some of these patients cannot maintain a sustained view of an object at any distance without suffering pain in and about the eyes. Examination with the ophthalmoscope, or paralysis of accommodation with atropine, will enable the surgeon to avoid mistakes.

In order to relieve this cramp, or to ascertain the real state of the refraction, especially in children, atropine must be freely instilled; and it will often be necessary to keep the accommodation paralysed for some days, and to commence the use of the correcting spectacles before the effect of the atropine begins to wear off. In this way a recurrence of the spasm may be often prevented.

As life advances, and the power of accommodation diminishes,

the manifest part of the hypermetropia increases, while the latent part decreases, until finally Hm. = H.

Etiology.—Typical hypermetropia is practically always axial—*i.e.* due to a short eyeball. Children are hypermetropic at birth, but with growth of the body the eye develops and becomes less hypermetropic, or emmetropic, or even myopic. So that the hypermetropic eye may be regarded as an undeveloped organ, and indeed the highest degrees of H. are met with in very small (microphthalmic) eyes, which are often the subjects of congenital malformations. The eyes of animals and of uncivilised nations are hypermetropic. When the period of growth ceases, any H. which may then exist remains stationary. There is never any progress, as in myopia; and very high degrees are rarely seen, even 12 D being unusual. Hypermetropic eyes are moreover healthy, and free from the complications which follow mechanically from the change in shape of the myopic eye.

Symptoms and Signs of H.—These depend chiefly on the relation of the H. to the amplitude of accommodation, and will be understood from what has been already stated. Both distant and near vision may be perfect, or near vision alone may be defective, or both may be imperfect. In high degrees of H. patients sometimes hold the book close to the eyes in order to obtain larger retinal images, but they cannot read the smallest type with the ease and fluency of the myope. Even with correction, vision is often defective in these cases, more especially if astigmatism be present in addition to the H. Slight redness and veiling of the edges of the optic disc with tortuosity of the retinal vessels is sometimes seen, and must not be mistaken for optic neuritis. The normal appearance of the retina known as "shot silk" is better marked and of more frequent occurrence in young hypermetropes than in other conditions of refraction. Hypermetropic eyes show increased curvature of the sclerotic at the outer side, when the eye is rotated inwards, the pupils are smaller than in Em., and the anterior chamber is shallow. Other consequences are accommodative asthenopia, and convergent strabismus.

Accommodative Asthenopia (*ἀ, priv.; σθένος, strength; ὤψ*).—This is the name given to the group of symptoms which occur when the patient is unable to sustain the accommodative effort required for near vision. A hypermetrope, having used up part of his ac-

commodation for distance, has for near objects actually less at his disposition than an emmetrope. Hence, hypermetropic people often complain of inability to sustain accommodative efforts for near objects for any length of time. After reading, sewing, etc., for a short time, sensations of pressure in the eyes, of weight above and around them, and more or less pains in the brow and temples, come on, and the words or stitches become indistinct, and cannot be distinguished, and the efforts to see are attended with lacrimation, frowning, and even with facial contortions. The work must then be interrupted, and after a few minutes' rest it can be resumed, but must soon again be given up. After a Sunday's rest the patient is often able to get on better than on the previous Saturday. These symptoms depend simply upon inability of the ciliary muscle to answer to the excessive demands made upon it.

Accommodative asthenopia often appears suddenly during or after illness, the explanation being that, although hypermetropia had always existed, yet in health the ciliary muscle was equal to the great efforts required of it, but in sickness it shared the debility of the system in general.

Internal, or **Convergent Concomitant Strabismus.**—This condition has a certain relation to hypermetropia. It will be treated of in the chapter on the Motions of the Eyeballs and their Derangements (chap. xvi.).

The Prescribing of Spectacles in Hypermetropia.—If a person be found to be hypermetropic, but his acuteness of vision without glasses be good, or as good as he desires, and he complain of no asthenopic symptoms, glasses need not, indeed should not, be prescribed for him. No harm will come to his eye from his going without glasses.

If the patient complain of imperfect distant vision due to hypermetropia, then those lenses which correct the Hm. may be prescribed for distant vision, to be worn either constantly or occasionally, as he may desire. Such a patient is almost certain to complain also of accommodative asthenopia; while many patients will be met with who complain of the latter, yet express themselves as perfectly satisfied with their distant vision. For relief of their asthenopia it is usually enough to prescribe spectacles for near work which will correct the Hm., along with 1 D or 2 D of the Hl., if the latter exist.

If there be excessive cramp of accommodation, or strabismus, glasses to correct the whole hypermetropia should be worn while the eye is under atropine; and afterwards as much of the Hl. as possible, along with the Hm., should be corrected by glasses to be worn constantly.

Astigmatism.

In this form of ametropia the refracting surfaces are not spherical, and consequently, rays of light from a luminous point are not brought to one focus. The defect usually lies in the cornea, and the astigmatism may be regular or irregular.

In *Regular Astigmatism*, which is congenital, the directions of the greatest and least curvatures of the cornea are always at right angles to each other, and usually fall precisely in the vertical and horizontal meridians, the meridian of greatest curvature being

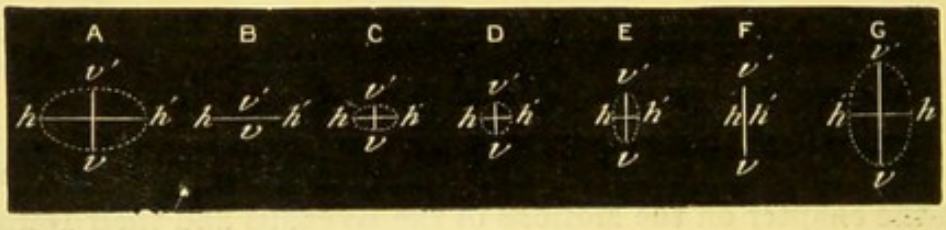


Fig. 141.

most frequently the vertical. The surface of the cornea then resembles the back of the bowl of a spoon, which is more convex from side to side than from heel to point. Astigmatism is said to be "with the rule" when the meridian of greatest curvature is vertical, and "against the rule" when this meridian is horizontal. Hence a pencil of rays passing into the eye, instead of meeting at a common focus, is refracted in such a way that the rays passing through the vertical meridian of the cornea are brought to a focus much earlier than those which fall through its horizontal meridian.

Fig. 141 shows the different forms which the image of a point assumes after the passage of the rays through an astigmatic surface.

At A neither vertical (v v') nor horizontal (h h') rays have yet been united at their foci, but the vertical rays are the nearest to their focus; and therefore here the appearance of the image on an intercepting screen, is an oval with its long axis horizontal, as shown

by the dotted line. At B the vertical rays have met at their focus, but the horizontal rays not as yet at theirs, the effect being a horizontal straight line. At C the vertical rays are diverging again from their focus, and the horizontal rays have not come to theirs. At D the same conditions exist, only a little farther on, where one set of rays is diverging, the other still converging, but each at the same angle; hence the figure is a circle. At F the horizontal rays have met, and the result is a vertical straight line. At G both sets of rays are divergent, and the figure is an oval with the long axis perpendicular. An astigmatic eye has, therefore, two foci, each being represented by a line, and not by a point. The interval between the foci of the two principal meridians (B and F, Fig. 141) is called the Focal Interval and is a measure of the astigmatism.

There are various kinds of regular astigmatism, according to the position of the two principal foci with reference to the retina, as follows:—

1. *Compound Hypermetropic Astigmatism.*—Both foci behind the

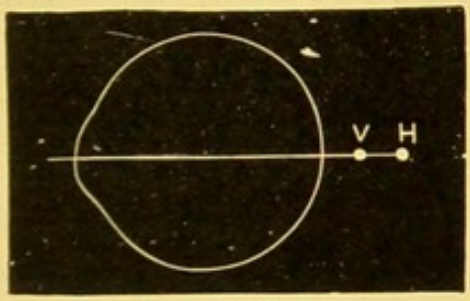


FIG. 142.

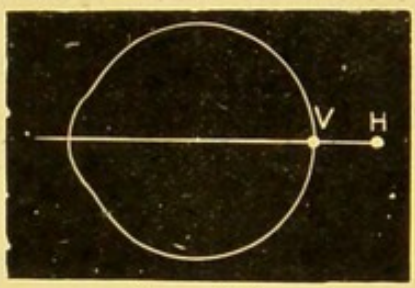


FIG. 143.

retina, that of the horizontal rays (H, Fig. 142) farther back than that (V) of the vertical rays. Hypermetropia in both meridians, but greater in the horizontal.

2. *Simple Hypermetropic Astigmatism.*—The focus of the vertical rays (V, Fig. 143) on the retina (emmetropia in that meridian); that of the horizontal rays (H) behind the retina (hypermetropia in that meridian).

3. *Mixed Astigmatism.*—The horizontal focus (H, Fig. 144) behind the retina (hypermetropia in that meridian), and the vertical focus (V) in front of the retina (myopia in that meridian).

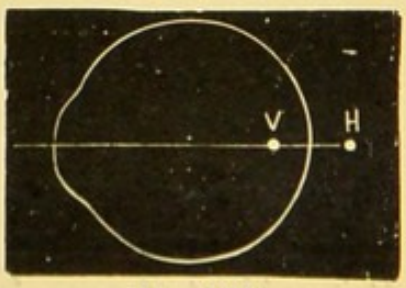


FIG. 144.

4. *Simple Myopic Astigmatism.*—The

horizontal focus (H, Fig. 145) on the retina (emmetropia in that meridian), the vertical focus (V) in front of the retina (myopia).

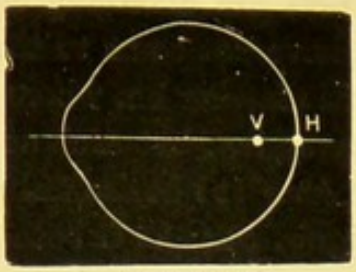


FIG. 145.

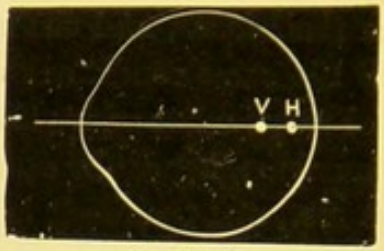


FIG. 146.

5. *Compound Myopic Astigmatism.*—Both foci in front of the retina, but the vertical focus farther forward (V, Fig. 146).

Symptoms of Regular Astigmatism.—We may conclude that an individual is astigmatic if he see horizontal (or vertical) lines, such as the horizontal portions of Roman capital letters, or the horizontal lines in music, or the horizontal rays in Snellen's Sunrise figure (see end of this book) distinctly, while the vertical (or horizontal) lines seem indistinct. Patients seldom, however, complain of this peculiarity in their vision.

To explain the perception of lines by an astigmatic eye, let us suppose an eye to be emmetropic in the vertical meridian, and ametropic in the horizontal meridian; we must first consider how a point will be seen by such an eye. The rays of light emitted from the point and passing through the horizontal meridian will not be brought to a focus on the retina, but will produce a blurring of the retinal image of the point at each side; while the vertical rays will unite on the retina, and consequently the point will appear distinctly defined above and below.

Now, a line may be regarded as a number of points, and it is

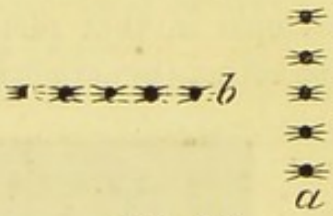


FIG. 147.

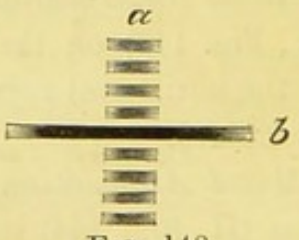


FIG. 148.

only necessary therefore to arrange a number of points, blurred at the sides, in horizontal and vertical lines—as at *a* and *b* in Fig. 147. It is evident at once, from mere inspection, that the horizontal line

will appear distinct, because the rays which diverge from each point of the latter in a vertical plane—*i.e.* at right angles to the direction of the line—are brought to a focus on the retina ; while those rays diverging in a horizontal plane, although not meeting on the retina, do not render the picture of the line indistinct, because the diffusion images resulting from them exist in the horizontal direction, and consequently cover or overlap each other on the line, and therefore are not seen, and do not confuse the sight. At the ends of the line only (*b*, Fig. 148) do the diffusion images cause a fuzziness or make the line seem longer than it is. In this case a vertical line (*a*, Figs. 147 and 148) seems indistinct, because, the horizontal meridian being out of the focus, the diffusion images existing in that direction are very apparent, as they are at right angles to the edge of the line. On the other hand, in order to see a vertical stripe accurately, it is necessary only that the rays diverging in a horizontal plane should have their focus on the retina ; and, therefore, if an individual can only see vertical lines distinctly at 6 metres we know that his eye is emmetropic in the horizontal meridian (and probably myopic in the vertical meridian). We do not, however, hear this complaint as often as might be expected, because simple astigmatism is not so common as one or other of the compound forms.

Astigmatic people do not generally see very distinctly, either at long or at short distances.

Even in hypermetropic astigmatism the book is very often brought close to the eyes, in order, by increasing the size of the retinal image, to make up for its indistinctness.

Astigmatic individuals frequently suffer much from headache, and sometimes from regular attacks of migraine with sickness, due to constant effort to see distinctly, and correction of the astigmatism often effects a cure.

It has been stated that epilepsy, hysteria, and neurasthenia, if not capable of being actually produced by refractive errors, especially by astigmatism, in persons with stable brains, may sometimes have such errors as their exciting cause, where there is already a predisposition to the disease.

All these signs and symptoms appertain to the rather high degrees of astigmatism. Slight degrees may cause no annoyance beyond some indistinctness of vision ; and indeed slight degrees of hypermetropic astigmatism often pass unnoticed until late in life,

when the accommodation begins to fail. But very low degrees of astigmatism may give rise to symptoms in neurotic individuals. The forms of Astigmatism most likely to cause annoyance are those contrary to rule or with the axis obliquely placed.

We are often led to suspect and to seek for astigmatism when, in examining the refraction with spherical glasses, we are able to bring about some improvement of vision, but cannot obtain normal V. with any glass, while there is no organic disease to account for the defect. Also if, in examining with spherical glasses, we find V. benefited equally by several glasses of considerable difference in power, even perhaps by convex as well as by concave glasses.

The ophthalmoscope affords an admirable means of diagnosing astigmatism, and of determining its amount. Just as the astigmatic eye cannot see horizontal and vertical lines equally well at the same moment, so is an observer unable to see both the vertical and horizontal vessels in the retina of the astigmatic eye simultaneously, but must alter his accommodation to be able to see first one set of vessels and then the other.

A comparison of the shape of the optic papilla, as seen in the upright and in the inverted images, may also give a clue to the presence of astigmatism. Inasmuch as the fundus oculi is very much magnified in the upright image by the dioptric media through which it is seen, and as this enlargement is greater in the direction of the meridian of shortest focus (meridian of highest refraction), which is most commonly the vertical meridian, a circular object, such as the papilla, will seem to be of an oval shape with its long axis vertical. But in the inverted image, if the principal focus of the lens be closer to the eye than 13 mm. (anterior focus of the eye), the magnification will be less in the meridian of greatest refraction ; and here, consequently, the round optic papilla is seen as an oval with its long axis horizontal. If the principal focus of the lens be farther from the eye than 13 mm., the magnification again becomes greater in the meridian of greatest refraction, and the oval again becomes vertical. Sometimes the papilla is really of an oval shape, and not round, and then the diagnosis is readily made by observing that in one image it is seen as an oval, while in the other image it is circular. Care must be taken in the indirect method not to hold the lens obliquely, as this would be sufficient to

make a circular disc appear oval, the long axis of the oval being in the direction of the axis round which the lens is rotated.

In astigmatic eyes a crescent, similar to that seen in myopia, is often present at the margin of the optic disc. The length of the crescent is parallel to the meridian of least refraction.

In cases of corneal astigmatism of high degree the image of Placido's disc (p. 154), reflected on the cornea, shows ellipses instead of circles, the short axes lying in the meridian of greatest curvature.

The Estimation of the Degree of Astigmatism and its Correction.—It is evident that to correct astigmatism the ordinary spherical lenses would be of little use, for they affect the refraction of the light passing through them equally in every direction. Cylindrical lenses (p. 404) are therefore employed, which refract light in one direction only—viz. at right angles to their axes.

Subjective Method.—Although astigmatism is nowadays almost universally, in the first instance, estimated by means of the ophthalmoscope, or by the astigmometer (p. 440), yet in order to give the reader a clear idea of the matter in the simplest way, a subjective method for its estimation will be now described, while its objective estimation by aid of the ophthalmoscope (erect image and retinoscopy) will be treated of in the next chapter.

Simple Astigmatism.—Snellen's Sunrise (*vide* diagram at end of book), or some such diagram, is placed at 6 metres from the eye (the other eye being excluded), and the patient is asked whether there be any line which he sees much more distinctly and blacker than the others, and can trace farther towards the central point. If that be so, he must be emmetropic in the meridian at right angles to that line, provided his accommodation be at rest, and ametropic in the meridian corresponding with that line.

In case the horizontal line below at each side be the distinct one, the eye is emmetropic in the vertical meridian, and probably hypermetropic in the horizontal meridian, because the latter is generally that of least curvature. Consequently, a convex cylindrical lens held with its curvature horizontally (axis vertical) before the eye will correct the defect. The highest convex cylindrical glass which renders all the lines equally distinct and which gives the patient the best possible distant vision will be the correcting glass. This would be a case of Simple Hypermetropic Astigmatism (As. H.). If the

lens required be + 2 D Cyl., it would be As. H. 2 D ; and in prescribing for the optician we would write " + 2 D Cyl. Ax. Vert."

If the central vertical line be the distinct one, then emmetropia exists in the horizontal meridian, and probably therefore myopia in the vertical meridian ; and a concave cylindrical lens held before the eye with its curvature vertical (axis horizontal) will correct the defect. The lowest concave cylindrical lens which gives the patient the best possible distant vision will be the correcting lens. This would be a case of Simple Myopic Astigmatism (As. M.). If the lens be — 2·5 Cyl., it would be As. M. 2·5 D ; and for the optician we should write " — 2·5 D Cyl. Ax. Horiz."

The reader should now make a few experiments for himself with cylindrical lenses, by means of which he can produce artificial astigmatism in his own eye. Let him place Snellen's Sunrise figure opposite his eye at a distance of about 4 to 6 metres. If he now hold a + 1·0 Cyl. before his eye, with its axis horizontal, it gives a myopia of 1·0 D to the vertical meridian of the eye, while the horizontal meridian remains emmetropic ; and consequently, he will see the central vertical line of the diagram distinctly, while the horizontal lines will be indistinct. By placing a — 1·0 Cyl. with its axis horizontal before the eye, in addition to the + 1·0 Cyl., the artificial astigmatism produced by the latter is corrected, and the whole diagram becomes distinct. Every other kind and degree of astigmatism can be similarly represented by lenses and similarly corrected.

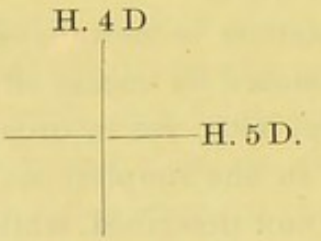


FIG. 149.

* *Compound Astigmatism.*—The spherical lens which corrects one meridian having been found, one set of lines will appear defined, and then the + or — cylinder necessary to bring the remaining lines into focus will give the amount of astigmatism. In the case represented by Fig. 149 the order for the glasses would read "+4 D Sph. ⊂ +1 D Cyl. Ax. Vert." [1] This is Compound Hypermetropic Astigmatism.

In an analogous way the examination is made for Compound Myopic Astigmatism, in which every meridian is myopic, but the vertical meridian more so than the others.

[1] The sign ⊂ indicates " combined with."

Mixed Astigmatism.—In a case of mixed astigmatism, such as is represented by Fig. 150, the correction can be made in two ways: (*a*) by a Sph. — 3 D, which will correct the vertical meridian, but will increase the hypermetropia in the horizontal meridian by 3 D, making it 8 D, which can then be corrected by combining a cylindrical lens of + 8 D, axis vertical, with the above spherical lens; (*b*) by a spherical + 5 D, which will correct the horizontal meridian, but will increase the myopia in the vertical meridian to 8 D, necessitating the combination of a — Cyl. lens of that number with the + 5 D Sph. For reading, writing, etc., an over-correction of the horizontal meridian with + 8 D Cyl., thus rendering the eye myopic 3 D in every meridian, and enabling the patient to read at, or near, his far point, might be the most suitable arrangement.

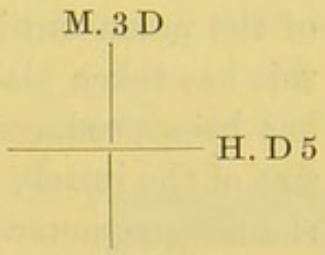


FIG. 150.

As it is necessary, in order to test the degree, etc., of astigmatism accurately, that the accommodation be at rest, it is desirable, before the examination for any of the hypermetropic forms in young persons, to instil atropine into the eye.

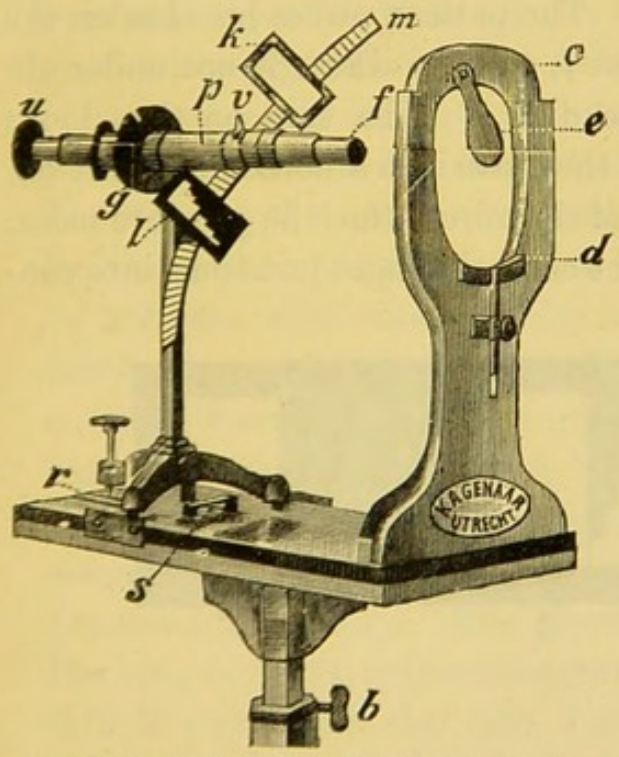


FIG. 151.—The Astigmometer.

* MEASUREMENT OF THE DEGREE OF ASTIGMATISM BY THE ASTIGMOMETER. — This is one of the most rapid and satisfactory methods of determining both the degree of corneal astigmatism, and the position of the meridians of greatest and least refraction.

The cornea reflects images of objects in the same manner as a convex mirror, and the smaller the radius of curvature the smaller will be the image of any given object. It is easy to calculate the radius of curvature of the cornea, if the size of the object, its distance from the cornea, and the size of the corneal image be

known. The only difficulty lies in the measurement of this image; and it has been found that the best method of effecting this is to double the image by means of prisms, and then to alter the strength of the prism until the two images just come into contact. When this has taken place, a displacement equal to the size of the image has been produced. The amount of displacement, and hence the size of the image, can easily be calculated. This is the principle of the astigmometer (Fig. 151).

In order to measure the degree of astigmatism by this instrument, we do not require to know the radius of curvature of the cornea, but need merely find out the difference in refractive power between the meridians of greatest and least curvature, and this the instrument enables us to do in a few seconds without any calculation.

The Astigmometer.—It consists (Fig. 151) of a telescope (*p*) containing a double refracting prism between the object glasses, and two reflectors or mires (*k* and *l*), movable on an arc (*m*), which is fixed to the telescope tube. The latter turns on its own axis, and enables the arc to be placed in any meridian, its position being indicated on a graduated circle (*g*). The patient places his chin on the rest *d*, and looks into the tube at *f*, the eye which is not under observation being covered by the disc *e*. The surgeon then looks through the telescope at *u*, turns the arc *m* into a horizontal position, and observes the corneal images of the mires, which he gets into focus. He then moves the mires until the central images just come into con-

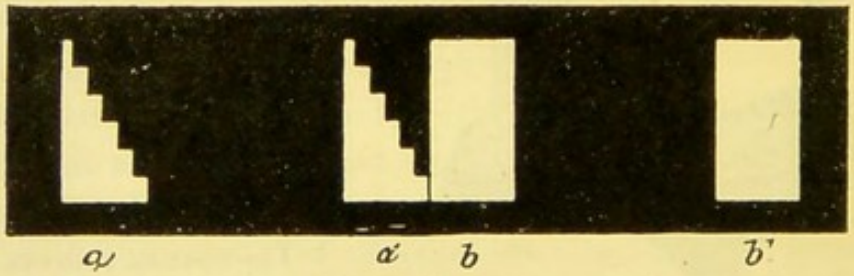


FIG. 152.

tact; the four images will then occupy the relative positions shown in Fig. 152. The arc is then rotated into the vertical meridian, and if the curvature of the cornea in this meridian be the same as in the horizontal meridian, the central images will still appear to be in contact; but if the radius of curvature in the vertical meridian be smaller,

the intervals a to b and a' to b' will diminish, and consequently the central images will overlap, as in Fig. 153, each step of a' representing a difference of 1 Dioptre. So that in this case (Fig. 153) there would be an astigmatism of 2 D, and the greatest refraction would be in the vertical meridian.

It is generally desirable to begin with the arc placed in the horizontal meridian. If the axes of the meridians of greatest and least curvature are oblique, then the images will not lie in one line, and the arc must be turned until they are on a level. An index which moves on the circle g (Fig. 151) gives the position of the axes. It will be seen from the above description that the astigmometer merely registers the amount of astigmatism, but does not enable us to estimate the general refraction of the eye. Moreover, it is the corneal astigmatism alone which is determined, and it will be found in most cases to differ only slightly from the total astigmatism. A useful modification in the mires consists in making them of complementary colours, for instance, one red and the other green, the overlapping portion then appears white and is easily seen. Another great advantage which these coloured mires possess is the absence of dispersion, due to the use of mono-chromatic light, which renders the appreciation of the contact of the images much more delicate. The latter is the instrument used at the Victoria Hospital, and it facilitates the observations considerably.

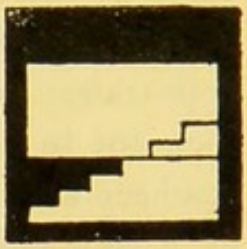


FIG. 153.

* *Lental Astigmatism.*—The astigmatism of the lens when at rest is supposed to be about 0·75 D, and contrary to the rule, and it tends therefore to correct or diminish corneal astigmatism with the rule. This assumption is based on the fact, that often, when there is no subjective astigmatism, the astigmometer shows a corneal astigmatism of 0·75 D with the rule, which the lental astigmatism presumably corrects. The theory also accounts for the fact that the astigmometer over-estimates the total astigmatism by 0·5 D or 0·75 D when with the rule, and under-estimates it by the same amount when against the rule; because in the latter instance the lental astigmatism must be added to that of the cornea, whereas in the former case, it must be deducted from it. This lental astigmatism may be caused by the shape of the lens, or by an obliquity in its position. A difference between the subjective or total

astigmatism, and that of the cornea as measured by the astigmometer, can also be accounted for by the fact that the visual line does not pass through the centre of the pupil, and therefore the portion of the cornea measured by the astigmometer is not exactly the same as that which produced the retinal image. These discrepancies, however, do not detract materially from the practical value of the instrument.

Disturbances of vision due to astigmatism often make their appearance for the first time at middle age or even later, and are then apt to be mistaken for amblyopia. In such cases the cornea has been astigmatic all through life, but the defect has been masked by a compensating astigmatism of the crystalline lens, produced, it is supposed, by an unequal accommodative contraction of the ciliary muscle. When, as life advances, the amplitude of accommodation diminishes, the power of the ciliary muscle to produce this active compensatory lental astigmatism also diminishes, and finally disappears, and then the corneal astigmatism becomes manifest; or, in astigmatic individuals the astigmatism may alter in degree at this time of life. Astigmatism "against the rule" is more common in old than in young persons. Under atropine, too, astigmatism may appear, the existence of which was not previously known. This is termed active, or dynamic, lental astigmatism.

Prescription of Cylindrical Lenses.—The required position of the axis of a cylinder in a prescription is indicated by a line at the extremity of which a number indicates in degrees its inclination to the vertical or horizontal, *e.g.* 2 D. Cyl. ax. /$^{30°}$. In spherocylinders one surface of the glass is spherical and the other cylindrical. Since the axis of cylindrical lenses must occupy a definite and unalterable position before the eyes, spectacle frames or rigid spiral-spring pince-nez should be ordered, and not folders. When first worn, cylindrical glasses frequently appear to cause distortion in the shape of objects, and unpleasant sensations of giddiness; these symptoms, however, disappear with a little perseverance in the use of the glasses.

Irregular Astigmatism.

In irregular astigmatism, the refraction of the eye differs not only in different meridians of the eye, but even in different parts of one and the same meridian. It is frequently due to irregularities

of the surface of the cornea, the result of former ulcers, and also sometimes to irregular refracting power in different parts of the crystalline lens. It cannot be corrected. Its presence can be detected by a distortion and irregular movement of the optic disc when the lens is moved during the indirect method of examining with the ophthalmoscope, by Placido's disc, and also by an irregular shadow in retinoscopy. In some cases, there is a certain amount of regular astigmatism combined with it, correction of which may improve the vision.

* Anisometropia.[1]

By this term is meant a difference in the refraction of the two eyes, one being myopic, hypermetropic, or astigmatic, while the other is emmetropic, or ametropic in a way different from its fellow. It has been shown that in these cases the same amount of accommodation takes place in both eyes. So long as the difference in refraction is but slight (say 1 D or 1·5 D), it is generally possible to give the correcting glass to each eye. When the difference is considerable it is often impossible fully to correct each eye, because, binocular vision having never really existed, the patients are unable to tolerate the presence of a clear image on each retina. We must then be content with correction of the least ametropic eye, or of that one which has the best vision; or, we may partially correct the most ametropic, and fully correct the least ametropic eye. If one eye be emmetropic no correction may be necessary. Each such case must be dealt with as it permits.

Estimation of the Refraction by Aid of the Ophthalmoscope.

Estimation of the Refraction by the Inverted Method.—The position of the inverted image, in other words its distance from the lens used, depends on the strength of the lens, its distance from the eye, and on the refraction of the eye. If the number of the lens and its distance be fixed, the refraction alone causes the alteration in the position of the inverted image. In Em., the emerging rays being parallel, the image is formed at the focus of the lens; in M., the rays being convergent, the image is closer to the lens; and in H. it is farther away, owing to the divergence of the rays coming out of the eye. The methods of measuring the refraction which are based on these principles have not, however, come into general practical use.

[1] *ἀ, priv.; ἴσος, like; μέτρον, a measure.*

By the Direct Method at a distance of about 50 cm. from the observed eye into which light from the ophthalmoscope mirror is thrown, the observer will be able to make the *qualitative* diagnosis of the refraction. If he can see some of the details of the fundus, the eye is either myopic or hypermetropic ; but if it be emmetropic, or have M. of less than 2 D, he will be unable to see any detail. The explanation of this is that, in myopia, the rays, from any one point on the retina, emerging from the eye, form an inverted image at the far point of the eye in the air, and this image can be seen by the observer who accommodates his eye for that point. In hypermetropia, the issuing rays being divergent pass into the observer's eye, and, by an effort of accommodation on his part, he will see an upright image of the portion of the patient's fundus oculi from which

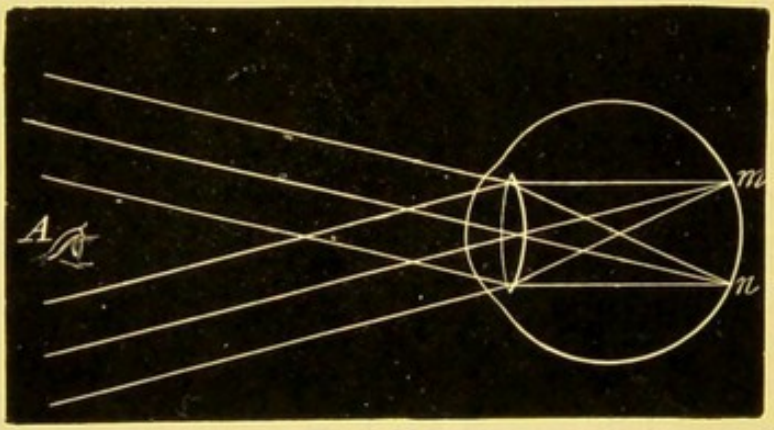


FIG. 154.

they come. But in emmetropia, or low degrees of ametropia, inasmuch as the rays come out either parallel or very nearly so, those from any two points (*m*, *n*, Fig. 154) at a short distance from each other in the fundus on emerging from the eye diverge quickly from each other, and the observer a little way off (at *A*) receives none of them into his eyes, or obtains only an indistinct image or red glare. If he go very close to the eye he can see details.

If, on the observer moving his head from side to side, the vessels etc., of the observed fundus move with him, the case is one of hypermetropia, if against him it is a case of myopia. In H. (Fig. 155) the observer at O sees an erect image of the fundus at F behind the plane of the pupil, P, and it appears to be situated at A ; on moving the head to O^1, the line of vision is O F, and F appears to be at A^1. In myopia (Fig. 156) the image is an inverted one lying in front of the

plane of the pupil at F, and when the observer changes to O′ the image appears to be in the pupil at A′.

* For the *quantitative* determination of ametropia a refraction ophthalmoscope is required. This instrument is provided with a number of convex and concave lenses capable of being brought into

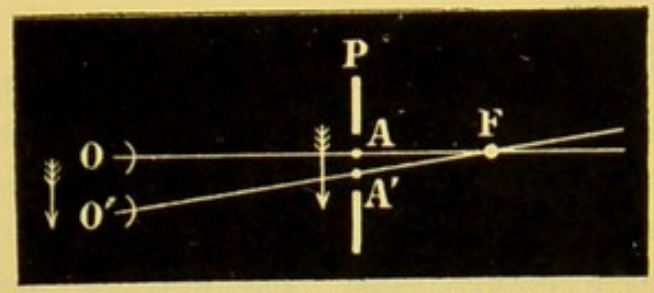


FIG. 155.—Apparent motion of fundus with the observer in H.

position behind the sight-hole in rapid succession by a simple mechanism ; and also with a tilted mirror which avoids the necessity of holding the ophthalmoscope in an oblique position, and thus the lenses are maintained in a position at right angles to the visual axis of the observer. The direct method, close up to the patient's eye, is employed.

It is necessary, in the first instance, that the observer be acquainted with the nature of his own refraction.

* *If the Observer be Emmetropic* he can see the fundus oculi of an emmetrope in the upright image without any lens, provided he go close enough, as the parallel rays coming from the examined eye

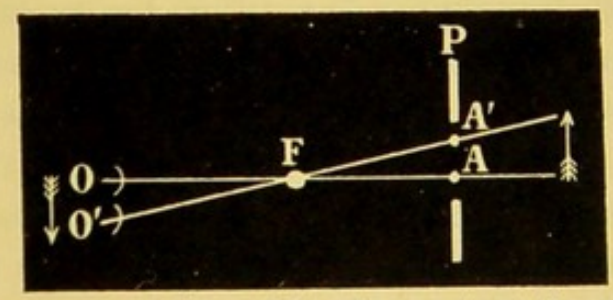


FIG. 156.—Apparent motion of fundus against the observer in M.

will be focussed on his retina, because his eye is adapted for parallel rays.

In order to see the fundus oculi of a hypermetrope without any effort of accommodation, he must place such a convex lens behind his ophthalmoscope as will render the divergent rays coming from the patient's eye parallel before they pass into his eye. This lens is

the measure of the patient's hypermetropia, because it shows how many dioptres the eye wants of being emmetropic. The lens which makes the divergent rays coming from the patient's retina parallel, would also give to parallel rays passing into the eye such convergence that they would meet on the retina—*i.e.* it would correct the hypermetropia if the patient were examined with test-types and glasses (p. 426). (See Fig. 140.)

The emmetropic observer can of course see the fundus oculi of a hypermetrope by the direct method without the correcting glass, if he use his accommodation to overcome the divergence of the rays coming from the observed eye, and this is usually the case in the lower degrees of hypermetropia. The observer generally relaxes his accommodation according as he substitutes convex lenses for it, until he reaches the *strongest* lens with which he can distinctly see the fundus. This is the correcting lens.

To see the fundus oculi of a myope, the emmetropic observer must place a concave glass behind his ophthalmoscope, in order that the convergent rays coming from the observed eye may be made parallel before they pass into his eye ; and the *lowest* concave lens which enables him to see the fundus oculi distinctly is the measure of the myopia (p. 414), as showing by how many dioptres it is in excess of emmetropia.

The emmetropic observer cannot possibly see the fundus oculi of a myope without the correcting glass, as the rays are brought to a focus in front of his retina, and if he use his accommodation he merely makes them still more convergent. But, by means of an effort of his accommodation he can see the myopic fundus with a lens which over-corrects the myopia, and hence the importance of selecting the *weakest* concave glass with which the fundus is distinctly seen.

If the observer be ametropic, he may either correct his ametropia by wearing the suitable lens, and then proceed as though he were emmetropic, or else, and which is perhaps the better plan, he must allow for the amount of his ametropia.

For example :—

* The *Hypermetropic Observer* of say 3 D requires a + lens of 3 D in order to see an emmetropic fundus oculi, this lens going altogether to correct his own defect. If in order to examine the fundus of another eye he require a + lens of 6 D, the examined eye must be hypermetropic 3 D, the other 3 D going to correct the observer's

H. If he be able to see the fundus oculi under observation without any lens, it shows that the eye has an excess of refraction corresponding with the want of retraction in his own eye—that is to say, it is myopic 3 D. If he require a concave 2 D, his want of refraction—his hypermetropia—is not enough by that number of dioptres, and he has to do with an eye which is myopic 5 D (3 D + 2 D). Again, if he can see the fundus distinctly with a + lens, say + 1 D, which is less than his own correcting glass, this shows that the eye he is examining is myopic, but myopic to a lesser degree—in this instance by 1 D—than he himself is hypermetropic, and the examined eye here would be M. 2·0 D (*i.e.* 3·0 — 1·0).

If the Observer be myopic the same method of reasoning applies.

* *The Existence and Degree of Astigmatism may be Determined with the Ophthalmoscope.*—We know that astigmatism is present, if in the upright image we see the upper and lower margins of the disc and the horizontal vessels well defined, while the lateral margins and the vertical vessels are blurred, or *vice versâ*. Again, we know that astigmatism is present if, in comparing the shape of the optic disc in the upright and inverted images, we find it to be an oval with its long axis perpendicular in the former, and with its long axis horizontal in the latter, showing that the refracting media are more powerful in the vertical than in the horizontal meridian.

We may ascertain the kind and degree of astigmatism as follows :—

If in the upright image with relaxed accommodation, we can see the retinal vessels in one meridian distinctly, while in order to see those in the opposite meridian a concave or convex lens behind the ophthalmoscope is required, we know that the case is one of simple myopic or hypermetropic astigmatism ; the emmetropic meridian being that at right angles to the vessels [1] seen without any lens, and the number of the lens indicating the amount of ametropia in the other meridian.

If, in the two principal meridians, two concave lenses or two convex lenses of different strength be required, we have to deal with a case of compound astigmatism, myopic or hypermetropic ; the greatest error of refraction being in the meridian at right angles to

[1] The vessels may be regarded as lines, and the explanation given on p. 434 applies to them also.

that one, the vessels of which are made distinct by the strongest lens.

If a concave lens be required to bring into distinct view the vessels in one meridian, while a convex lens is required for the opposite meridian, the case is one of mixed astigmatism. Myopia exists in the meridian at right angles to that in which the vessels are brought into view by the concave lens, and hypermetropia exists in the opposite meridian.

Retinoscopy.

Retinoscopy, or the Shadow Test, is the most useful method for determining the refraction by the ophthalmoscope. It consists in illuminating the eye with the plane or concave mirror at a distance

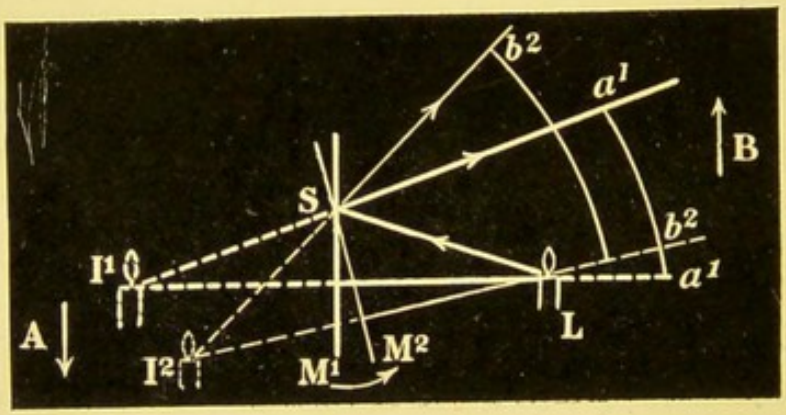


Fig. 157.—Motion of the virtual image in rotation of a plane mirror.

of a little over a metre, or more, and then moving the light into different positions by rotation of the mirror round an axis lying in its own plane, the observer noting on which side of the illuminated pupil the shadow appears, and in which direction it moves across the pupil.

Direction of Displacement of the Image when a Mirror is rotated round an Axis lying in the Plane of the Mirror.—When a *plane mirror* is rotated, the image of the source of light moves in a direction opposite to that in which the mirror is rotated. In Fig. 157 when the mirror is rotated from M_1 to M_2 the image of the light, L, will be found on the perpendiculars to the mirror, M_1 and M_2, at I_1, and I_2. The cones of rays emerging from these images, a_1 a_1 and b_2 b_2, will move with the rotation of the mirror as indicated by arrow B, while the images have moved in the *opposite* direction, shown by arrow A. When a *concave mirror* is rotated, the image moves in the *same* direction as the mirror. In Fig. 158

when the mirror is in the position M^1, the image of L is formed at I^1, on the secondary axis passing through the centre of curvature C^1; and, on rotating the mirror into the position M^2, the corresponding image will be

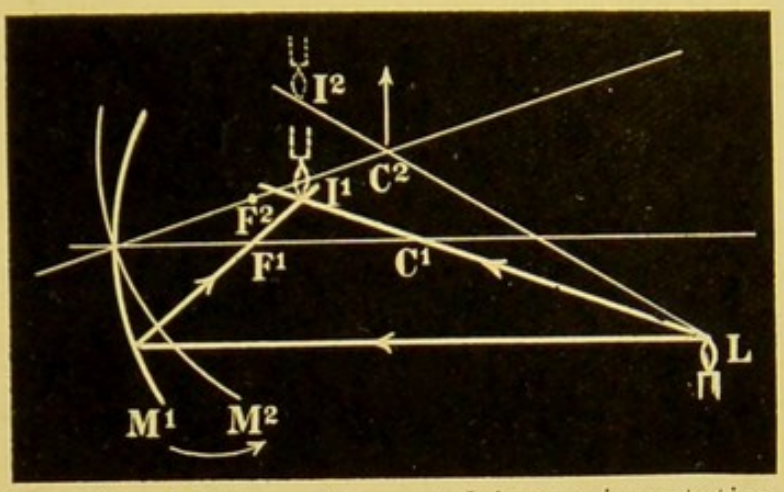


FIG. 158.—Motion of inverted image in rotation of a concave mirror.

found on the secondary axis L C^2, say at I^2, the change of position of the image being in the direction of the arrow, and with the movement of the mirror.

Theory of Retinoscopy.—In the explanation which follows, the *concave mirror* is supposed to be used. In Fig. 159, rays from the light, O, placed at the side of the patient's head, strike the mirror, A, which forms an inverted aerial image, A′, as explained in chap. ii. This image is now the immediate source of light, rays from which, entering the eye, are made

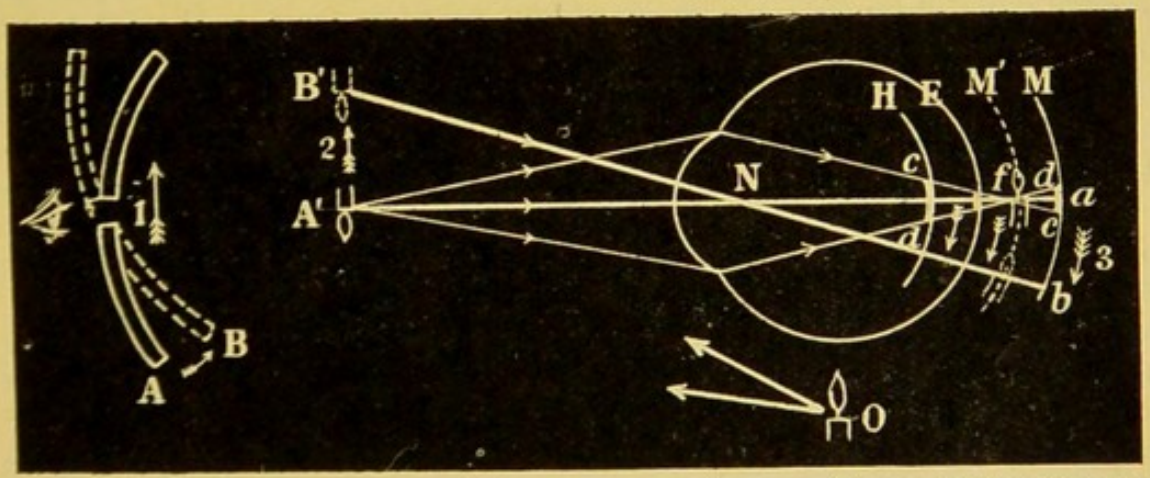


FIG. 159.—Retinoscopy with concave mirror. Shows that the real movement of the retinal image is the same in all conditions of refraction. 1. Motion of mirror, or of light area on patient's face. 2. Motion of aerial image produced by mirror (immediate source of light). 3. Real motion of retinal image of light.

to converge toward their conjugate focus, *f*, on the secondary axis, A N *f*, passing through the nodal point, N. If the retina be at M′, or in other words, if the eye be myopic, with its far point at A′, a distinct and bright image of the light A, will be formed on the retina at *f*. In any other

condition of refraction such as emmetropia, E., hypermetropia, H., or any higher degree of myopia, M., a circle of diffusion, *c d*, is formed by each point of light, and a blurred image is the result; so that the area of illumination is less bright, and its boundary less defined. The farther the retina is from *f*, the less will be the brightness and the definition of the margin of the illuminated area.

Now let the mirror be rotated from A to B, the movement of the light area, surrounding the eye, on the patient's face will, of course, take the same direction, indicated by the arrow 1. As explained at the beginning of this chapter, the immediate source of light will move to B′, shown by arrow 2, and its image will be formed, more or less distinctly, on the retina, at the point at which it is intersected by the secondary axis B N *b*. The retinal image, therefore, will move in the direction of arrow 3, from *a* to *b*, and this motion, as the figure shows, is the same in all positions of the retina. The real motion of the retinal image of the light in the observed eye is therefore independent of the refraction of the eye, and is in a direction contrary to that of the immediate source of light, and also against the motion of the concave mirror.

The observer cannot, however, see directly what is taking place on the retina of the observed eye, since he can only examine it through its refractive media. It remains, therefore, to determine the effect of the refraction of the observed eye on the motion as it appears to the observer; this may be called the apparent movement. What the observer sees is the image, real or virtual, formed by the observed eye, at its conjugate focus or far point, and therefore the apparent movement will depend on the position of the far point.

In H (Fig. 160) the immediate source of light, A, illuminates a portion of the retina at *a*. The rays *e*, *f* emerging from this point diverge, and entering the observer's eye seem to him to come from *α*, the far point of the hypermetropic eye. When, by reason of a rotation of the mirror to B, the light moves to B′, its retinal image *b*, seems to be at *β*. The illuminated area seems therefore to have moved in the direction of arrow 4—that is, *against* the motion of the mirror (arrow 1).

In Em. similarly, the emergent rays are parallel, and the image is projected by the observer to a position behind the eye under examination. Stated simply, in both cases an erect image of the fundus is seen, therefore no reversal of the rays takes place between the eye of the observer and that of the person under observation; and consequently, the apparent motion is the same as the real. As the light moves from to and so passes on, the pupil will first appear to become darkened above, and the shadow will move across it as shown in the circle P.

In Myopia, on the other hand (Fig. 161), the rays from the illuminated area *a* converge to form an inverted image at *α*, the far point of the eye, situated on the secondary axis AN*α*. When the immediate source of light moves from A′ to B′, the apparent movement is from *α* to *β*. In this case a reversal of the relative position of the rays takes place, before they enter the observer's eye; the upper rays become the lower and *vice versa*. Hence this is sometimes called the point of reversal. In this case the darkness will appear first at the lower edge of the pupil, and will

travel upwards as indicated in the circle P, that is to say, in the same direction as arrow 1, *with* the movement of the concave mirror.

The above explanation only holds good in myopia, when, as in the

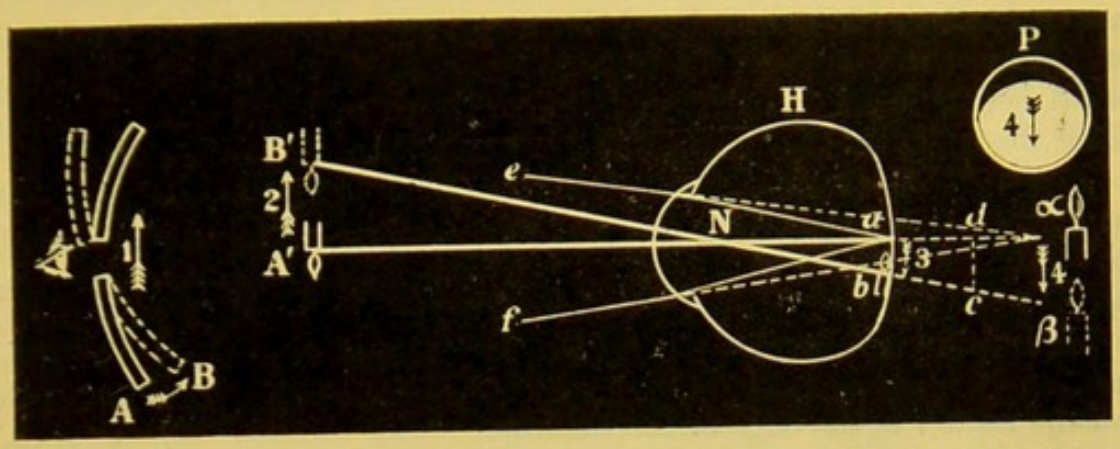


FIG. 160.—Retinoscopy, with concave mirror, in hypermetropia. 1. Motion of mirror. 2. Motion of immediate source of light. 3. Real motion of retinal image. 4. Apparent motion of retinal image.

figure, the far point of the eye under observation lies in front of the observer's eye. If, however, the far point be situated farther back than the observer's eye, the rays will not have met to form the inverted image, but will enter his eye retaining the relative positions which they bore to each other on emerging from the eye under observation ; consequently, the observer will see an erect image of the illuminated area, and the movement will be as in H. and Em., namely, against the concave mirror. It is obvious, that the lower the degree of myopia the farther away the observer must be in order that he may see the reversal of the movement.

An error of refraction in the observer's eye does not influence the apparent movement, but merely renders the appearance more or less

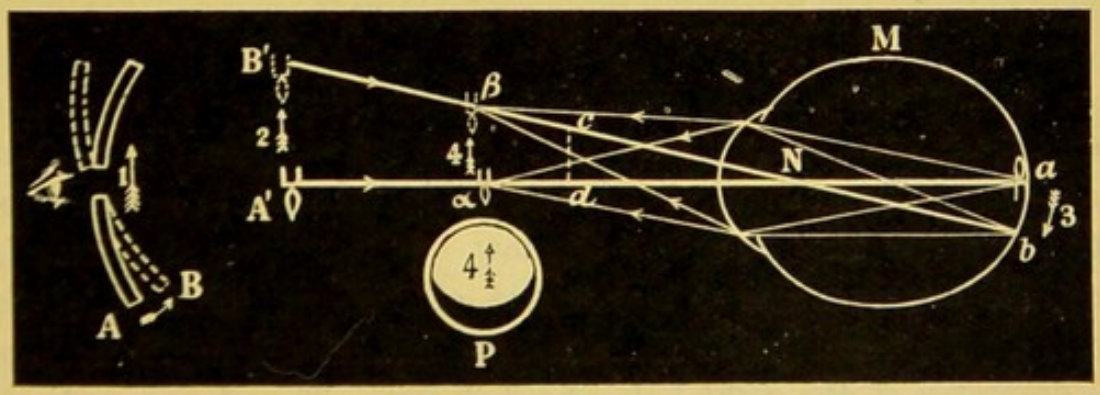


FIG. 161.—Retinoscopy with concave mirror in Myopia. Numbers as in Fig. 160.

distinct to him. It should also be stated, that as the observer accommodates for the patient's pupil, and not for the far point of the retina of the patient, the image seen is always more or less diffuse.

Retinoscopy with the plane mirror.—The immediate source of light in the case of a plane mirror is a virtual upright image behind the mirror

(Fig. 157). It moves in the opposite direction to the motion of the mirror, and not with it, as in the case of the concave mirror. Hence the real movement of the retinal image in the patient's eye will be with the mirror. The apparent movement will, therefore, be the same; that is, *with* the mirror, in Em., H., and in low M., where the point of reversal is farther away than the observer. In higher degrees of M., with the point of reversal nearer than the observer, the real motion will be reversed, and hence the apparent motion will be *against* the motion of the mirror.

Degree of illumination, form, and rate of movement of the shadow.—As shown in Fig. 159, when the retina is at the conjugate focus of the immediate source of light, the illumination is at its greatest. The farther away the retina is from the conjugate focus, that is to say, the higher the H. or M., the larger must be the area over which the light is spread, and therefore the more defective the illumination becomes, and the less defined and the fainter is the edge of the shadow.

The higher the error of refraction, the nearer to the eye is the far point, and the smaller is the remote image; but with the smaller image a larger field is obtained, and more of the circular edge of the shadow is seen; hence, the latter appears crescentic. In the lower degrees of ametropia and more especially in Em., the magnification is much greater and the field is smaller. Therefore, a small portion only of the large circular edge is visible, causing the shadow to appear less crescentic and more linear.

The apparent rate of movement depends more on the degree of magnification of the remote image, than on the real rate of movement of the retinal image. The less the magnification the slower the movement appears, for instance in Figs. 160 and 161, if the far point were in each case at c, the light would have to travel only from d to c, instead of from α to β, with the same rotation of the mirror. At c, therefore, it would appear to travel a shorter distance in the same time, and would therefore appear to move slower. The higher the ametropia, then, the slower appears to be the movement of the shadow.

Practice of Retinoscopy with the Concave Mirror.—The examination is conducted in the dark room. The light is placed at the side of, or above the patient's head, and behind the level of his eye, so that the latter may be in the shadow. If the concave mirror be used, the observer sits at a distance of 1·25 m. in front of the patient. The focal length of the mirror should be about 22 cm., and the diameter of the sight-hole about 3 mm. The observer should correct any error in his refraction. The light is then thrown into the patient's eye, near the region of the macula lutea, but not on it, unless the pupil be dilated by atropine, otherwise the pupil becomes too small and the red reflex too faint. The observer accommodates for the pupil, and rotating the ophthalmoscope, usually in the horizontal and vertical meridians, he observes the shadow at the cir-

cumference of the pupil. When the mirror is rotated—say, in the horizontal meridian—the edge of the shadow will be vertical, it will move horizontally, that is at right angles to its edge, and it will indicate the refraction of the horizontal meridian. If the movement of the shadow be with the movement of the mirror, or with the light on the patient's face, myopia is present; if it move *against* the mirror, Em., H., or M. of less than 1 D is present.

The reason why the shadow is against the mirror in cases of less than 1 D is that, in M. of 1 D, the inverted image or point of reversal of the emerging rays is situated at the far point of the patient's eye, namely 1 m. in front of the patient, and the observer being 25 cm. farther away sees this inverted image. But if the myopia be less than 1 D, the far point, or point of reversal, lies behind the observer's head, and he now sees an erect image as in Em. or H., and the apparent movement is then the same as in Em. or H., namely against the mirror.

In order to estimate the error of refraction, a trial spectacle-frame is put on the patient's face. If the shadow move with the mirror, we know at once the eye is myopic. To find the degree of myopia the observer puts a low concave-glass (say — 1 D) into the frame; and if the shadow still move with the mirror, he puts in a higher number (say — 1·5 D), and so on until he comes to a glass which makes the image move against the mirror. If this be — 3 D, the myopia is 3 D. It might be supposed, as the shadow now moves against the mirror, that this glass over-corrects the myopia; but this is not so, because, as already explained, when the myopia is very low the image is formed close to the observer's eye, or behind his head, and he consequently gets a shadow moving against the mirror, although low myopia, and not emmetropia, is present. Consequently, — 0·5 D, or — 1 D, has to be added on to the lens, which gives the effect of no distinct shadow; or rather, by the above plan, it is not deducted from the lowest lens, which makes the shadow move against the mirror.

If the shadow move against the mirror, we have to determine whether the eye is emmetropic, hypermetropic, or slightly myopic. Should the illumination be bright, and the shadow well defined, the eye is emmetropic, or not far removed from it; and if the shadow be ill defined and crescentic, we may feel sure the eye is highly hypermetropic. We first put on + 1 D, and if the motion be still

against the mirror, the case is one of hypermetropia, and higher numbers are at once proceeded to, until that one is reached which causes the shadow to move with the mirror. The measure of the hypermetropia is 1 D less than the glass so found, for it has evidently over-corrected the defect, having made the eye 1 D myopic.

If, however, on putting on + 1 D we find the shadow to move with the mirror, we change it for + 0·5 D ; and if still the motion be with the mirror, the eye is, beyond doubt, slightly myopic, — 0·5 D or so. But if with + 1 D the shadow move with the mirror, while with + 0·5 it continue to move against it, the eye is emmetropic.

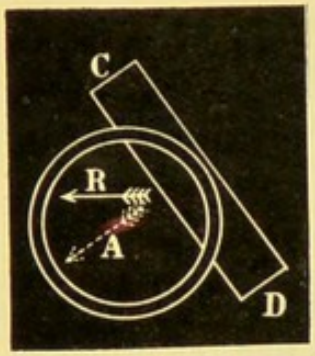


FIG. 162.—If the ruler C D be moved behind the circle in the direction of R, its obliquity being preserved, it will appear to a person who sees only the portion inside the circle, to move in direction A.

In *astigmatism*, the light being differently focussed in two meridians at right angles to each other, and being drawn out into a line or oval of diffusion, causes the illuminated area to appear like a band. The boundary of the shadow therefore is more of a straight line than a circle. If the axes of the astigmatism be oblique, the edge of the shadow will lie in one of the meridians, and the movement will take place in the other one—according to the direction of the rotation of the mirror. Even if the mirror be not rotated in the direction of the meridian of greatest or least refraction, the edge of the shadow will nevertheless lie in the direction of one of these meridians, namely in that which is nearest to the axis of rotation, and will appear to move in the meridian at right angles to it. This is due to an optical illusion explained by Fig. 162.

It may be found that in opposite meridians there is a difference in the motion of the shadow, and this indicates the presence of astigmatism. When the difference is one merely of rapidity of motion, or of intensity of illumination and shadow, it is either simple hypermetropic or compound astigmatism. But if in the two meridians there be a difference in the direction of the motion, then it is either simple myopic or mixed astigmatism.

In some rare cases the refraction is different at opposite sides of the pupil, and a double shadow is seen. These shadows move simultaneously in opposite directions ; that is, towards or away

from each other, like the blades of scissors, and hence the condition is known as "scissors movement." In conical cornea, an irregular or triangular shadow is seen, with its apex near the centre of the pupil; it rotates round its apex with the movements of the mirror. In irregular astigmatism, the shadow appears broken up very irregularly, and different portions of it move in various directions.

In retinoscopy the best method of ascertaining the degree of astigmatism and its correcting glass is to correct each of the principal meridians separately with spherical lenses. In compound astigmatism, the difference between the two lenses found indicates the degree of astigmatism, and also the cylindrical lens which, combined with the correcting spherical lens for the least ametropic meridian, is required to neutralise the defect. In mixed astigmatism, the addition of the two numbers gives the cylindrical lens, while one or other of them, usually the — D, is used as the spherical lens.

Retinoscopy with the plane mirror.—As explained on p. 448, the immediate source of light moves in a direction the reverse of that which is produced by the concave mirror; therefore, the apparent movement is *with* the mirror in H., Em., or low M., and *against* it in the other degrees of M. It will be noticed that this is the same as the apparent movement of the vessels when the observer moves his head (p. 445). The advantage of the plane mirror is, that the observer can stand farther away from the patient, and thus diminish the error of observation. If, for example, the distance be a little more than 4 m. when the shadow moves with the mirror, the observer knows, if M. be present, it must be less than 0·25 D. He has still to decide whether this indicates E. or H. He does so by putting a low + lens (say + 0·25) before the patient's eye, and if then, standing at a distance of 4 metres, the motion be altered by this glass to one against the mirror, he knows that the eye has not a hypermetropia of 0·25 D, consequently that it is emmetropic. But if this lens does not at that distance cause a change in the motion of the shadow as originally obtained, the eye must be hypermetropic to at least the extent of 0·25 D; and, in order to ascertain how much more of H. than this may be present, it is now only necessary to continue increasing the strength of the lens in front of the patient's eye, until one is reached which, at 4 metres from the eye, produces the myopic motion. The observer knows that he has now slightly

over-corrected the hypermetropia of the eye, and that the next lens lower is its measure.

A plane mirror of 4 cm. diameter, and of which the sight-hole is 4 mm. in diameter, is the pleasantest to use for retinoscopy.

ANOMALIES OF ACCOMMODATION.

Presbyopia.

This is a diminution in the amplitude of accommodation (p. 7), which commences at an early age, and is due to natural changes taking place slowly in the crystalline lens. It might not, therefore, strictly speaking, be regarded as an anomaly. The power of accommodation commences to diminish in early childhood, the near point beginning then to recede from the eye. The accompanying diagram of Donders (Fig. 163), illustrates the decrease from the tenth year of age, and indicates the amplitude of accommodation at different ages.

The numbers at the top indicate the ages in years, those on the left the amplitude of accommodation in dioptres. The curve *r r* shows the refraction of the eye when in a state of rest. This is unchanged until the fifty-fifth year, when it begins to diminish ; the emmetropic eye then becoming hypermetropic, the hypermetropic eye more hypermetropic, and the myopic eye less myopic. The curve *p p* shows the positive refracting power of the eye, corresponding with the punctum proximum, and its gradual diminution as life advances, and how at the age of 65 it becomes even less than the minimum refraction in former years. The two curves meet at the age of 73, and then all power of accommodation ceases. The number of dioptres included between the two curves on the vertical line corresponding with any given age represent the amplitude of accommodation at that age—*e.g.* at 30 years of age the amplitude is 7 D ; at 50 years it is only 2·5 D. The amplitude of accommodation is the same at the same age in all forms of ametropia, as well as in emmetropia.

The cause of presbyopia lies chiefly in a progressive change in the crystalline lens, which becomes less elastic and more homogeneous in its different layers, and refracts light less strongly than before. In more advanced life, diminished energy of the ciliary muscle probably becomes a second factor in the production of presbyopia.

The near point gradually recedes from the eye until it reaches a distance beyond that at which the person usually reads, writes, sews, etc. Employments of this kind then become difficult, because the retinal images are too small to be clearly discerned, owing to the increased distance at which the work must be held from the eye; and, in order to make up for this smallness of the images, the individual is often seen to improve their brilliancy by procuring stronger light.

Presbyopia (πρέσβυς, *an old man*; ὤψ) was defined by Donders

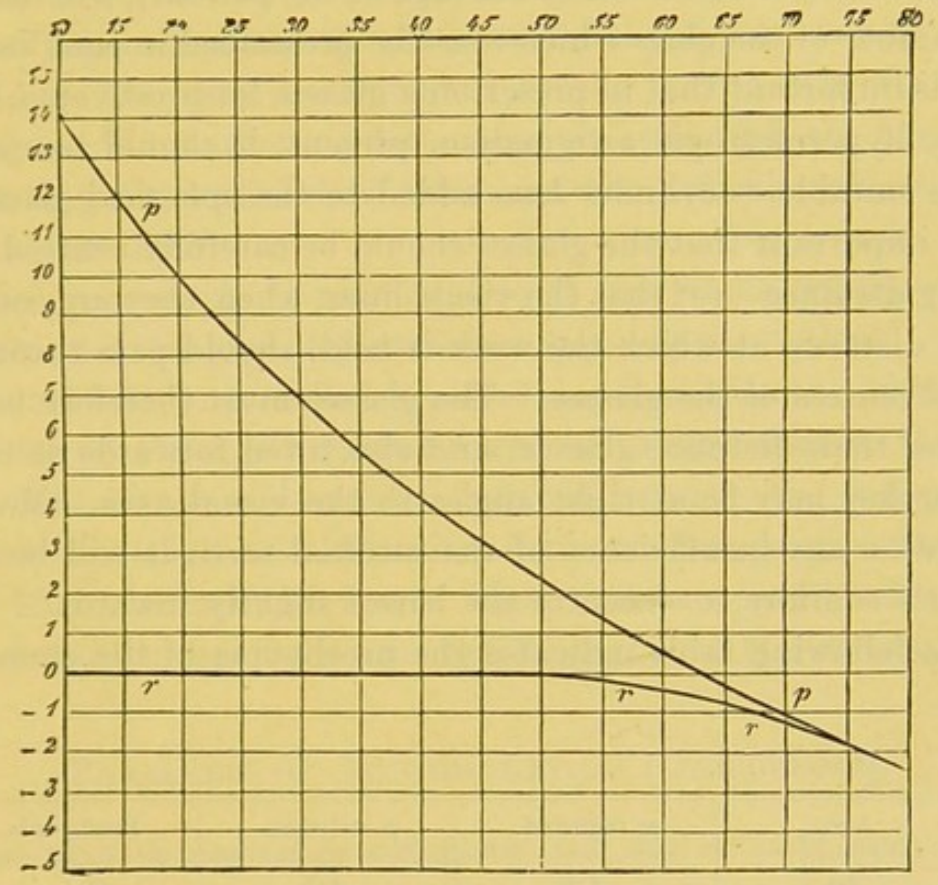


FIG. 163.

to be present when the near point lies at more than 22 cm. from the eye, and we correct it by giving such a convex glass for reading, etc., as will bring the near point back to 22 cm. Now in order to focus an emmetropic eye for that distance a positive refracting power (p) of ($\frac{100}{22}$ =) 4·5 D is necessary, and if the eye have not so much accommodation, a convex glass must be given to it of such power as will bring p up to 4·5 D; and this lens is the measure of the presbyopia. At the age of 40 (*vide* Donders' diagram, Fig. 163) the eye possesses a positive refraction of just 4·5 D; and therefore from this age presbyopia is said to commence in emmetropic eyes. The

presbyopia, then, is equal to the difference between the accommodative power possessed by the eye and 4·5 D, and the number thus found is the correcting glass for the presbyopia. The distance of 22 cm. is rather close to the eyes for the comfort of most people, and 33 cm. is more commonly taken as the reading distance. Presbyopia on the latter assumption is postponed for two or three years.

The glass required in presbyopia must also depend on the nature of the patient's work, which, of course, may require to be placed at some definite distance. This distance, the refraction of the eye, and the amplitude of accommodation (age of the patient), will determine the number of the glass which must be prescribed in each case.

It is important that in prescribing glasses for presbyopia, if there be any hypermetropic astigmatism present, it should be corrected by the suitable + cylinder lens added to the spherical glasses. It is also important that the glasses should be carefully centred for the reading distance—*i.e.* that the visual lines, when they are converged to the distance at which the work is held, should pass through the optical centres of the glasses. The glasses must therefore be closer together than distance glasses, and also tilted forwards at the top, so that they may be at right angles to the visual axes. Moreover, if there be any insufficiency of the internal recti, it will be for the patient's comfort to decentre the lenses slightly inwards.

The following table indicates the presbyopia of the emmetropic eye :—

Age.	*p.* required.	*p.* existing.	Presbyopia.
40	4·5	4·5	0
45	4·5	3·5	1·0
50	4·5	2·5	2·0
55	4·5	1·5	3·0
60	4·5	0·5	4·0
65	4·5	0·25	4·25
70	4·5	−1·0	5·5
75	4·5	−1·75	6·25
80	4·5	−2·5	7·0

It is hardly necessary to point out that presbyopia comes on at a much earlier age in hypermetropes than in emmetropes ; while in myopes its advent is postponed ; or, in the higher degrees of myopia, it may not come on at all. The hypermetrope of 3 D would be

presbyopic at the age of 27 ; because, in order to arrive at the 4·5 D of positive refraction required, he must have an amplitude of accommodation of (3 D + 4·5 D) 7·5 D, and this he has up to that age only (Fig. 163).

The myope of 4·5 D can get along until something over 60 years of age without any glass for reading (*vide* above table). At 65, if he were emmetropic, he would have presbyopia of 4·25 ; consequently he will now require a + glass of only 0·25 D.

Persons who have worn full myopic correction constantly need to have the power reduced for reading at the presbyopic age.

Presbyopia must not be mistaken for slight paralysis of accommodation. They are distinguished by the fact that in the former the amplitude of accommodation corresponds with the age of the patient as given in Donders' table, and the difficulty of near vision comes on gradually.

When presbyopia is associated with ametropia, which requires correction for distance, *bifocal lenses* are very convenient. A thin, oval or circular, lens (called a paster) representing the addition required for near vision is ground, fused, or cemented on to the lower part of the distance glass, or is inserted between the two portions of which this is formed. The size of the reading portion should be about 12 mm. broad, by 8 mm. high, and its upper border should be a few millimetres below the optical centre of the distance lens.

Paralysis of Accommodation (Cyclopegia).

This may be partial or complete, and one or both eyes may be affected. It is usually combined with paralysis of the sphincter iridis (mydriasis), and the condition is then called ophthalmoplegia interna ; but it is also seen without paralysis of the sphincter, and either alone or with paralysis of some of the orbital muscles supplied by the third pair, which also supplies the ciliary muscle—rarely with paralysis of the external rectus.

The Symptoms are similar to those of presbyopia, but come on rather suddenly. They give inconvenience to the patient according to the state of his refraction. If he be emmetropic, his distant vision continues good, while his vision for near work is much impeded. If he be hypermetropic, as he requires his accommodation for distant objects, vision for distance is interfered with, and still more so, vision

for near objects. If he be myopic, vision is less affected than in either of the other forms of refraction; indeed, if he have more than 4D of M, being thereby enabled to see near objects at his far point, he may suffer little or no inconvenience.

Micropsia is a common symptom in cases of partial paralysis of accommodation, and is due to the fact that, while the retinal image is unaltered in size, the great effort of the defective accommodation gives the sensation of the object being much nearer to the eye than it really is.

Causes.—Paralysis of accommodation may be caused by poisons acting locally (atropine) or through the system (ptomaines, nicotine, lead); but it is also the result of, or is attendant upon, various diseases. It is one of the symptoms of paralysis of the third nerve; it may be due to rheumatism or to exposure to cold; or it may depend upon syphilis, syphilitic periostitis at the sphenoidal fissure, syphilitic gumma, or syphilitic inflammation of the nerve itself.

Double paralysis of accommodation is often nuclear. Paralysis of accommodation and mydriasis are sometimes forerunners by many years of serious mental derangement.

Diphtheria is a frequent cause of paralysis of accommodation, usually without, but sometimes with, mydriasis. The onset occurs most commonly some weeks after the throat affection, which need not have been of a severe character. Indeed, the faucial attack may have had no apparent diphtheritic character, and may have been so slight as almost to have escaped the notice of the patient, although sometimes albumen will be found in the urine, the speech may be somewhat nasal in character, and the patellar reflexes defective. The lesion in these cases is probably a nuclear one, and the evidence points to miliary extravasations of blood in the floor of the fourth ventricle; but some hold that the paralysis is due to a poison, that it is a toxic paralysis.

In influenza, paralysis of accommodation is seen, occurring sometimes in the acute stage and sometimes during convalescence. One recorded case went on to bulbar paralysis, and ended fatally; but complete recovery is usual.

Paralysis of accommodation in middle life may be due to diabetes, and should raise the suspicion of the presence of this disease. It may also occur in chronic alcoholism and in diseases of the spinal cord—*e.g.* locomotor ataxy.

Blows on the eye are apt to cause paralysis of accommodation, usually with mydriasis.

The Treatment depends, of course, upon the cause of the paralysis. The instillation of a 1 per cent. solution of sulphate of eserine or of muriate of pilocarpine may be employed in all cases, and will at least produce temporary improvement of sight; but it can hardly be said to assist in the cure, except perhaps in slight diphtherial cases. Iodide of potassium and mercury are indicated in syphilitic cases, and iodide of potassium and salicylate of sodium in rheumatic cases. The prognosis in these cases must be very guarded, as it often happens that recovery does not take place. No further symptoms may occur, but in some instances it may be followed by external ophthalmoplegia (p. 488). Where cure does not result the patient may be enabled to make better use of his eye or eyes by means of a convex glass or spectacles; but in this matter each case must be dealt with for itself—no general rule can be laid down.

In diphtherial cases a general tonic treatment, especially iron, is indicated; and here the prognosis is invariably favourable.

Accommodative Asthenopia

has been already treated of under the head of Hypermetropia (p. 430).

Spasm of Accommodation.

Spasm, or cramp, of accommodation in connection with hypermetropia and myopia has already been referred to. A few cases of acute spasm of accommodation have been reported. Occurring in an emmetropic or slightly hypermetropic eye, such a spasm produces apparent myopia. In some of the cases there was no assignable cause for the spasm, in some it was due to overwork, and in one to trauma of the cornea. The treatment is a lengthened course of atropine locally.

CHAPTER XVI.

THE ORBITAL MUSCLES AND THEIR DERANGEMENTS.

Normal Action of the Orbital Muscles.

The eyeball, which is held in position by the orbital fascia and capsule of Tenon with its orbital prolongations, is moved round a point on its antero-posterior axis, situated (in the emmetropic eye) 14 mm. behind the cornea, and 10 mm. in front of the posterior surface of the sclerotic. Its motions are effected by means of the six orbital muscles, arranged in three pairs, each pair consisting of two antagonistic muscles; thus the rectus internus and rectus externus are antagonists, the former rotating the eye inwards, and the latter rotating it outwards. The remaining pairs are the recti superior and inferior, and the obliqui superior and inferior.

The Primary Position of the Eyeball is that one in which, the head being held erect, the gaze is directed straight forwards in the horizontal plane. This is the starting-point from which the actions of the muscles are considered. In this position the visual axes are parallel.

The Rectus Externus and Rectus Internus, lying from their origin to their insertion in a plane which corresponds with that of the horizontal plane of the eyeball, move the latter on its perpendicular axis directly inwards and outwards, and have no other action.

The Superior and Inferior Recti arise at the back of the orbit to the inner side of the eye, and pass forwards and outwards. Therefore the plane of these muscles does not correspond with the antero-posterior vertical plane of the eyeball, but passes from within and behind, forwards and outwards. Consequently their axis of rotation, though lying in the horizontal plane, is not the horizontal axis of the eyeball, but one which, passing from within and before, back-

wards and outwards, forms with the antero-posterior axis an angle of 70° (Fig. 164). Being inserted *in front* of the centre of rotation, their action is mainly to rotate the eyeball upwards and downwards, but, coming from the inner side, they also rotate it somewhat inwards. Moreover, the superior rectus gives to the vertical meridian of the cornea an inward inclination,[1] or inward wheel-motion, or torsion of the eye (*vide infra*), while the inferior rectus gives this meridian an outward inclination, or outward wheel-motion of the eye. The power of these muscles over the upward and downward motions is greatest when the eye is turned out, for then their axis of rotation coincides most closely with the horizontal axis of the globe; and their influence over the wheel-motion is greatest when the eye is turned in, for then their axis of rotation coincides most closely with the antero-posterior axis of the globe.

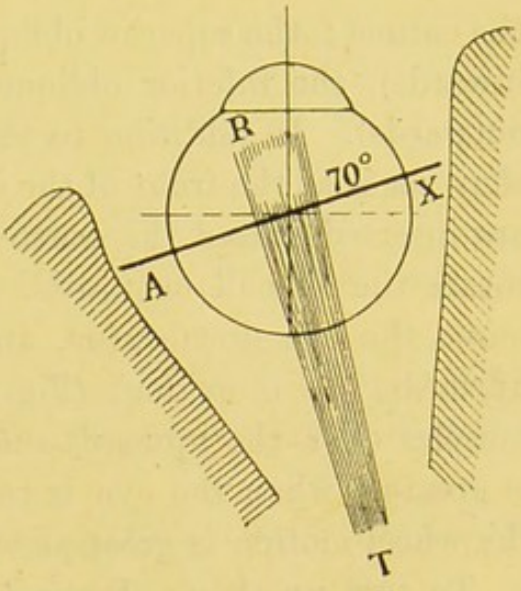


FIG. 164.—Left eye.

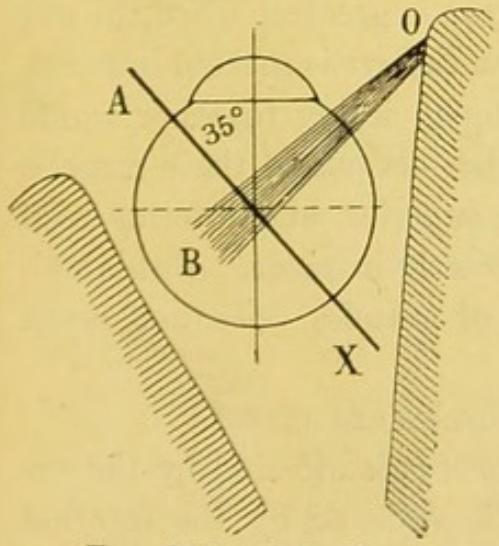


FIG. 165.—Left Eye.

The plane of the *Oblique Muscles* of the eyeball also approaches the antero-posterior vertical plane of the eyeball, the axis upon which they rotate the latter passing from within and behind, forwards and outwards, and making with the antero-posterior axis an angle of 35° (Fig. 165). The principal action, accordingly, of the oblique muscles is to incline the vertical meridian of

[1] In speaking of the inclination of the vertical meridian of the cornea it is the upper extremity of this meridian which is meant. Inward means toward the nose or median plane of the head, and outward towards the temple. These wheel-motions are sometimes designated by the terms intorsion and extorsion.

the cornea ; the superior oblique inclines it inwards (wheel-motion inwards), the inferior oblique inclines it outwards (wheel-motion outwards). In addition to this, since the fixed point from which they act is at the front of the inner side of the orbit, and since they are inserted *behind* the centre of rotation, they will each of them rotate the eyeball outwards. Moreover, the superior oblique will move the eye downwards, and the inferior oblique will move it upwards. It is evident (Fig. 165) that the power of the oblique muscles over the upward and downward motions of the eyeball is greatest when the eye is turned in, and that their power over the wheel-motion is greatest when the eye is turned out.

To sum up then : *Vertical motion.*—The recti move the eye in the direction indicated by their names, the superior upwards and the inferior downwards. The obliques move the eye in the opposite direction to their names, the superior oblique moving it downwards, and the inferior oblique upwards.

Horizontal motion.—The recti move the eye inwards, the obliques move it outwards.

Wheel-motion (torsion).—The superior (rectus and oblique) muscles rotate the vertical meridian inwards ; the inferior (rectus and oblique) muscles rotate the vertical meridian outwards. The action of the obliques on the wheel-motion is greatest when the eye is rotated outwards, and of the recti when the eye is rotated inwards.

It may also be noted that the obliques acting together would move the eye directly outwards, the other actions of these muscles neutralising each other ; similarly the superior and inferior recti acting together would rotate the eye directly inwards. But simultaneous action of these several pairs of muscles does not occur under normal conditions.

1. *In the Primary Position* all the muscles are at rest.

2. Motion of the eyeball *directly outwards* is affected by the external rectus alone, and motion *directly inwards* by the internal rectus alone.

3. Motion of the eyeball *directly upwards* and *directly downwards* is effected chiefly by aid of the superior and inferior recti. But these muscles acting alone rotate the eye slightly inwards, and tilt the vertical meridian, which in this position should be upright. The assistance of the obliques is therefore necessary to counteract these subsidiary effects. For example, the superior rectus moves

the eye upwards and inwards, and inclines the vertical meridian inwards ; the inferior oblique moves it also upwards, but at the same time turns it outwards, and inclines the vertical meridian outwards, so that when the two muscles act together, the second and third effects mentioned neutralise each other, and the result is a vertical motion upwards. Similarly, the inferior rectus requires the assistance of the superior oblique.

In oblique positions of the eyes, the vertical meridian no longer remains vertical but becomes tilted, as shown in Fig. 166 (compare with Fig. 171).

4. Rotation *upwards and outwards* is effected by the superior

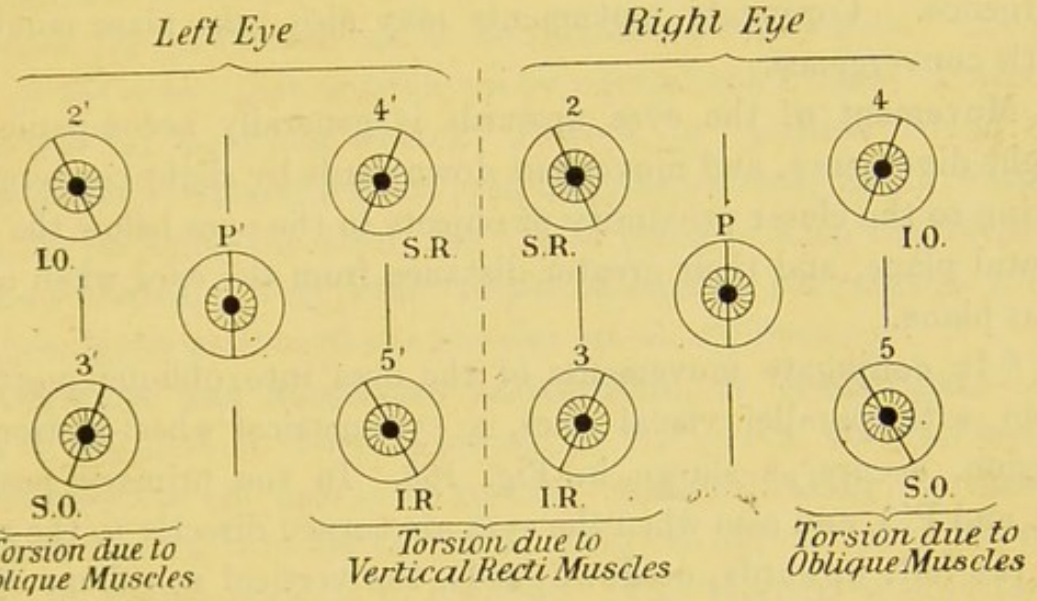


FIG. 166.—Illustrates the torsion of the vertical meridian in oblique positions of the eyes. In motions of both eyes the meridians are inclined in the same manner, as at 2 and 2′, 3 and 3′ and so on. Compare this with Fig. 171.

rectus, inferior oblique, and external rectus ; but since in an outward position of the eyeball the torsion effect of the obliques is at its greatest, while that of the recti is diminished or *nil*, the action of the inferior oblique in this respect will preponderate, and the vertical meridian will therefore be inclined *outwards* (2′ or 4, Fig. 166).

5. Rotation *downwards and outwards* is due to the action of the inferior rectus, superior oblique, and external rectus, and here also the torsion effect of the oblique muscle will prevail, and the vertical meridian will be inclined *inwards*. (3′ or 5, Fig. 166.)

6. *Upward and inward* rotation is produced by the superior rectus, inferior oblique and internal rectus, but in the inward position

of the eyes the torsion effect due to the rectus will prevail over that due to the inferior oblique, and the vertical meridian will thus be inclined *inwards*. (4′ and 2, Fig. 166.)

7. In rotation *downwards and inwards* the inferior rectus, superior oblique, and internal rectus act together; and, for the reason just mentioned, the vertical meridian will be inclined outwards by the inferior rectus. (5′ and 3, Fig. 166.)

The movements of each eye have been considered, so far, as taking place separately, but in reality the eyes move together, their movements being associated. Parallel movements of the eyes in various directions are called conjugate, while inward rotation of the eyes, for the purpose of fixation of near objects, is known as convergence. Conjugate movements may also take place combined with convergence.

Movement of the eyes upwards is generally accompanied by slight divergence, and movement downwards by slight convergence, owing to the closer proximity of objects to the eyes below the horizontal plane, and their greater distance from the eyes when above that plane.

* In conjugate movements of the eyes into oblique positions, even with parallel visual axes, a symmetrical wheel-motion, or torsion, occurs, as shown in Fig. 166. In the primary position (P. and P′.), and also when the eyes are turned directly to the right, to the left, upwards, or downwards, the vertical meridians of the corneæ (as indicated by the lines passing through the pupils), maintain their vertical direction. In other positions this meridian becomes tilted to one or other side, but in the same direction for each eye. For example, on looking to the left and upwards the inclination of the vertical meridian is to the left in both eyes (Fig. 166, 2′ and 2.). The effect of motion in the three other oblique positions is also shown. The explanation of this torsion has already been given when the movements of the eyes separately were discussed.[1]

* The muscles which act together in conjugate movements are said to be associates. The right internal rectus, for example, is

[1] This effect is often called "false torsion," because it is not directly due to the twisting of the eye on its antero-posterior axis, but to the fact that the rotation into the oblique position is accomplished by movement of the eye on an oblique axis, which lies in the equatorial plane (Listing's plane) of the eyeball.

the associate of the left external rectus, in movements of both eyes to the left. In the vertical movements directly upwards and downwards, the two muscles engaged in one eye are associated with the corresponding two muscles in the other eye; but, in the oblique positions, the muscles which are mainly associated in their action are those of which the names are opposed in every way. For example, in looking to the left and upwards (in addition to the lateral recti) the real associates are the *left superior rectus* and the *right inferior oblique*; because, in this position, the axis of the left eye lies in the plane of the recti muscles, while the axis of the right eye lies in the plane of the oblique muscles.

Conjugate motions and movements of convergence are the only motions of the eyes which can be accomplished voluntarily. Divergence of the eyes is not possible under normal conditions—it would be useless for binocular vision. Torsion, or rotation round an antero-posterior axis, which has been described above, occurs, within limits, on inclining the head, the object being to keep the vertical meridian vertical. Very slight torsion occurs on convergence also. But these latter actions of the muscles are all involuntary.

* **Objective and Subjective Localisation, or Orientation.**—An image of the field of vision is formed on the retina, and the image of each object in the field is 'projected' outwards along the secondary axis passing through the nodal point, or optical centre of the eye, to its proper position in the field. This relation of objects to one another in space is called *objective* localisation.

Subjective localisation consists in the appreciation of the position of the body and of the eyes in relation to external objects, and is gained chiefly through the sense of muscular effort necessary to bring the eyes into position for the fixation of those surrounding objects. Hence arises the false judgment of position and the resulting giddiness, caused by sudden loss of power in the orbital muscles.

* **The Field of Fixation.**—The field of fixation, which shows the range of mobility of the eyeball, contains all points that the eye can successively see or 'fix' with the macula lutea, without movement of the head. It can be measured with the perimeter, as in testing the field of vision, except that here the patient is made to move the eye as far as possible in each meridian, and the limit of each movement is measured by observing the corneal reflex of a candle flame,

or ophthalmoscope mirror, which is moved along the arc of the perimeter. The *binocular* field of fixation contains all points which can be seen as single with the two eyes and without movement of the head. The averages give, for movement of one eye, inwards 44°, outwards 46°, upwards 44°, and downwards 50°.

Strabismus.

When looking at any object with both eyes it is necessary, in order to avoid seeing double, that the visual axis of the eyes should meet at the point fixed. When this does not take place, one of the eyes must be in a faulty position, or, as it is commonly termed, it squints. This condition is called *Strabismus*, and may arise either from over-action or from paralysis of one of the muscles. Strabismus may occur in any direction, but vertical and oblique deviations are less common than the convergent or divergent forms.

In order to ascertain, in slight cases, which of the two is the deviating eye, the patient is made to fix an object, and one eye, say the left, is rapidly covered with the surgeon's hand; then, if the right eye, which is not covered, make no movement, it must have been looking at the object before the left one was covered; but if now, on covering the right eye, the left make a movement in order to fix the object, then this eye must be the squinting one. The movement is always in the opposite direction to the deviation. For instance, if the eye be turned inwards too much, it must of course turn outwards to fix the object, when its fellow is covered. Another good method consists in observing the position of the corneal reflex when the patient looks at the ophthalmoscope (see Measurement of Strabismus). But the most delicate test is the character of the diplopia, if diplopia be present.

Apparent Strabismus is due to a large angle γ (p. 3). In this case, as the visual axes are both directed to the point fixed, there will be no movement of either eye on covering the other, as in true strabismus.

Real Strabismus may be Paralytic, Concomitant, or Latent.

* **Latent Strabismus,** also called **Muscular Insufficiency** or **Heterophoria.**—In these cases strabismus only occurs in exceptional conditions, such as the use of tests which interfere with, or render more difficult, binocular vision. Under the usual conditions, binocular

vision is maintained in these cases, but this involves a muscular effort greater than normal, and hence these patients suffer from muscular asthenopia.

Binocular Vision. Sense of Fusion.—When an object is looked at, the visual axes meet at that object or point of fixation (*binocular fixation*), and the two retinal images are fused into one by a cerebral process, so that the object appears single. This constitutes *binocular single vision*. All objects situated about the same distance from the eyes and in that portion of the field which is common to both, form images on corresponding parts of the retinæ, and they too are perceived as single. The slight differences in the images of an object as seen from the point of view of each eye generate the perception of relief or stereoscopic vision, which is the highest grade of binocular vision. The *fusion sense—i.e.* the mental desire for single vision—develops in infancy, but in different individuals it exists in different degrees. Binocular fixation may, for instance, be present without true fusion, only one of the images being perceived, while the other is suppressed; as is proved by the inability sometimes to produce double vision by means of a prism. Not only this, but the sense of fusion is more easily disturbed in some persons than in others, when binocular vision is rendered difficult by artificial means.

The existence or otherwise of true binocular vision may be ascertained by the simple experiment of giving the patient a book to read, and then holding a cedar pencil halfway between his eyes and the page, at right angles to the lines of type. If binocular vision be present, the pencil will not offer any impediment to the reading; but, if it be not present, parts of the page will be hidden behind the pencil. The reader may prove this by performing the experiment on himself, first with both eyes open (binocular vision), and then with one eye shut.

Another method is that known as Hering's Drop Experiment. A hollow cylinder about 25 cm. long, and wide enough to take in both eyes of a person, is provided—at the opposite end from that placed around the eyes—with two strong wires 18 inches long, which jut out in continuation, as it were, of the cylinder, but which are bent outwards sufficiently to keep them out of the view of the patient. Between the ends of these wires a fine thread is stretched, with a small bead fastened at its middle point, so that the bead may occupy the centre of the field when the patient looks through the cylinder.

During the experiment the thread is in the horizontal position, and the bead is used as the patient's fixation point. Small balls of different sizes (peas, beans, etc.) are then let fall from a height, one after another, a couple of dozen times or more, some of them in front of the thread, some of them behind it. If the patient have normal binocular vision, he will be able to say each time with certainty whether the ball falls in front of, or behind the thread; but if he have not true binocular vision, if only one eye be used, he will merely guess at the position of the falling ball, and will make frequent mistakes.

Binocular Vision can also be tested by the stereoscope in its various forms, or by the amblyoscope, the diploscope, or diaphragm test.

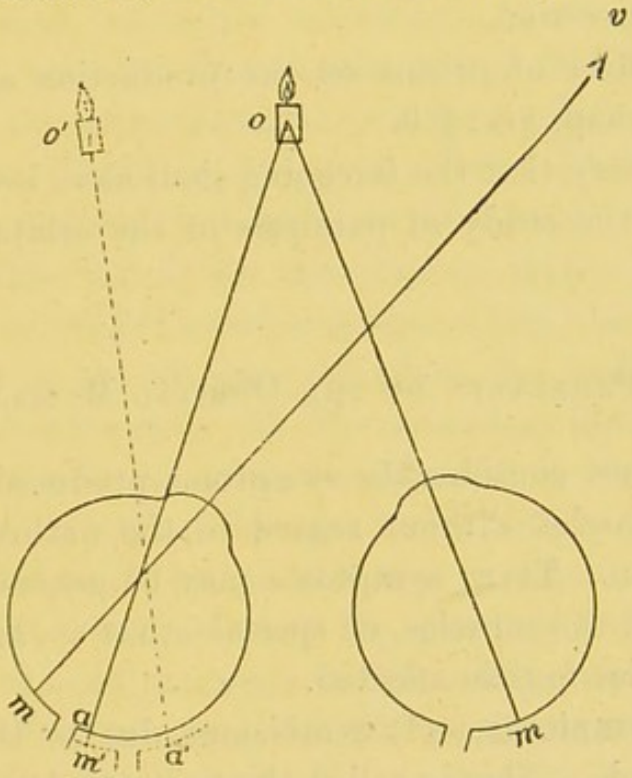
Diplopia, or double vision, always occurs in the absence of binocular fixation—*i.e.* when strabismus is present—provided binocular vision had previously existed. One image is seen by each eye, and the double vision disappears on closing one eye. This is binocular diplopia, as distinguished from monocular diplopia, in which two images are formed on the retina of one eye, as the result of irregular refraction (incipient cataract, dislocated lens, irregular astigmatism, double pupil).

The image seen by the eye which looks at, or fixes, the object is called the 'true image.' That which corresponds with the deviated eye is the 'false image'; and, as it does not lie on the macula lutea, it appears less distinct than the former. The false image always appears to the patient to be, or is 'projected' by him, in the opposite direction to the displacement of the eye, so that the diplopia is the reverse of the position of the eyes.

When the image seen by the affected eye lies to the corresponding side, the diplopia is termed homonymous. *Homonymous double vision* therefore always indicates *convergence* of the visual lines. Fig. 167 explains the occurrence of homonymous diplopia in convergent paralytic strabismus.[1] The right eye fixes the object *o*, and its image falls on the macula lutea *m*; but the left eye, by reason of paralysis of the external rectus, is turned in, and its visual axis lies in the direction *m v*, and the image of *o* falls to the inner

[1] For the sake of simplicity in the diagram the effect which rotation of the eye has on the nodal point is omitted.

side of the macula lutea at *a*. Now why should this image not be referred to its correct position along the line *a o*? The reason is that the patient is not conscious of the deviation of this eye; and, having always been in the habit of superposing his fields of vision, so that the visual axes of the eyes meet at the object fixed, he imagines this to be still the case, and that *v m* lies in the position of *o a*, and that the macula lutea *m* is at *m'*. But if this were so, *a* would be at *a'*, and in this position of the eye, images formed at *a'* to the inner side of the macula lutea are projected to the outer side of the field, along the line *a' o'*, and the patient imagines that *o* occupies the position *o'*, as seen with the left eye.



Left Eye. Right Eye.

FIG. 167.

If the left eye were deviated outwards, the image of *o* would fall to the outside of the macula, and would therefore be projected to the right of the true position of the object. The right image would then belong to the left eye and *vice versa*; this is *crossed diplopia*, and indicates *divergence* of the visual lines. A very simple experiment will prove this: when a finger is held up in front of the eyes, and a distant object is fixed, it will be noticed that the finger is seen double; if now the right eye be closed, the left image of the finger will vanish. The diplopia here is crossed because the convergence of the eyes is less than that required for fixing the finger—there is, in

fact, a relative divergence. If the finger be now fixed, a bright object farther away will be seen double, but the diplopia will be homonymous, because the eyes are convergent. This is a physiological diplopia, to which we habitually pay no attention, and as the images are formed on parts of the retina other than the macula lutea, we are not disturbed by its existence, although it unconsciously enables us to locate the position of objects as being nearer or farther than the object fixed.

When an eye is deviated upwards or downwards, the corresponding image is projected downwards or upwards; and torsion of the vertical meridian in one direction produces a tilting of the image in the opposite direction.

For the effect of prisms on the production and correction of diplopia, see chap. xiv. § 9.

It is necessary that the foregoing shall have been clearly understood, before the study of paralysis of the orbital muscles is approached.

Paralyses of the Orbital Muscles.

We shall now consider the symptoms produced by paralysis of the orbital muscles without regard to the nature or seat of the causative lesion. These symptoms may be general, that is to say, common to all the muscles, or special—that is to say, dependent on the particular muscle affected.

General Symptoms.—(1) Strabismus due to the action of the opponent muscle. This is called the primary deviation. (2) Loss or diminution of movement in the direction of normal action of the affected muscles. (3) Diplopia, due to the strabismus; or, if the paralysis be but slight, actual diplopia may not be present, but the double images overlapping each other will cause dimness or confusion of sight. (4) Giddiness and uncertain gait, due partly to the diplopia, and partly to faulty projection of the object. (5) False projection, by which is meant the false conception of the position of the image in the field of fixation. It causes difficulty in walking and working, and is most noticeable when a depressor muscle is affected. (6) Some patients turn the head towards the side of the paralysed muscle, in order to diminish or eliminate the diplopia—*e.g.* if the left ext. rectus were paralysed, the head would be turned towards

the left; if it were the left int. rectus, the head would be turned towards the right. By this manœuvre the loss of the action of the affected muscle is less felt for those objects which lie straight in the patient's path, while he walks about; because it involves a rotation of the eye towards the side of the healthy antagonist, in which region of the binocular fixation field the diplopia is reduced to a minimum. Some patients close one eye to procure single vision. It will be noted that 1, 2, and 6 are objective symptoms, while 3, 4, and 5 are subjective.

In peripheral paralysis it is most common to find only the muscle, or muscles, supplied by some one nerve—the third, fourth, or sixth —affected; although, of course, exceptions to this are not rare especially where a neoplasm forms at the base of the skull.

In studying a case of paralysis of an orbital muscle the following *General Principles* should be borne in mind:—(1) The defective mobility and the diplopia increase towards the side of the affected muscle—towards the left, if the left external rectus be paralysed; towards the right, if the left internal rectus be paralysed. The image which is farthest in the direction in which the diplopia increases belongs to the paralysed eye. (2) The secondary deviation (*i.e.* the deviation of the sound eye while the affected eye fixes) is greater than the primary deviation; because the muscle in the sound eye, which is associated in its action with the paralysed muscle in the affected eye (*e.g.* the rect. int. with the rect. ext.), must receive a nervous impulse of equal intensity to that sent to the weak muscle, and, as the latter requires a considerable impulse to excite its action, its associate will be over-excited. Let us suppose the left external rectus to be paralysed, and that, shading the right eye with a hand, we direct the patient to fix with his left eye an object held somewhat to his left side; we may notice, on removing the shading hand, that the right eye has been rotated inwards to an extent far exceeding that of the primary deviation of the left eye, and has now to make an outward motion in order again to fix the object. (3) The image formed on the retina of the affected eye is projected (*i.e.* seems to the patient to lie) in the direction of the paralysed muscle; in other words the position of the false image corresponds with the normal action of the paralysed muscle, because the deviation of the eye is in the opposite direction to the action of the paralysed muscle—*e.g.* if the left ext. rect. be paralysed, the image corresponding with

that eye will be projected to the left of the image belonging to the right eye. (See Diplopia, p. 470.) When the affected eye fixes alone, the faulty projection is twice as great as when fixation is binocular. (See General Principle, No. 2.)

The deviation of the eye, the strabismus, alone is in the opposite direction to the paralysed muscle; all the other signs, defective mobility, false projection, increase of diplopia, secondary deviation, and position of the head, are towards the paralysed muscle.

The SPECIAL SYMPTOMS due to paralysis of individual muscles will now be considered.

Paralysis of the External Rectus of the Left Eye.—If this be complete or considerable, it is easy of diagnosis, for along with convergent strabismus there is marked loss of power and motion of the left eyeball outwards, and the patient complains of double vision. He keeps his head turned to the left, in order to diminish the influence of the paralysed muscle as much as possible.

If, however, the paralysis be but slight, the patient may not complain decidedly of diplopia, but only of indistinctness or confusion of sight, especially when he looks towards the left. To decide the diagnosis in such a case, the double images must be examined. A long lighted candle is used as the object to be looked at; and one eye—let us say here the left eye—is covered with a bit of red-stained glass in order to differentiate the images.[1] The candle is now held on a level with the patient's eyes, and straight opposite him, at about three metres' distance (eyes in primary position). (*a*) In this position the images are seen very close together or overlapping each other, both of them upright and on the same level, the red candle to the left, the white to the right—*i.e.* homonymous diplopia = convergence. This convergence must be due to paralysis of one or other external rectus muscle, but we cannot say at this stage of the experiment which of them is affected. (*b*) In order to determine this point the candle must be carried from side to side, and the increasing or decreasing distance of the images from each other noted. If the candle be carried slowly to the right, the patient following it with his eyes without turning his head, the images come closer together, or only one candle is seen. But if the candle be carried to

[1] Maddox's Rod Test, described further on, is very suitable here, and in the investigation of other forms of ocular palsy.

the patient's left, the images go farther apart, their relative positions being maintained. We now know that it is the left external rectus which is affected : because towards the left—the direction in which the action of this muscle is most wanted, and consequently its loss most felt—the distance between the double images increases. The images are erect, as no wheel-motion is caused by action of the external rectus. (*c*) If, however, the candle be held to the left and raised aloft, the image belonging to the left eye will seem to lean away from, and to be a little lower than, that of the right eye (Fig. 168). The reason of this is that, owing to the paralysis of the external rectus, the left eye cannot look sufficiently outwards, but merely looks upwards. The inferior oblique loses some of its torsional power, but retains a greater power of elevation. The left eye therefore is higher than the right, and its vertical meridian remains vertical. But the right eye, which is free to follow the candle, looks up and to the left. Its vertical meridian is therefore inclined to the left. That is, the vertical meridians of the two eyes converge at the top, which necessitates a divergence of the upper extremities of the images. The rotation of the right eye in this position is physiological, and its image is therefore judged to be vertical ; while the image of the left eye diverging from that of the right, though really vertical, is judged to be oblique. An analogous displacement of the eye downwards, and defective rotation of the vertical meridian due to the superior oblique, takes place in the position below and to the outside. (*d*) If the patient be told to direct his gaze specially towards the red candle—*i.e.* the image which belongs to the left, the affected, eye—the distance between the two candles will be much greater than if he direct his gaze towards the white candle. This is explained by General Principle No. 2 (p. 473).

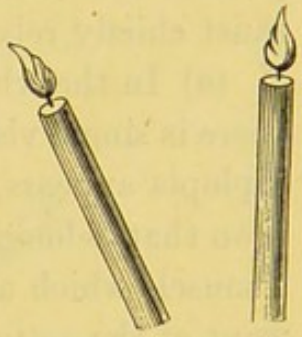


FIG. 168.

If the patient's good eye be closed, and an object (surgeon's finger) be held up within his reach, but towards his left side, and he be requested to aim rapidly at it with his forefinger, he will aim to the left of it. The nervous impulse sent to his left external rectus, to enable him to turn the eye towards the object, is of such intensity as to lead him to fancy that the object lies much farther to the left than is the case (incorrect projection of the field of view) ; for we, to

a great extent, estimate the distance of objects from each other by the amount of nervous impulse supplied to our orbital muscles in motions of the eyeball.

A prism held horizontally before the affected eye with its base outwards brings the double images closer together; or, if the correct prism be selected, the images will be blended into one.

* **Paralysis of the Superior Oblique of the Left Eye.**—This paralysis will be most apparent when a demand is made for motion of the eyeball downwards and inwards, the action of the superior oblique as a depressor being greatest in this position. Yet absolute defect of motion is sometimes difficult to detect, even in complete paralysis of this muscle, owing to vicarious action of the inferior rectus and of the internal rectus. Careful examination of the secondary deviation will often be successful as to this point. But it is on the examination of the double images that we must chiefly rely for the diagnosis, as follows :—

(*a*) In the whole of the field of vision above the horizontal plane there is single vision. Below the horizontal plane in the median line diplopia appears, the image belonging to the left eye standing lower than that belonging to the right : because the superior oblique being a muscle which assists in rotating the eye downwards, the latter, for want of the action of this muscle, now stands higher than its fellow (right eye). The position downwards and inwards of the eyeballs is that in which the greatest demand is made upon the superior oblique for rotation of the eye downwards : therefore it is in this position its want for this purpose is most felt ; and when the candle is held in this position, the vertical distance between the double images is greatest. (*b*) The superior oblique assists also in rotation of the eye outwards : therefore loss of its power must commit the eyeball to a certain extent to the power of the muscles which move it inwards, and a rotation in this latter direction (convergence) takes place, with the result of making the image belonging to the left eye stand to the left of the image belonging to the right eye (homonymous diplopia). (*c*) The superior oblique inclines the vertical meridian inwards : therefore, in rotation directly downwards, loss of its power commits the eye to the outward wheel-motion imparted to it by the inferior rectus. This gives to the image belonging to the left eye an inclination to the patient's right hand. (*d*) The power of the superior oblique to incline the vertical meridian inwards is greatest when the

eye is turned downwards and outwards: consequently, in this respect its paralysis will be felt chiefly in this position, and therefore here the inclination of its image to that of the sound eye will be most marked. (*e*) A remarkable phenomenon usually noticed in this paralysis (and sometimes in paralysis of the inferior rectus), is that the image belonging to the affected eye seems to stand nearer the patient than that of the sound eye. This, it is believed, is due to the fact that the lower image is projected on a plane nearer to the patient, say where it appears to meet the floor.

To sum up, then (Fig. 169): below the horizontal plane there is homonymous diplopia, while the image (*A*) of the affected eye stands on a lower level, is inclined towards the other image, and seems to be nearer the patient. Furthermore:—

(*f*) In an extreme lower and outer position the image of the affected eye may sometimes seem to stand higher than that of the sound eye, owing to an excessive outward inclination of the vertical meridian, which throws the image on the lower and inner quadrant of the retina.

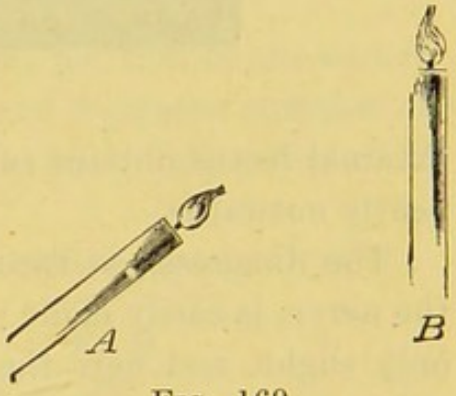


FIG. 169.

In order to do away with or to diminish the diplopia, the patient inclines his head forwards and towards the right shoulder, and turns his face towards the side of the good eye.

For the prismatic correction of the diplopia, two prisms will be required; one with its base downwards in front of the left eye, to correct the vertical difference, and a second with its base outwards in front of the right eye, to correct the lateral difference, or it may be possible to correct it by a single prism in an oblique position.

Paralysis of the Third Nerve (Internal Rectus, Superior Rectus, Inferior Rectus, Inferior Oblique, and Levator Palpebræ).—Complete paralysis of all the branches of the third nerve produces a remarkable appearance. The upper lid droops (ptosis), the eyebrow is raised—from compensatory action of the occipito-frontalis—the pupil is semi-dilated and immovable, the power of accommodation is destroyed, and the eyeball is often slightly protruded, owing to the backward traction of the recti being wanting. There is divergent strabismus. Motion inwards exists but to a slight degree, and motion

downwards and outwards is effected only by aid of the superior oblique, and is accompanied by marked inward wheel-motion, which can be detected best by noting the change in position of a conjunctival vessel. If the paralysis be of some little standing, the

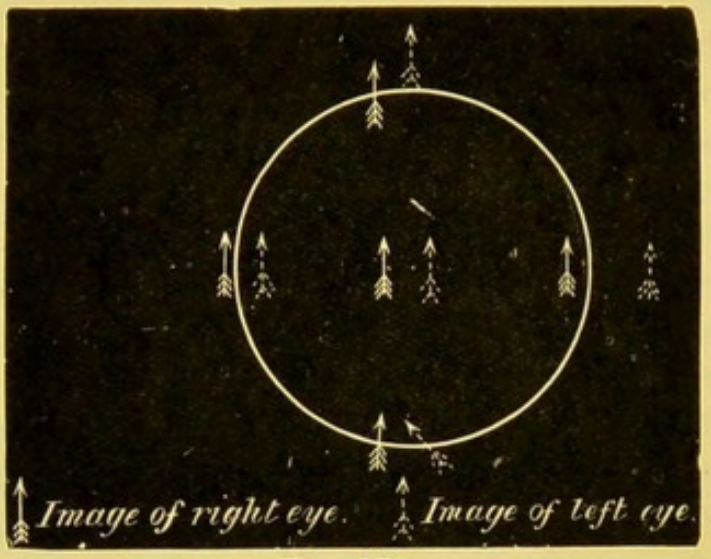


FIG. 170.

external rectus obtains rule over the eyeball, and rotates it permanently outwards.

The diagnosis, in cases of complete paralysis of all branches of the nerve, is easily made ; but not so sometimes, if the paralysis be only slight, and here the examination of the double images is of value, as follows :—

If (Fig. 170) the left third nerve be partially paralysed in all or most of its branches, there will be crossed diplopia either in the whole of the field of vision—for want of power in the internal rectus —or towards the patient's right at the least, and the lateral distance between the images will increase as the visual object is carried farther towards the right. When the visual object is held aloft the left eye will not follow it—for want of the action of the two muscles which turn the eye upwards—and, consequently, in this position its image will stand, not only to the right of but also above that of the right eye ; while, when the visual object is held below the horizontal plane, the eye will—owing to paralysis of the inferior rectus—remain higher than the right eye, and consequently its image will appear to be lower than that of the right eye. It will, moreover, be inclined towards the latter image, in consequence of the inward wheel-motion imparted to the eye by the healthy superior oblique.

When some branches of the third nerve are paralysed in each eye, the diagnosis is often extremely complicated. The ptosis, however, which is nearly always present, and is readily recognised, and the paralysis of the sphincter iridis (mydriasis) and of accommodation, which often exist, and are also easily observed, give valuable aid. Moreover, any loss of motion upwards must be due to paralysis of the third nerve; but if there be loss of motion downwards, the differential diagnosis between paralysis of the inferior rectus (3rd Nerve) and of the superior oblique (4th Nerve) has to be made. For this see the paragraph on paralysis of the latter muscle.

As may be imagined from the foregoing, it is often difficult in practice to keep clearly before one's mind the different actions of the orbital muscles, and from the character of the diplopia to deduce the paralysis which may be present. The mnemonic diagram here given (Fig. 171) will assist in this respect, and it will serve also as a control in reasoning on this subject.

The larger circles in Fig. 171 indicate the position of the cornea resulting from the action of the elevator and depressor muscles of the eye, the smaller central circles represent the pupils. R and R

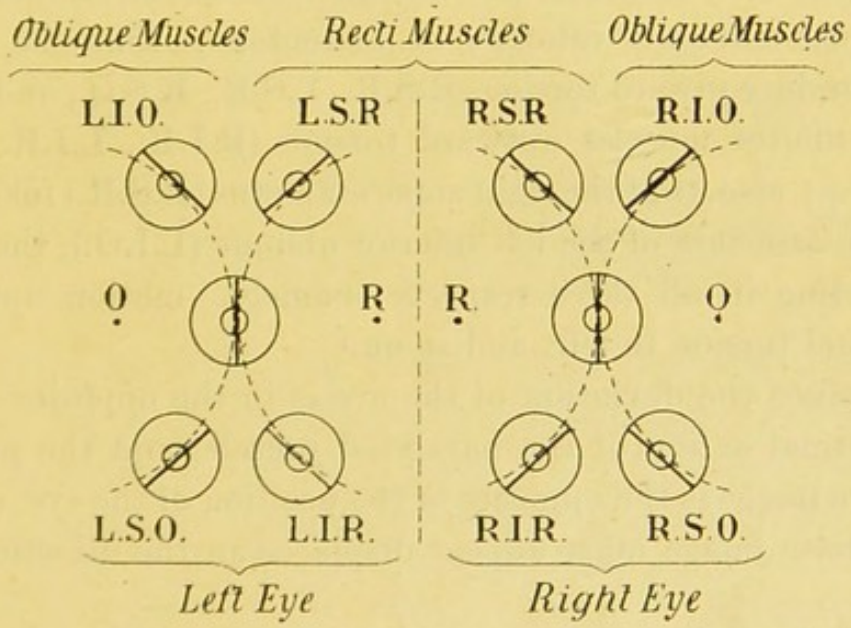


FIG. 171.—Diagram illustrating the separate actions of the elevator and depressor muscles. R.I.O. = Right Inferior Oblique, and so on.

represent the anterior extremities of the axes of rotation of the recti muscles, which lie to the inner side of the cornea, and O and O similarly the extremities of the axis of rotation of the obliques at the outer side of the cornea. The dotted arcs of circles are those

described by the centre of the cornea in rotation of the eyes on these axes. The two central arcs with their concavities towards each other represent the action of the recti muscles, and the two outer arcs the action of the obliques. The vertical meridian of the cornea, indicated by a line passing through its centre, is tangential to the circles described by the centre of the cornea, and consequently, when one muscle acts at a time, this meridian can be vertical only in the primary position.

Now, to find the action of the right superior rectus, it is merely necessary to look at the right superior quarter of the centre of the figure (R.S.R.) and it will be seen at once that this muscle moves the eye inwards, upwards, and inclines the vertical meridian inwards. In the same way the action of an oblique muscle will be found in the outer portion of the figure on its own side, but as the vertical action of the obliques is in a direction opposite to that indicated by their names, the superior oblique will be found below and the inferior above. The action of the left inferior oblique is found in the outer portion of the figure, on the left side, above (L.I.O).

Many facts can at once be understood by reference to the figure: for example, that the recti are inward rotators or adductors, and the obliques outward rotators or abductors; that the superior muscles produce inward torsion (R.S.R., L.S.R., R.S.O., and L.S.O.), and the inferior muscles outward torsion (R.I.R., L.I.R., R.I.O., and L.I.O.); also, that the right superior rectus (R.S.R.) for instance, is the true associate of the left inferior oblique (L.I.O.), their action corresponding in all three respects—namely, motion upward, to the left, and torsion to left, and so on.[1]

Now, since the deviation of the eye is in the opposite direction to the normal action of the paralysed muscle, and the projection of the false image is the opposite of the position of the eye, it follows that the false image must appear displaced in the direction of the

[1] The action of the muscles is considered as if the observer were looking at his own eyes from behind. This view is taken in order that this figure may correspond with Fig. 172, illustrating the diplopia, in which also the observer considers himself to be the patient. To be quite accurate it should be remembered that as the cornea moves out of the primary position, it comes to lie more and more behind the plane of the paper in the figure. In fact the arcs of circles are seen sideways and therefore appear elliptical. The idea of this figure was suggested by Landolt's method of demonstrating the action of the muscles on a rubber ball.

action of the muscle, therefore Fig. 172, illustrating the diplopia, is practically the same as Fig. 171.

In Fig. 172 the form of diplopia which characterises paralysis of each muscle is expressed by the position of the dotted candle bearing the name of the muscle. The dotted lines represent the false images belonging to the affected eye, the continuous lines the true images belonging to the unaffected eye.

In the case of the recti, the false images enclose a lozenge-shaped space in the centre of the figure, whereas the false images corresponding with the obliques will be found in the outer portions. It will also be noted that the dotted lines extend upwards and downwards beyond the others, indicating respectively that the false images are higher or lower than the true ones. Another fact which the diagram

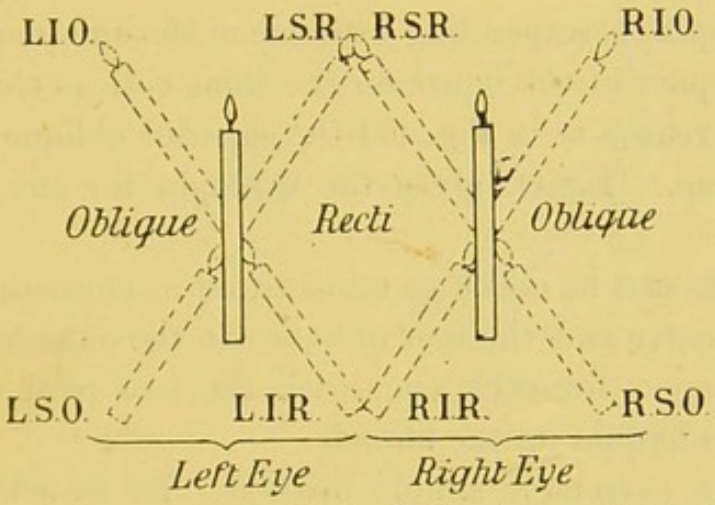


FIG. 172.—Diagram of the diplopia due to paralysis of any one of the elevator or depressor muscles.[1]

indicates is that, in the case of the muscles represented in the upper halves of the figures, the diplopia occurs in the *upper* part of the field of fixation, or, in other words, in upward movements of the eyes. A similar rule holds good with regard to the lower halves.

The method of using the diagrams will be better understood by taking a particular muscle as an example. Suppose, for instance,

[1] Fig. 172 is a combination of two mnemonic diagrams which appeared in previous editions of this book. They have been so combined in order to correspond exactly with Fig. 171, illustrating the action of the muscles. A comparison of Figs. 166, 171, and 172 will reveal that they are practically the same, and that Fig. 171 which shows the action of the muscles will consequently also represent the diplopia characteristic of each muscle, and also the torsion which occurs in extreme oblique positions. (L. W.)

that we wish to know what kind of diplopia results from paralysis of the *left inferior* rectus, it is simply necessary to look at the *left inferior* part of the centre of the figure (recti), which gives the diplopia. If we analyse this we find (1) that the diplopia is *crossed*, for the false image corresponding with the *left* eye is on the *right* of the true image —*i.e.* the right image corresponds with the left eye; (2) that the false image has its *upper end inclined towards the true one*; (3) that the false image is *lower* than the true one, for the dotted line extends *lower* than the other one; (4) that the diplopia occurs in *downward* movements of the eyes, for it is in the *lower* half of the diagram that the false image lies.

The same method applies to the other recti: the diplopia for the *right upper* rectus is found in the *right upper* quadrant, and so on for the rest.

The diplopia corresponding with one of the obliques will be found in the outer part of the figure on the same side as the muscle, and for the same reason as in Fig. 171 the superior oblique will be below and *vice versa*. L.S.O. gives the diplopia for the left superior oblique.

The figures can be called to mind either as consisting of the four recti in the centre and the four obliques at the outsides, or as being made up of an × for each eye, with the two recti on the inside and the two obliques on the outside.

This is an extremely simple method. By bearing the figures in mind it is possible to tell immediately what kind of diplopia would result from paralysis of any one of these muscles, and conversely, given the diplopia, to determine to which muscle it is due. Fig. 172 may be used alone, without reference to the action of the muscles, when there is little time for thought.

* Some of the paralyses seem to resemble one another very closely in the form of the diplopia produced; for example, paralysis of the left superior oblique, and of the right inferior rectus, in which the diplopia occurs in both cases below the horizontal plane, and the false image is to the left of, and lower than, the true one, and inclined towards it. The distinction is made by observing that the false image belongs to the left eye (homonymous diplopia) in the case of the oblique muscle, and to the right eye (crossed diplopia) in the case of the rectus. Figs. 173 and 174 explain this.

Again, as Duane points out, the position of the eye in which the vertical element of the diplopia is at its maximum is of the greatest importance for the diagnosis of the muscle at fault, in the case of the elevators and depressors. In the above cases, for instance, the vertical separation of the images in paralysis of the left superior oblique will be at its greatest, when an attempt is made to turn the eye downwards and *inwards*; and the maximum deviation in this respect, in the case of the left inferior rectus, will be found when the eye looks downwards and *outwards* (p. 463).

* In case the diplopia does not correspond with any of the recognised forms characteristic of paralysis of any single muscle, the condition becomes complicated, and the solution of the question as to which muscles are at fault is frequently impossible, but there

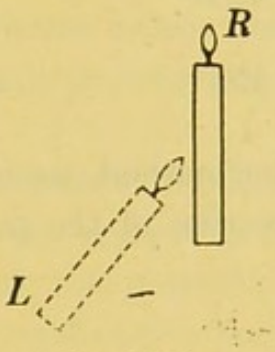


FIG. 173.

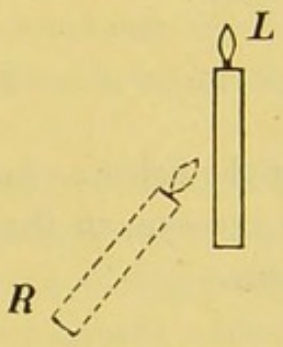


FIG. 174.

Fig. 173.—Paralysis of left sup. oblique. Homonymous diplopia. R, image of right eye. L, image of left eye.

Fig. 174.—Paralysis of right inferior rectus. Crossed diplopia. R, image of right eye. L, image of left eye.

are two very simple causes through which the nature of the diplopia may be changed and which should be mentioned. In the first place the patient may fix with the paralysed eye, and when this occurs the image belonging to it will seem to him to be in a correct position, and that of the other eye will be apparently displaced. It is merely necessary to suppose that the diagram of the diplopia in the particular case is rotated, so that the image belonging to the paralysed eye becomes vertical. For example, Fig. 175 in this case would be converted into Fig. 176.

* Again, if paralysis of an elevator or depressor occurs in a patient with a latent horizontal deviation, either convergence or divergence, a crossed or homonymous diplopia may be reversed, on account of the latent deviation becoming manifest in con-

sequence of the impossibility of fusing the images, and thus Fig. 175 would be changed to Fig. 177.

* *Measurement of the degree of paralysis* is useful for prognosis, and also for estimating the progress of the case. It may be measured by noting the amount of separation of the double images. Maddox's rod-test with scale is very suitable for this, or the prism required to correct the diplopia may be noted, the deviation being equal to

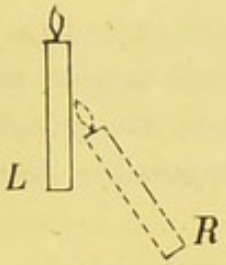


FIG. 175.

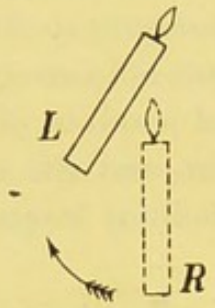


FIG. 176.

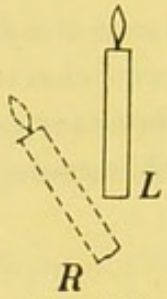


FIG. 177.

half the angle of the prism. Another method consists in measuring the mobility of the eye, in the direction of the paralysed muscle, with the perimeter.

THE CAUSES OF PARALYSES OF ORBITAL MUSCLES.

Loss of power of one or more of the muscles of the eyeball is, of course, always to be regarded as a symptom, not as a disease.

This loss of power may be due to lesions in several different situations, namely :—(1) Lesions situated in the orbit. (2) Basic lesions —*i.e.* lesions situated at the sphenoidal fissure, and those at the base of the skull, between the sphenoidal fissure and the pons. (3) Pontine lesions, which may be Fascicular—*i.e.* involving the ocular nerve fibres in the substance of the pons—or Nuclear—*i.e.* only attacking the nuclei of the nerves in the aqueduct of Sylvius and floor of the fourth ventricle. (4) Cerebral lesions—*i.e.* supra-nuclear, in the internal capsule, corona radiata, or cortex. These four classes differ considerably in their clinical aspect, in their pathological causes, and in their significance for the well-being of the patient.

The first class—loss of power due to orbital lesions—will be considered in the chapter on Diseases of the Orbit.

The second class—those due to basic lesions—provides by far the largest number of cases of paralyses of the orbital muscles. Basic paralyses are chiefly of rheumatic or syphilitic nature.

Rheumatic paralysis, to which the external rectus is specially prone, will be noted if there be symptoms of general rheumatism, or if there be a history of exposure to cold or wet immediately preceding the attack.

Syphilis will be suggested as a cause, if there be a specific history, and that other causes can be excluded. Peripheral paralyses of the orbital muscles due to syphilis are amongst the later symptoms of the disease, and may depend on exostoses or gummata at the base of the skull, or to syphilitic neoplasms, or meningitis, in the course of the nerve. The third nerve seems to be particularly liable to be attacked by a solitary gumma at the base of the skull, especially at the sphenoidal fissure, ptosis being commonly the first symptom.

Other neoplastic growths can, of course, cause these paralyses in the same way.

Fracture of the base of the skull may be indicated by a fourth nerve paralysis, as the only symptom, due to injury of the nerve as it passes over the apex of the petrous portion of the temporal bone, but paralysis of the sixth nerve is more common with this lesion.

In the diagnosis of a basal lesion as the cause of the paralysis, the gradual and successive involvement of different cranial nerves according to their anatomical position, or even independently of their anatomical arrangement, is suggestive ; as for example facial neuralgia, or anæsthesia occurring along with paralysis of ocular muscles. And the presence of atrophy of one or of both optic nerves, or of a bi-temporal hemianopsia, would furnish conclusive evidence of the basal origin of such paralysis.

Prognosis.—In peripheral paralyses recovery is very frequent ; much, however, depending on the nature of the lesion. In cases where a cure is not effected, the diplopia eventually becomes less troublesome and the antagonist muscle often contracted, the eye being then rotated permanently and excessively in the corresponding direction. In cases of old standing, a permanent contraction of the muscles of the neck may be brought about, from the inclination of the head which the diplopia has obliged the patient to adopt.

Treatment.—In these cases the medical treatment consists in drugs suitable to the fundamental disease (rheumatism, syphilis,

etc.). Local depletion at the temple by the artificial leech in the early stages, and galvanism later on, may be employed with advantage. The most common method of applying galvanism is through the closed lid; but it is probable that the episcleral method—*i.e.* with the electrode placed directly over the muscle—is more effectual. A good method is for the surgeon to take one rheophore, well wetted, in one hand, and, having secured good contact with the skin of the palm, the index finger is applied to the patient's globe in the situation of the various external muscles of the eye. The finger is covered with a single thickness of well-moistened muslin, and the conjunctiva should be previously rendered insensitive by cocaine. The other rheophore, a moistened plate, is placed on the nape of the patient's neck. The strength of the current advised is from 1·5 to 2 milliampères, and the alternate application and lifting of the finger, by closing and opening the circuit, gives rise to a feeling of a slight electric shock in the terminal point of the finger. The operator should first test the strength of the current upon the patient's cheek. The point of the finger thus employed acts as a sentient rheophore, and can be applied with nicety and delicacy to various parts of the eye, the operator being constantly aware, by the feeling in his finger, of the strength of the current employed.

Passive orthoptic treatment occasionally gives a rapid and brilliant result, while, again, it is useless. It is performed as follows:—The conjunctiva at the corneo-scleral margin, near the insertion of the paralysed muscle, is seized with a forceps, and the eyeball is drawn in the direction of the muscle, and as far as possible beyond its ordinary limit of contraction, and back again. These movements are continued for about a minute once a day, cocaine being used.

Prismatic glasses may be used, either to eliminate the diplopia, or to excite the weak muscle to exert itself. In the former case, the glass selected must completely neutralise the diplopia; but, as it can do so only for one position of the eyes, prisms are rarely employed in this way. In the latter case, a prism slightly weaker than that sufficient to completely neutralise the diplopia is selected, in order that, with a little effort, the weak muscle may be enabled to bring about single vision, and, this effort having been successfully maintained for some days, a still weaker prism is then prescribed, and so on. Since more than a 4° prism in each eye can seldom be worn,

and the diplopia varies in different positions, the use of prisms here is very limited.

It is important for the patient's comfort while awaiting his cure, unless a cure by prisms as above described is being attempted, that the affected eye should be covered, so that the distressing double vision may be obviated; or, better still, if it be a lateral muscle that is paralysed, by excluding only the half of the field of the defective eye in which diplopia occurs, it can take part in the act of vision in the remaining half of the field.

Surgical treatment is justifiable only when, after six months or a year, other means have failed to restore muscular equilibrium. Advancement of the paralysed muscle with, if necessary, tenotomy of the antagonist is indicated. Tenotomy of the associated muscle of the other eye is sometimes performed to establish equilibrium, but in this case a compensatory movement of the head must take place. This surgical treatment applied to the internal and external rectus sometimes gives satisfactory results; but in the cases of the superior and inferior recti it is less useful. The oblique muscles should not be operated on, but tenotomy of the associated muscle in the opposite eye (in the case of the R. sup. oblique, the L. inf. rectus) may give relief.

* A peculiar and rare form of peripheral or basal paralysis is **Intermitting Paralysis of the Third Nerve of one Eye,** sometimes inaccurately termed **Ophthalmoplegic Migraine.** The patients are generally children or young adults, who usually suffer, at long or short intervals, measured it may be by months or years, from attacks of headache on the side corresponding with the paralysed eye, and frequently from vomiting. This 'bilious attack' is attended, or soon followed, by paralysis of one or more branches of the third nerve. The paralysis may be complete or partial, and the attack varies in its duration from a few days to a few months. Excessive salivation, perspiration, or discharge from the nose occurs in a few cases. Some cases are purely periodical—*i.e.* in the intervals between the attacks of paralysis all the muscles supplied by the third nerve act in a completely normal manner; while in other cases these muscles, or some of them, do not completely recover their functions in the intervals. There are no visual symptoms such as occur in migraine, neither do the patients, as in migraine, belong chiefly to the intellectual classes. We are as yet quite in the dark as to the

cause of these periodical paralyses of the third nerve. It is possible that the purely periodical cases are of a functional nature—reflex, or due to recurrent toxæmia, possibly of gastro-intestinal origin—and that the periodically exacerbating cases alone are due to a lesion of the root of the nerve, of an undefined kind, at the base of the skull. In three cases of the latter kind, in which an autopsy was made, there was disease of the trunk of the nerve at the base of the skull.

In intermitting paralysis the *Prognosis* of the purely periodical form is favourable, inasmuch as the attacks in the course of time become fewer and less severe, until, finally, they entirely cease. In the exacerbating form the prognosis for complete recovery is less favourable. Out of twenty-six cases collected by Darquier only one patient died, and from a cerebral cause.

In view of the obscurity which still surrounds the causation of these intermitting paralyses their *Treatment* must consist, in each case, in the relief of any general dyscrasia or concomitant symptoms which may be present. Purgatives and drinking of hot water have proved of service in some cases.

The third class of paralyses of orbital muscles above enumerated —those due to lesions of the nuclei of the orbital muscles in the aqueduct of Sylvius and floor of the fourth ventricle—are known by the term

* **Ophthalmoplegia Externa,** and also as **Nuclear Paralysis.**—The first of these terms was originally employed to denote those remarkable cases in which all, or nearly all, of the orbital muscles of both eyes are paralysed, while the intra-ocular muscles often remain intact. There can be no doubt, however, that these cases do not differ in their nature from many of those in which, in one eye, several orbital muscles supplied by different nerves—*e.g.* third and fourth—are wholly or partially paralysed ; or where all the orbital muscles in one eye are wholly or partially paralysed ; or where in each eye muscles supplied by the same nerve—*e.g.* both sixth nerves—are wholly or partially paralysed ; for such cases are often mild forms of the disease, or else stages in its development. At one time it was considered essential for the diagnosis, that the intra-ocular muscles should retain their functions, but cases occur in which the sphincter iridis and ciliary muscle are paralysed.

When these two latter muscles alone are paralysed, the condition is called Ophthalmoplegia Interna. When both they and groups of

orbital muscles are paralysed the terms Ophthalmoplegia Interna et Externa, or Ophthalmoplegia Universa, are employed.

The term Nuclear Paralysis indicates any orbital paralysis due to a lesion of the nuclei of the orbital nerves in the pons, and ophthalmoplegia externa often comes within this category.

Ptosis, even in cases of complete binocular ophthalmoplegia externa, is often incomplete, and it is remarkable that in some chronic cases, without any improvement in the condition itself, the diplopia, which was at first present, quite disappears.

Occurrence and Progress.—The condition may be congenital, or may make its appearance soon after birth, and may remain permanently without becoming complicated with any further disturbance. Congenital ptosis, which is frequently combined with loss of power in the superior rectus, and is usually binocular, is of this nature. But Nuclear Paralysis is more commonly seen as an acquired condition in childhood, or in adult life, either in an acute or chronic form. Marked cerebral lethargy is often seen with both forms, and the tendon reflexes may be defective.

Acute Nuclear Paralysis is due either to an acute inflammatory process in the nuclei—comparable to the process which produces polio-myelitis anterior acuta, and hence it is called by Byrom Bramwell polio-myelitis acuta—or to hæmorrhagic lesions.

The acute inflammatory cases are apt to have a sudden onset, attended with fever, headache, vomiting, and convulsions, which may subside after a few days, leaving only the ophthalmoplegia behind ; and this, too, after a lengthened period, may undergo cure, partial or complete. Transient paralysis of conjugate movements often occur at the beginning of the attack. The intra-ocular muscles and levator palpebræ are often spared. Sometimes these attacks are complicated with paralysis of the facial nerve, or the diseased process may extend to the spinal cord, and the symptoms of acute polio-myelitis become developed ; or, again, acute bulbar paralysis may come on.

Acute peripheral neuritis of the ocular nerves, which is sometimes seen in cases of alcoholic poisoning, may be mistaken for acute nuclear palsy. The symptoms of the two states are the same, except that in the case of peripheral neuritis there are no head symptoms at the commencement.

The onset of acute hæmorrhagic ophthalmoplegia is sudden, but

is unattended by headache, vomiting, or convulsions. It takes different courses. Sometimes it is rapidly fatal; again, it goes on to softening of the nuclei, and becomes chronic; while, again, it undergoes a slow cure.

It is extremely probable that to this hæmorrhagic class some of the cases of paralysis of orbital muscles belong, which occasionally follow on an attack of diphtheritic sore-throat. These paralyses appear in from one to six weeks after the outbreak of the primary affection. The latter need not have been of a severe kind; indeed, sometimes patients are unaware that they have had a sore-throat. These diphtheritic paralyses always recover in the course of some weeks.

In diabetes, paralyses of orbital muscles are not very uncommon, and are probably to be classed as nuclear. The same may be said of orbital paralyses in lead poisoning, influenza, syphilis sometimes, and in Gerlier's disease (Vertige Paralysant). Other causes are:—cold, poisoning by nicotine, sulphuric acid, carbonic oxide, and ptomaines.

The Prognosis in all these instances is favourable.

Chronic Nuclear Paralysis (Chronic Polio-encephalitis Superior, of Wernicke) is much more common than the acute form. It depends on a degenerative atrophy of the nerve nuclei, analogous to that which occurs in progressive muscular atrophy and in chronic bulbar paralysis. The onset is gradual, the loss of power in the muscles being at first very slight, but ultimately complete paralysis of the affected muscles results. There is no fever, nor any cerebral symptom. The condition may become associated with chronic bulbar paralysis, with progressive muscular atrophy, or with locomotor ataxy; but this is not so liable to occur in infants as in adults.

In some cases there may be partial paralysis of the orbicularis palpebrarum, which, according to Mendel, is innervated from the third nerve nucleus through the facial nerve, along with other muscles of the oculo-facial group (frontalis and corrugator supercilii).

Coarse lesions, especially tumours of the pons, or of its neighbourhood which press on it, may produce orbital paralyses closely simulating those due to nuclear lesions, as we have recently observed in a case of tumour of the pituitary body. But here the paralysis

is only one of the symptoms in the case, which are likely to include headache, vomiting, optic neuritis, and, according to the situation of the lesion, hemianopsia, hemiplegia, etc. Softenings, patches of disseminated sclerosis, and internal hydrocephalus with over-distension of the aqueduct of Sylvius, are other lesions which may give rise to similar orbital paralyses, but which cannot be regarded as true nuclear ophthalmoplegia. The mode of onset, and the concomitant symptoms, of each case must serve as our guides in arriving at a diagnosis, which will sometimes be difficult enough.

According to Bernheimer, the diagnosis of a nuclear paralysis of the muscles must take into account the accompanying symptoms, etiology, course of the disease, etc., for the grouping of the affected muscles, whether intra- or extra-ocular, functionally associated or otherwise, is not sufficient in itself to warrant the assumption of a nuclear origin of the affection.

* *Conjugate Lateral Paralysis* of the eyes is a symptom which may be caused by a lesion in the pons. It is held that the voluntary motor impulses, coming down from the cortex to produce associated lateral motions of the eyeballs—*i.e.* action of the external rectus of one eye, along with action of the internal rectus of the other eye—first reach the nucleus of the sixth nerve, and then pass on under the corpora quadrigemina, through the posterior longitudinal bands, the neurons of which connect the sixth nucleus with the third nucleus of the same side and so through crossed third nerve fibres finally reach the internal rectus of the opposite side (Fig. 178). The sixth pair of one side supplies in this way the external rectus of its own side, and also influences the internal rectus of the opposite side ; and it is quite probable that similar connections may exist in the nerve supply of other orbital muscles. Hence a lesion at, let us say, the left sixth nerve nucleus would paralyse the conjugate lateral motions of the eyes towards the left side ; and there would in consequence be conjugate lateral deviation of the eyes towards the right —the eyes looking away from the lesion. In conjugate paralysis or deviation, whether due to a pontine lesion, or, as will be described in a later paragraph, to a cerebral lesion, the combined action of the internal recti for the purpose of convergence of the eyes is retained.

Paralysis of the orbital muscles from nuclear disease, apart from the primary conditions already described, may occur in

Locomotor Ataxy, Disseminated Sclerosis, General Paralysis, Chronic Alcoholism, and more rarely in Exophthalmic Goitre and Severe Multiple Neuritis.

* *Fascicular Paralyses* are mainly distinguished by the presence of other symptoms due to involvement of neighbouring structures. They are rarely symmetrical. Vertigo is common with fascicular third-nerve paralysis, owing to implication of the red nucleus in the tegmentum which is connected with the superior peduncle of the cerebellum. Bernheimer thinks that fascicular and nuclear paralysis are not separable clinically.

* In *Myasthenia Gravis* the symptoms include some which are due to derangement in the power of orbital muscles. It occurs mostly in young people the subjects of malnutrition. Ptosis is a common symptom ; it is usually bilateral and more marked on one side than on the other. It may be constant, or it may only be present towards the latter end of the day, or if the patient looks up for any length of time, when the lids gradually fall. Owing to weakness of the occipito-frontalis muscles, their compensatory over-action, so common in other forms of ptosis, does not occur except in the incipient stage. Weakness of the orbital muscles with resulting diplopia is often present. Sometimes one muscle is more affected than others, sometimes there is a general paresis affecting all the orbital muscles, while in some cases complete and persistent ophthalmoplegia externa is present. An alteration in the relative position of the two images is a striking feature. In some cases irregular nystagmoid movements are induced upon conjugate lateral motion of the eyes. The ocular muscles, as is the case with other voluntary muscles, become readily fatigued, the patients complaining that after reading a few lines the words and letters run into each other. Pupil changes are exceptional, but the pupils are sometimes unequal. In Buzzard's case, after prolonged convergence, the pupils showed a tendency to oscillatory movements. The power of accommodation does not become fatigued.

The general features of the disease are :—Weakness of some or all of the voluntary muscles of the body, which may amount to complete paralysis. After a long rest—*e.g.* on awaking in the morning—they may respond normally to the will, but become rapidly exhausted after a little use. The affected muscles often exhibit the myasthenic reaction, becoming exhausted by faradic

stimulation. The entire system of voluntary muscles may be affected, but those muscles are most apt to be implicated which normally act most continuously or frequently, such as the cervical muscles and the extrinsic muscles of the eyeball. The symptoms fluctuate from day to day, or from month to month, and may even disappear for months or even years, and then reappear. There are no sensory symptoms. Death occurs in a large proportion of the cases, but no structural changes have been found to account for the symptoms.

* **Cerebral Paralyses of Orbital Muscles** form the fourth and last of the classes enumerated. They include all the orbital paralyses due to lesions above the nuclei—*i.e.* in the cortex, corona radiata, or internal capsule. They are usually associated with other symptoms which aid us in localising, more or less accurately, the lesions which cause them. These paralyses are always physiological, associated, or conjugate, as they are variously and with equal correctness termed—they are, in short, paralyses of motion rather than of muscles.

Conjugate lateral paralysis—loss of power of motion of the eyes to one side or to the other, while the power of convergence of the optic axes is retained—is by far the most common form of this symptom. We do not as yet know where the cortical centre for the associated lateral motions of the eyes is situated.[1] But even if we did know its position, it is not likely that much would be gained so far as clinical localisation of the cerebral lesion is concerned; for this centre, wherever it may be, is extremely sensitive, and is apt to be thrown out of gear by lesions of many different parts of the cortex. Conjugate deviation is, in short, very apt to be a distant symptom, especially in cerebral hæmorrhage, when it is often accompanied by a rotation of the head in the same direction, and lasts only a short time. Moreover, it is thought that, when this

[1] This centre has been placed by various authors in the inferior parietal lobule (Wernicke, Henschen, Munk, etc.), and in the second frontal convolution (Ferrier, Horsley, and Beevor). Stimulation of the centres of vision in the occipital lobe has also been found to produce conjugate movements (Schæfer, Munk), and these have been regarded as reflex by some; but Knies holds that the visual centre contains the motor centre for the eye-muscles as well. Moreover, it is stated that the visual cortex contains motor pyramidal cells. The latest experiments (Bernheimer) place this centre in that portion of the inferior parietal lobule known as the angular gyrus.

centre may happen to be actually involved in the lesion, its function, being largely bilateral, is rapidly taken up by the opposite hemisphere ; and hence, even when conjugate lateral deviation plays the part of a direct cortical symptom, it rarely can be recognised as such, owing to its evanescent character. In paralysing lesions the deviation of the eyes is of course towards the side of the lesion—the eyes look at the cerebral lesion, as Prevost has expressed it—while in irritating lesions the spasm of the affected muscles causes the deviation to be from the side of the lesion, that is, towards the convulsed limbs if convulsions be present. These conditions are the reverse of what happens in conjugate lateral deviation due to lesions in the pons (p. 491), and we are thus enabled to differentiate between lesions in the two positions.

There are four possible cases :—

Cerebral Lesions	Destructive.	Eyes turned away from paralysed side.
	Irritative.	,, ,, towards convulsed side.
Pontine Lesions	Destructive.	,, ,, towards paralytic side.
	Irritative.	,, ,, away from convulsed side.

The cerebral cases show that the centre for associated movements is on the opposite side of the brain—*e.g.* in movements of eyes to the left, the left external rectus and right internal rectus are innervated by the right hemisphere of the brain ; consequently, a destructive lesion here would produce paralysis of the left side of the body and of the associated movements of the above orbital muscles, and therefore the eyes would be drawn to the right by their opponents—*i.e.* away from the paralysed side. A destructive lesion of the right side of the pons would also, of course, produce paralysis of the left side of the body ; but, involving the right sixth nucleus, it would cause paralysis of the associated movements of the right external rectus and left internal rectus, and, consequently, the eyes would be drawn to the left by the opponents—*i.e.* towards the paralysed side.

The reverse of the foregoing would occur in irritative lesions. Fig. 178 serves to illustrate the points referred to.

A destructive lesion at 12, the right cortical centre, involving also motor centres of the body, would cause left hemiplegia ; and, since the external rectus of the left eye and internal rectus of the right eye would be paralysed, the antagonists would turn the eyes to the right—*i.e.* away from the paralysed side. A destructive

lesion of the right side of the pons, also producing left hemiplegia, if it involve the sixth nucleus, will produce paralysis of the external rectus of the right eye and of the internal rectus of the left eye, and the antagonists would turn the eyes to the left—*i.e.* towards the paralysed side. Obviously irritative lesions would produce exactly the opposite effects.

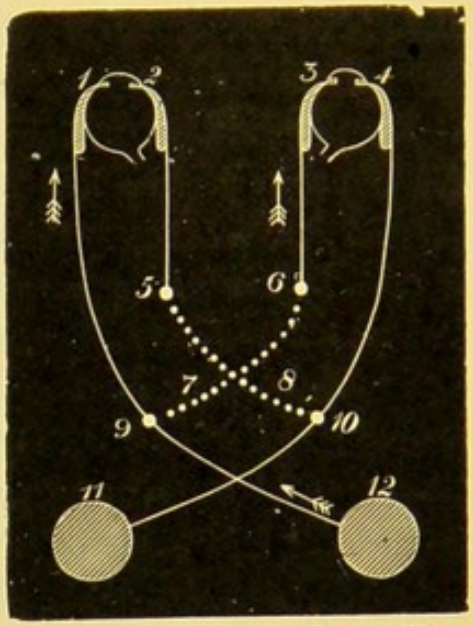


FIG. 178.—1. Left Ext. Rectus; 2. Left Int. Rectus; 3. Right Int. Rectus; 4. Right Ext. Rectus; 5. Nucleus left third nerve; 6. Nucleus right third nerve; 7 and 8 Post, longitudinal bands from sixth nerve to opposite third nerve; 9. Nucleus left sixth nerve; 10. Nucleus right sixth nerve; 11 and 12. Left and right cortical centres. An impulse starting from 12 would travel down to 9, and produce an associated movement of the eyes to the left.[1]

When the acute symptoms have passed off, the conjugate deviation, due to irritation, disappears even though a conjugate paralysis and hemiplegia may remain.

Hemianopsia interferes to a certain extent with the conjugate movement towards the affected side, in so far as this is guided by visual impressions (p. 365). According to Knies, the difficulty in reading in right hemianopsia is mainly due to this cause.

Conjugate deviations have been found with disease of the middle peduncle of the cerebellum of the pons, corpora quadrigemina, optic thalamus, and cerebral cortex.

Some authors (Sauvineau) believe that a lower centre exists in the grey matter of the corpora quadrigemina overlying the aqueduct of Sylvius, which regulates the associated movements of the eyes, it would thus constitute a supra-nuclear co-ordinating centre intervening between the cortical centre and the nerve nuclei. Lesion of a centre of this kind would readily explain associated vertical deviations as well as lateral deviations.

[1] According to Bernheimer's view, in the above diagram 9 (6th nucleus) would be connected with 5 (3rd nucleus of same side) and from 5 some fibres would also pass into the opposite 3rd nerve through 6. It simply means that the decussation would take place lower down.

In conjugate deviations the internal rectus involved is still capable of taking part in the act of convergence; moreover, diplopia does not occur since there is no strabismus.

It seems important here, even at the risk of some repetition, to direct special attention to

* **The Localising Value of Paralyses of Orbital Muscles in Cerebral Disease.**—*Paralysis of the Third Nerve.* As regards this nerve we are struck with the fact that ptosis, partial or complete, may be present as a focal symptom in cortical lesions—cerebral ptosis, as it is called—without any other third-nerve branch being paralysed. That a separate cortical centre for this branch of the third nerve exists, and that it innervates the muscle of the opposite side, is very probable. The existence of such a centre would not be inconsistent with the view that, as regards the motions of the eyeballs, associated centres alone are present; for, although as a rule the elevators of the lids are associated in their motions, yet by an effort of the will most people can throw one of them into motion separately, or more than the other. No doubt the power to voluntarily innervate one levator and orbicularis alone varies in different individuals, and in many persons the levator centres are practically associated centres, and probably this is the reason why cerebral ptosis is rather rare. The position of this centre is still an open question, but it is believed to be situated in front of the upper extremity of the ascending frontal convolution close to the arm centre.

Ptosis, then, has no value as indicating the locality of a lesion in the cortex; but it may be of use in distinguishing a cortical lesion from one situated elsewhere in the brain, for monolateral ptosis, as the only focal symptom, occurs with cortical lesions alone.

It is probable that ptosis, as the result of a cortical lesion, is a distant symptom in not a few of the cases where it is present.

Ptosis on the side of the lesion has occasionally formed a symptom in disease of the pons, without paralysis of the other branches of the third nerve—except, sometimes, in so far as conjugate deviation (*vide supra*) is concerned—and without the third nerve being involved in the lesion.

Again, ptosis, by forming a factor of a crossed paralysis, may serve to localise a lesion in the crus cerebri. When the third nerve is paralysed by a lesion in this situation it is the rule to find it paralysed as a whole; but paralysis of only some of the third-nerve

branches may be produced by a lesion of the cerebral peduncle, and the branch to the levator palpebræ seems to be the one most frequently implicated alone.

To complete the subject of ptosis, mention must be made of *Sympathetic Ptosis* which is accompanied by other eye-symptoms, as well as by symptoms of vasomotor paralysis of one side of the body, such as elevation of temperature, and redness and œdema of the skin. In these cases, there is (1) apparent ptosis on the paralysed side, owing to the contraction of the palpebral aperture, but the lid can be raised; (2) contraction of the pupil on the same side; (3) diminished intra-ocular tension; (4) a shrinking back of the eyeball into the orbit, so that it seems to have become smaller; (5) an abnormal secretion of thin mucus from the corresponding nostril, of tears from the affected eye, and of saliva from the corresponding side of the mouth. In the later stage, the side of the face becomes paler and thinner, its temperature is lower, and it perspires less than the other side, or not at all. This train of symptoms has been found in lesions of the corpus striatum, but is chiefly due to lesions of the cervical sympathetic, or of the spinal cord at or above the level of the eighth cervical and first dorsal nerve, or of these nerves alone.

A common sign of disease of the crus cerebri is what is known as *Crossed Hemiplegia.* Paralysis of the third nerve, on the side of the lesion, with hemiplegia, hemianæsthesia, often facial, and sometimes hypoglossal, paralysis on the opposite side of the body is a frequent form of it. The lesion may implicate all the branches of the third nerve, or only some of them. The optic tract lying as it does close to the crus may also be affected by the lesion which would then give rise to hemianopsia on the same side as the hemiplegia. But the localising value of crossed hemiplegia, as Hughlings Jackson long ago pointed out, depends chiefly on the hemiplegia and paralysis of the cranial nerve coming on simultaneously. If they occur at different times they may be due to two distinct lesions, neither of which may be in the crus; for the hemiplegia might be due to a lesion in the hemisphere, and the third-nerve paralysis to a basal lesion of earlier or later date. Yet a few cases have been observed where, with a lesion in the cerebral peduncle, the third-nerve paralysis preceded the hemiplegia by a considerable interval.

That basal lesions are by far the most frequent cause of paralysis of the third nerve is beyond doubt: and here it is usual, but not

constant, to find it paralysed in all its branches. The diagnosis to be made, when direct symptoms are being considered, is, for the most part, between a lesion in the crus and a lesion at the base. We cannot pretend to be able to make this diagnosis with certainty in all cases. Complete paralysis of every branch of the third nerve without any other paralysis is almost always basal; so also are those cases in which, where there is hemiplegia, it is slight, as compared with the degree of the third-nerve paralysis; and those cases, too, to which reference has already been made, where there is an interval between the onset of the paralysis of the extremities and of the third nerve, are apt to be basal. Of course there may be such a combination of paralyses of the other cerebral nerves with that of the third nerve, as to leave no doubt with reference to the basal position of the lesion.

The third nerve may be paralysed by lesions in the inter-peduncular space, in which case the paralysis may be partial (ptosis alone, or abolition of upward and downward motion alone), complete, monocular, or binocular. This is the commonest situation for a syphilitic basal affection, which may extend in a forward direction and involve the chiasma as well. When both nerves are affected there is generally also paralysis of the other orbital nerves, or of the facial nerve; and hemiplegia or hemianopsia may also be present.

Thrombosis of the Cavernous Sinus invariably produces paralysis of the third nerve; but all the orbital nerves, as well as the fifth and the optic nerve, may also be involved, giving rise to complete immobility of the eye, with loss of conjunctival and corneal sensation. The pupil is usually contracted at first, but later on dilates. The venous obstruction causes exophthalmos, œdema of the lids, and chemosis. The ophthalmoscope sometimes shows the presence of congestion papilla. The general symptoms are rigors, high temperature, and vomiting. Its principal causes are infective inflammation of the orbital cavity; erysipelas of the face; infective inflammation in the buccal, nasal, and pharyngeal cavities, and of the body of the sphenoid; and extension of thrombosis of the sinuses from purulent otitis. The thrombosis in more than half the cases spreads to the other side through the circular sinus. When the invasion occurs from the intracranial direction, pain in some or all of the branches of the first division of the fifth nerve is usually an early symptom.

Third-nerve symptoms—in addition to those included under the headings conjugate deviation, or paralysis, and ptosis—are sometimes distant symptoms. Tumours of the cerebral hemispheres, more particularly if accompanied by violent general head symptoms, indicating probably high intracranial pressure, are the lesions most apt to produce these distant third-nerve symptoms. As a rule, the slighter the general cerebral symptoms, the more likely are the third-nerve paralyses to be direct symptoms. This rule, indeed, applies to other as well as to third-nerve focal symptoms.

Paralysis of the Fourth Nerve, when combined with paralysis of other motor eye-nerves, is difficult to recognise ; and consequently in such cases it furnishes but little aid for localisation. Solitary paralysis of this nerve as a symptom of cerebral focal lesion is extremely rare. Nieden has placed a case on record in which paralysis of one fourth nerve was the only focal symptom to which a tumour of the pineal gland, of the size of a walnut, gave rise. But the isolated fourth-nerve paralysis is more apt to be produced by a basal lesion. Pfungen has pointed out that, in meningitis, exudation in the space between the corpora quadrigemina and the splenium of the corpus callosum may implicate the fourth nerves in the valve of Vieussens, and believes it is prone to do so in tubercular meningitis. In combination with paralysis of the third nerve it speaks for a lesion in the cerebral peduncle, extending back to the valve of Vieussens.

Pseudo-paralysis of the fourth nerve, usually only transitory, sometimes occurs after radical operations on the frontal sinus, from displacement of the pulley of the superior oblique muscle.

When *Paralysis of the Sixth Nerve* occurs as the only focal sign it is probably due to disease at the base, or it is a distant symptom. There is no cranial nerve so liable to provide a distant symptom as the sixth. Gowers refers this liability to the lengthened course this nerve takes over the most prominent part of the pons, which renders it readily affected by distant pressure. One or both nerves may in this way be paralysed. Wernicke states that sixth-nerve paralysis is most apt to be present as a distant symptom, when the lesion, especially a tumour, is situated in the cerebellum ; differing in this way from the third nerve, which is more likely to give distant symptoms with a lesion in the cerebral hemisphere.

Paralysis of the sixth nerve, simultaneous in its onset with

hemiplegia of the opposite side of the body, indicates a lesion in the pons, usually a hæmorrhage, on the side corresponding with the paralysed nerve. We know that the fifth and facial, and sometimes the auditory, spinal accessory, and hypoglossal nerve, may all, in varying combinations, form one of the elements in a crossed paralysis from a lesion in this position; but, if special localising value is to be given here to the participation of any one cranial nerve, that nerve is the sixth. The paralysis of this nerve, simultaneously with palsy of the opposite side of the body, while other conditions point to an intracranial lesion, speaks, then, almost certainly for pontine disease.

Basal paralysis of the sixth nerve is frequently double, especially in syphilis. Fracture of the apex of the petrous portion of the temporal bone may also cause it.

Paralysis of the facial with the sixth is not an uncommon combination caused by a lesion in the pons, which at the same time produces hemiplegia of the opposite side of the body. This combination is a natural one, in view of the close relations of the nuclei of the sixth and seventh nerves. The manner in which the root of the facial nerve winds round the sixth-nerve nucleus must also have an important bearing on the occurrence of associated paralyses of these nerves.

Paralysis of one or both sixth nerves sometimes occurs in connection with a purulent otitis media without any symptoms of intracranial complications, and is not usually a sign of serious importance, although in some cases it may be the first symptom of intracranial mischief. It is probably due to a localised area of infection, causing slight meningitis or necrosis at the apex of the petrous bone or the infective material may be carried up through the carotid canal, but on the other hand it may be reflex in character, and may be brought about by the connection of the sixth nerve with Deiter's nucleus into which the vestibular nerves pass.

Hemiplegia due to a lesion of the cortical motor region, which might happen to be combined with paralysis of the sixth nerve as a distant symptom, offers no difficulty in its diagnosis from hemiplegia with sixth-nerve paralysis in pontine disease; for, while in the latter the paralysis is crossed, in the former it is homonymous.

Paralysis of the Seventh Nerve. When lagophthalmos occurs as a symptom in focal cerebral disease, it is useful in localising the disease by assisting in differentiating a lesion in the internal capsule,

or in the facial motor centre of the cortex, from one implicating the portio dura in the pons, as it is absent, or very slight, in the former cases, but very often markedly present in the latter. With a lesion in the lower part of the pons we are apt to have lagophthalmos with crossed hemiplegia; but if the lesion be in the upper part of the pons—the fibres from the opposite side not having here joined the motor tract—the hemiplegia and lagophthalmos will be homonymous.

Paralysis of the Fifth Nerve, with hemiplegia of the opposite side, points to disease in the pons. Neuroparalytic ophthalmia is said to be the rule in basal lesions of the fifth nerve, and to occur very rarely in nuclear or fascicular lesions.

The *Orbicular Sign* may be noticed in some attacks of apoplexy with hemiplegia after consciousness has returned. It consists in this, that the hemiplegic person, who during health has been able to close each eye separately, and who even now can close both eyes together, or the eye on the sound side alone, is unable to close the eye on the paralysed side by itself. This sign usually passes away after a short time. Sometimes when both eyes are closed it requires a greater effort to bring the eyelids together on the paralysed side

Extensive basal lesions, especially those due to syphilitic disease, may produce symptoms due to involvement of widely separate structures, without interfering with those which intervene; hence they tend to implicate several nerves without reference to system or function.



FIG. 179.—Congenital ptosis with epicanthus.

* **Congenital defects of motion** of the eyes are not very uncommon, and are sometimes hereditary. Ptosis (chap. xvii.) with, or without defect of upward movement of the eyeballs, is the commonest form, and is often associated with epicanthus (Fig. 179), but all degrees of impairment of mobility, and even total loss of motion, may be met with, as well as unnatural associated movements of the eyes. In paralysis of outward movement, retraction of the eyeball occurs in some cases on looking inwards. The power

of convergence is frequently retained, although lateral movement may be impaired or absent. The pupils and accommodation escape as a rule. There is no diplopia or secondary deviation as in acquired paralysis. (According to Duane secondary deviation does occur.) Vision is usually impaired, and the patients are often mentally dull. The defective mobility is due to absence or defect (aplasia) of the muscles, nerves, or nuclei. For congenital ptosis with associated lid-movement see chap. xvii.

Strabismus Fixus is a rare condition in which both eyes are turned inwards to an extreme degree and practically immovable. It is probably the result of a form of congenital ophthalmoplegia. It is almost impossible to remedy it by operation owing to secondary contracture of the muscles, and probably also of the capsule of tenon.

Convergent Concomitant Strabismus (Non-Paralytic Strabismus).

This is the condition which is popularly known as inward 'cast' or 'squint.' It makes its appearance in children, when they begin to take an interest in small objects, such as toys and pictures; or a little later, when the first lessons are learned—in short, when they begin to make frequent and prolonged demands on their internal recti and accommodation, most commonly from the age of three to six years.

It is non-paralytic, and the term 'concomitant' (*concomitatus*, accompanied) is given to it in contradistinction to 'paralytic' strabismus; because in it the squinting eye accompanies the straight one in all its movements to an equal extent. In the primary position of the eyeballs, in a case of concomitant squint, the parallelism of the visual axes is defective, and, as the eyes are moved from side to side, the defective parallelism continues in the same degree, neither increasing or decreasing. Moreover, the secondary deviation (p. 473), in the sound eye, in these cases of concomitant strabismus, is equal in degree to the primary deviation of the squinting eye; because the internal rectus of the good eye being associated in its action with the external rectus of the squinting eye, when the latter muscle is forced to roll its eye outwards in order to bring it to fixation, the internal rectus of the good eye, receiving a similar nervous

impulse, rolls that eye inwards to the same extent as the squinting eye has been rolled outwards. The good eye will therefore present, under the covering hand, an internal strabismus of the same amount as that which has previously been present in the squinting eye. This is an important point, for it is an aid in the differential diagnosis of this form of strabismus from the paralytic form, in which the secondary deviation is greater than the primary one (see General Principle No. 2, p. 473). Diplopia and giddiness are absent in concomitant strabismus.

In concomitant strabismus, both eyes never squint simultaneously, as one hears it sometimes stated by parents; although the excessive convergence, as will be explained later on, is present in both.

The method of distinguishing the squinting eye from the fixing eye is given at p. 468.

Donders pointed out that, in a large proportion of cases of convergent strabismus, the refraction is hypermetropic; and he drew the conclusion that hypermetropia is to be regarded as the cause of the strabismus in the following way:—It has been shown (p. 8) that with each degree of normal convergence of the optic axes, for the purpose of single vision, a certain effort of accommodation, in order to see the object distinctly, is associated. The greater the angle of normal convergence, the greater is the possible effort of accommodation.

Of this physiological fact, Donders said, the hypermetrope often unconsciously takes advantage, and in order to brace up his accommodation in an excessive degree for the sake of distinct vision with one eye, he increases the angle of convergence of the optic axes.

The over-convergence is not, however, as usually described, limited to the squinting eye; both take part in it, and the effect is to render the strabismus manifest in the eye which does not fix. To explain this it may be desirable to consider what occurs, when convergence and accommodation are normal. In Fig. 180 the eyes are converging on, or fixing, the point O, and the object is seen singly, and at the same time distinctly, because the amount of accommodation required is normally associated with this degree of convergence. Although the right eye (R) is in the primary position, it is taking part in the act of convergence as much as the left eye (L). If O were at O′, at the same distance from the eyes but in the middle

line, L and R would converge through equal angles, *a* and *b*. Now, if the eyes make a lateral movement to the right (arrow 3), the deviation of L would be made up of the angles *a* and *c*, *a* being due to convergence, and *c* to the lateral movement in the same direction, both brought about by the left internal rectus; whereas the convergence in R (arrow 2), due to the internal rectus, is neutralised by the lateral movement (arrow 3) which is in the opposite direction in this eye. If this eye had not been converging, it would have remained parallel to L O in the lateral movement, and would have moved outwards. L is considerably rotated inwards, but it is not squinting, because it is fixing O.

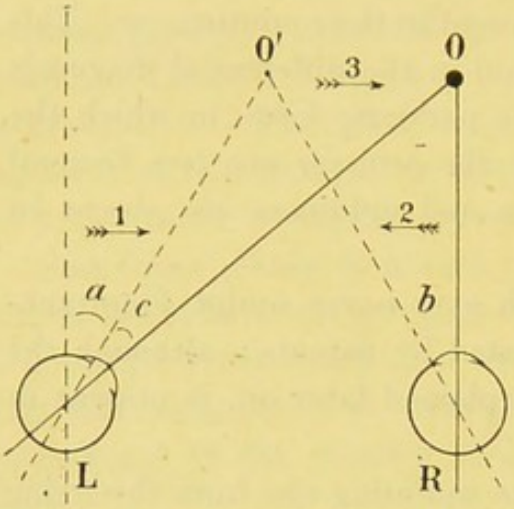


FIG. 180.—Binocular fixation with convergence and accommodation for O.

Fig. 181 represents concomitant convergent strabismus. The patient wishes to see the object at O distinctly, but owing to his hypermetropia, the accommodation normally associated with this degree of convergence is not sufficient. By converging for a nearer point (B) an additional effort of accommodation can be made, but then the patient could not fix O, and it would appear double. In order to avoid this dilemma a lateral movement of the eyes is made from B to B′, and thus the right eye (R) is brought into line with O, and sees it distinctly by means of the additional accommodation gained by convergence for B. The left eye now no longer

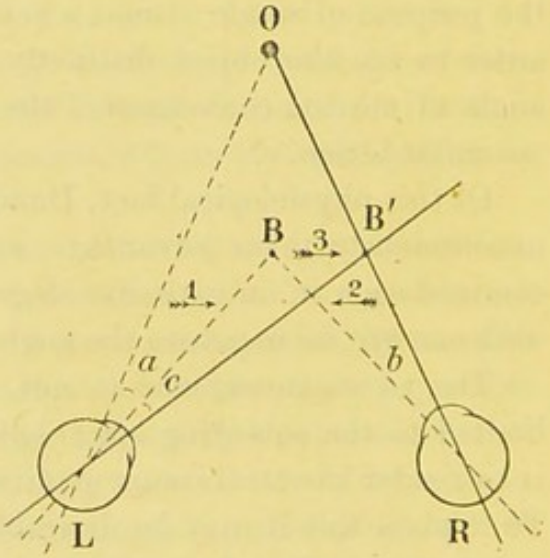


FIG. 181.—Concomitant convergent strabismus; binocular convergence for B′ with monocular fixation and accommodation for O.

fixes O, and therefore squints. The deviation of the squinting eye is made up of the angles *a* (excess of convergence for B) and *c* (lateral movement to B′). In the right eye, the excess of convergence is neutralised by the lateral motion in the opposite direction. In fact, it is only the desire for fixation which keeps both eyes from squinting. In some cases there is no lateral movement, as the patient turns his head, in the above case to the right, to bring the right eye into line with O.

Inasmuch as all hypermetropes do not squint, Donders considered that there were contributing circumstances, which caused each hypermetrope to unconsciously decide between distinct monocular vision with strabismus, and indistinct binocular vision. The latter, he said, is likely to be preferred if the condition of the refraction and the acuteness of vision is the same in each eye ; while, if one eye be amblyopic, or if the retinal images differ much, by reason of one eye being more ametropic than its fellow—from nebulous cornea, or from other causes—the desire for binocular vision would be less strong, and the imperfect eye would deviate inwards for the sake of the resulting increase of accommodation in the perfect eye.

It is admitted that hypermetropia is one of the causes of internal strabismus, but it is not the only cause, and probably not even the principal cause, for the following reasons :—(1) If Donders' theory be complete, convergent strabismus must always appear, whenever there is binocular hypermetropia, along with the conditions which reduce the value of binocular vision. But strabismus is often absent, while the degree of ametropia is markedly different in the two eyes, or while the acuteness of vision is very defective in one eye. Again, the number of cases of strabismus is very small in proportion to the number of hypermetropes, since nearly all children are hypermetropic. (2) In periodic strabismus, the influence of hypermetropia and of the accommodative effort is very evident ; and yet these cases only go to show that, while hypermetropia is very frequently one of the causes of strabismus, it is not the only or most important one ; for here, clearly, some factor necessary for the production of a permanent squint is wanting. (3) Donders' theory fails to explain the occurrence of convergent strabismus in emmetropic and in myopic individuals, where, of course, no excessive effort of accommodation is required.

The fact that very few squinters are found amongst high hyper-

metropes is not an argument against Donders' theory, as high degrees of this error are met with much less frequently than low or moderate degrees, moreover the demand on the accommodation in such cases may be so great that over-convergence does not enable the patient to obtain sufficient accommodation for distinct vision.

Congenital want of equilibrium between the muscles has been advanced as an explanation of convergent squint, but no proofs of this preponderance of certain muscles can be given.

Spontaneous cure of strabismus sometimes takes place, most commonly between the tenth and sixteenth year of age. That it may happen with hypermetropia, and with defective vision in one eye, is strongly against Donders' theory, assuming, of course, that the hypermetropia has not diminished much, as it naturally tends to do at this time of life.

The most probable cause is defective development of the sense of fusion (p. 469), aided or caused by conditions which render fusion difficult, such as hypermetropia, or amblyopia, either congenital, or acquired in early life. Illness may weaken accommodation, and the temporarily altered relation between the latter and convergence may cause a squint to appear even in emmetropia, if the sense of fusion be imperfect. In alternating strabismus, where the patient squints with either eye, the vision is generally good and equal in both eyes ; yet, according to Worth, the faculty of fusion is always wanting in these cases.

Priestley Smith upholds the theory of the defective development of the sense of fusion, which is acquired, as stated before, in infancy. During the first few years of life, this newly acquired faculty is less stable than at a later period, and is more easily disturbed. Hence the greater liability to strabismus in infancy. Among three hundred and forty-seven cases, where the onset age was ascertained, two hundred and fifty-four, = 73 per cent., began before the children were five years old. Three years was the most common age. The hypermetropic child is specially liable to convergent strabismus, because he has to overcome a special difficulty : he must learn to converge normally, while he accommodates abnormally. Failing in this, he squints in order to see clearly. Many squints arise in this way, but the influence of hypermetropia must not be exaggerated.

Infantile disorders—convulsions, whooping-cough, measles, a

fright, a fall, etc.—are often the starting-point of strabismus, because the controlling influence of the higher brain centres is weakened at such times. Priestley Smith believes that a continuous squint involves weakening or loss of visual function, and that the younger the child the more readily does this occur. The sense of fusion, being no longer exercised, is gradually lost, and may prove irrecoverable a few years later, even though the eyes be made straight. Furthermore, an eye which never fixes the object at which the patient looks, loses the power of true fixation. Such loss is found most often amongst cases of early onset and long duration; it is rarely, if ever, found until the squint has become continuous for at least six months. Again, it is probable that the early onset of strabismus, with complete disuse of the squinting eye, may arrest the development of form-perception in the latter, and thus render it permanently amblyopic.

* *Single Vision in Concomitant Strabismus.*—For the most part these patients do not complain of double vision, as in cases of paralytic strabismus. Why is this? The image of the object looked at, it will correctly be said, must be formed in the squinting eye in each of these kinds of strabismus, on a part of the retina not identical with that in the fixing eye, but lying to the mesial side of it; and hence the image of the object should be projected by the squinting eye to its own side of the true position of the object (homonymous diplopia), and the latter should therefore be seen doubled. It is seen doubled in the paralytic form; why not also in the concomitant form? The explanation commonly given is that convergent concomitant strabismus being a quasi-physiological condition, the patient's mind involuntarily suppresses the annoying image belonging to the squinting eye, in a manner analogous to that by which, when we are deeply interested in conversation, all extraneous sounds are unperceived, although they, too, must reach the nerve of hearing. This suppression of the image belonging to the squinting eye was believed to be the more easy owing to the indistinctness of the image itself, formed as it is on a peripheral part of the retina, while in the good eye it falls on the macula lutea. We often find, moreover, that the squinting eye is *ab initio* more defective (macula cornea, higher degree of hypermetropia, astigmatism, etc.) than its fellow, and it was held that this, too, rendered suppression of its image more easy. Such a suppression of the image is possible,

and it no doubt does occur in many cases of strabismus; but it is certain that it does not occur in all of them, perhaps not even in the majority of them. The suppression affects only the macular region, for the remainder of the field of the squinting eye is made use of by the patient.

In those cases in which the image of the squinting eye is not suppressed, one of two events takes place :—Either the region of the retina, on which, in the squinting eye, the image of the visual object is formed, becomes functionally developed into a spot to a great extent physiologically 'identical' with the macula lutea of the straight eye, and then something approaching normal binocular fusion of the images comes about, and hence single vision; or else, diplopia is actually present, although, as a rule, it passes unnoticed by the patient, owing to its having become habitual to him. In some cases the first of these conditions is the actual state, in others it is the second which exists. In support of the first is the occurrence, not rarely observed, of crossed diplopia after operation for concomitant convergent strabismus, even when there is no divergence produced; and in support of the second, the diplopia which intelligent patients often admit, when they are carefully examined with the aid of a red glass before the good eye. If the strabismus be the result of a want of development of the faculty of binocular vision, then the absence of diplopia need not be a matter for surprise.

* *Amblyopia of the Squinting Eye.*—In a large proportion of the cases of internal concomitant strabismus the squinting eye—even where there is no marked astigmatism, and where the media are clear—is amblyopic. It has been a very generally accepted opinion that this amblyopia is due to want of use on the part of the squinting eye, in consequence of the suppression of the image on its retina, and hence it is termed amblyopia ex anopsiâ. According to Schweigger, if this view were the correct one, we ought always to find only slight amblyopia of the squinting eye in children soon after strabismus comes on; while it should be of high degree—in fact, the eye should be almost sightless—in adults who have not been operated on, and in whom monolateral strabismus had been present since childhood. And yet marked amblyopia may often be found in children in the squinting eye, while in adults the squinting eye often has very good vision—in short, the amblyopia of the squinting

eye is not progressive, as it would be were it ex anopsiâ. Again, many squinting eyes, when the straight eye is covered, instead of fixing the visual object with the macula lutea, remain unchanged in position, or even turn inwards more than before (amblyopia with excentric fixation); and in less well-marked cases of the same sort, although there is no excentric fixation, yet the preference for fixation with the macula lutea is lost, and uncertainty of fixation results, no one part of the retina being more useful for that purpose than another. It is held by many that this form is characteristic of amblyopia ex anopsiâ, and is the result of the strabismus; but it is identical with a form of congenital amblyopia, sometimes present without strabismus in one eye only. Worth, however, points out that in these cases there is greater error of refraction in the amblyopic eye, and that even in spite of the amblyopia the fusion sense is well developed. A strong argument in favour of amblyopia ex anopsiâ is the improvement which often seems to take place in the vision of the squinting eye by systematic separate use, or after the strabotomy. Schweigger thinks that, where the improvement takes place, the defective vision has been due rather to retinal asthenopia than to amblyopia; and if, at the outset, patients be pressed to discern the test-types, they often succeed in producing a better acuteness of vision than they at first seemed to possess. In many cases, separate use fails altogether in improving the vision of the squinting eye, even when it is not very defective—a fact which is unfavourable to the amblyopia ex anopsiâ theory. The circumstance that in alternating strabismus the sight of each eye is good, cannot be regarded as proof in favour of amblyopia ex anopsiâ. Schweigger believes that the amblyopia in the squinting eye is congenital; and, far from being the result of the strabismus, is a factor in its production, just as opacities of the cornea, or high degrees of ametropia, have always been admitted to be. The views of different observers vary greatly on this point, and depend very much on the age of the patient when first treated, on the methods employed for testing and developing the vision, and on the perseverance of the surgeon, and of the patient's parents. Except in cases of very defective vision where there may be a central scotoma (not specially for any particular colours) the field of vision is normal in the amblyopic eye.

Worth's views are similar to Priestley Smith's. He believes that

the power of central fixation is lost very rapidly in infancy, and that the earlier the onset of the strabismus the greater will be the amblyopia. After six years of age, amblyopia ex anopsiâ seldom takes place to any great extent. This weakens Schweigger's argument based on the non-progressiveness of the amblyopia.

There are *Three Clinical Varieties of Convergent Concomitant Strabismus.*—(1) Periodic. (2) Permanent alternating. (3) Permanent monolateral. Periodic strabismus occurs only now and again, perhaps when a greater effort of accommodation is required. It is sometimes the first stage of permanent monolateral, or of alternating strabismus; but these two latter forms do not always have their beginning in the periodic form, which often continues as periodic to the end of the chapter. In alternating strabismus

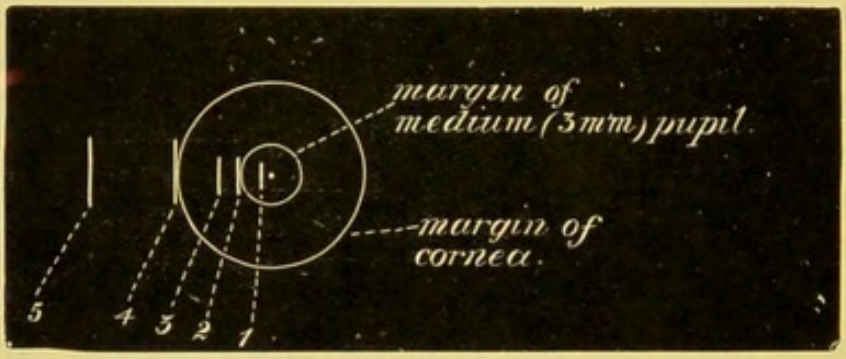


FIG. 182.

the patient squints with either eye indifferently. In permanent monolateral strabismus the squint is confined to one eye.

Measurement of Convergent Strabismus.—The amount or degree of the deviation of the squinting eye is measured by one of the following methods. In all of them it is important that the patient be directed, during the test, to regard an object placed in the median line and on a level with his eyes (the Primary Position, p. 464). The angle of the squint usually increases with accommodation when the object of fixation is near.

1. Hirschberg's Method consists in making the patient fix a candle flame, or the ophthalmoscope mirror, held straight in front of, and about a foot from, the eyes, when the observer estimates the degree of deviation by the position of the corneal reflex. Where there is no squint, this reflex is situated at, or (with large angle γ) slightly to the inner side of, the centre of the pupil in each eye.

In a convergent squinting eye it is displaced outwards, and Hirschberg recognises five groups of strabismus. Group 1 (Fig. 182 representing the right eye), in which the reflex is nearer to the centre than to the margin of the pupil. This represents a strabismus of less than 10°. Group 2, in which the reflex is at or about the margin of the pupil, representing a strabismus of 12° to 15°. Group 3, in which the reflex is outside the pupillary margin, about half-way between the centre of the pupil and the corneal margin. This represents a strabismus of about 25°. Group 4, in which the reflex is on or near the corneal margin, represents a strabismus of 45° to 50°. Group 5, in which the reflex is on the sclerotic, between the margin of the cornea and the equator bulbi. This represents a strabismus of 60° to 80°. This is a modification of the linear method, and is a convenient one in routine practice.

2. Priestley Smith measures strabismus by means of a double tape (Fig. 183), used in conjunction with the ophthalmoscope, as shown in the accompanying figures. The patient places the ring *P* on one of his fingers, and holds it to his cheek. The observer places the ring *O* on the forefinger of the hand which holds the ophthalmoscope ; this keeps his eye at a distance of one metre from the patient's face. He uses his disengaged hand as a fixation object for the patient, holding it edgewise towards the patient, and letting the graduated tape slide between his fingers. A small weight at the end of the tape keeps it stretched, as the hand moves in either direction.

Fig. 184 illustrates the measurement of a convergent strabismus of the right eye. The patient, seated below the lamp and holding the tape as above described, is told to look at the mirror. The observer, holding the ring *O* and the mirror in the right hand, throws the light on the patient's left eye (*L*)—*i.e.* the fixing eye. He sees the corneal reflex in the centre of the pupil, and knows thereby that this eye is fixing properly. He then throws the light on the right eye (*R*), and sees the reflex situated eccentrically outwards, and knows that this eye deviates inwards. Taking the graduated tape between the fingers of his left hand, and telling the patient to watch this hand, he moves it outwards along the tape, and meanwhile watches the corneal reflex in the deviating eye. When the reflex reaches the middle of the pupil the observer reads the position of the hand upon the tape. The axis of the deviating eye

(R) has moved from R' to O, through the angle $R'\ R\ O$. The axis of the non-deviating eye (L) has moved through an equal angle ($O\ L\ L'$). The angular movement of L, as measured by the tape, equals the angular deviation of R.

Fig. 185 illustrates the measurement of a divergent strabismus of the right eye. The hands are reversed, but the principle of course is the same as before.

Maddox's tangent scale, and Worth's deviometer in which an electric light is flashed on the cornea, are based on the same principle, and are very useful, the latter especially so, for infants.

FIG. 183.

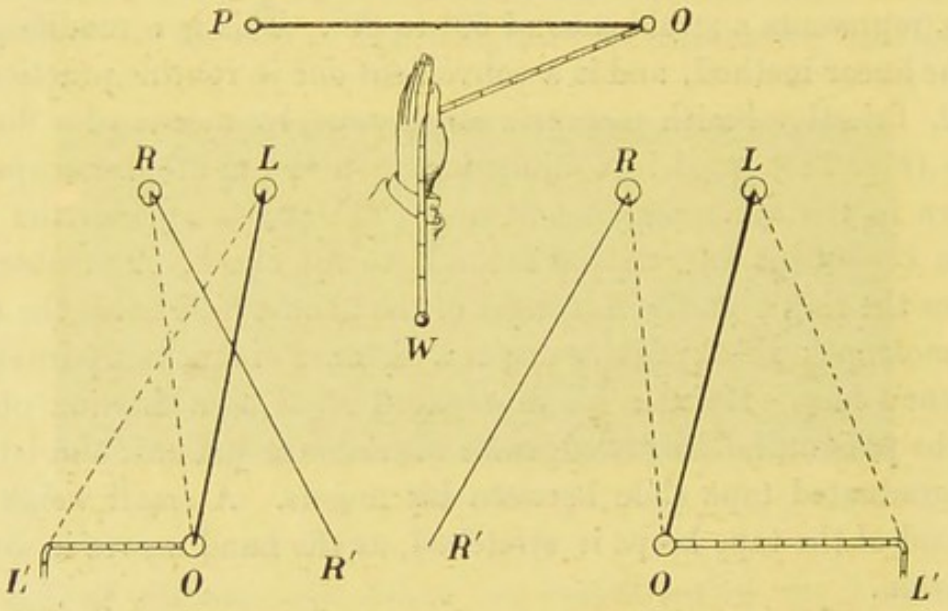


FIG. 184.

FIG. 185.

The graduated tape is in fact a substitute for a graduated arc of a circle, and represents the tangents of the angular deviations. In this mode of measuring a strabismus it is the excursion of the fixing eye which is actually measured, and the excursion of the deviating eye is taken to be equal to it. If the excursions of the eyes be unequal, that is to say, if the strabismus be not a concomitant one, the result is faulty. The method, though difficult to explain in words, is quick and satisfactory in practice.

3. Perimeter Method.—The object aimed at here is to determine the size of the angle, which the visual axis of the squinting eye makes, with the direction it should normally have. For this purpose a perimeter is employed. Let us suppose that the right eye

(R, Fig. 186) be the squinting eye, and that $P\ o\ P$ be the arc of the perimeter. The patient is placed at the instrument, as though the field of vision of his squinting eye were about to be examined. He is directed to look at a distant object (A) with his good eye (L). The visual line from R should now pass through the point o, but it passes through the point n, and therefore $o\ R\ n$ is the angle of the strabismus. The surgeon finds the position of n by carrying the flame of a candle along the perimeter, until, with his eye placed behind the flame, he finds that the corneal image of the flame occupies the centre of the pupil. The flame itself will then be at n, and the size

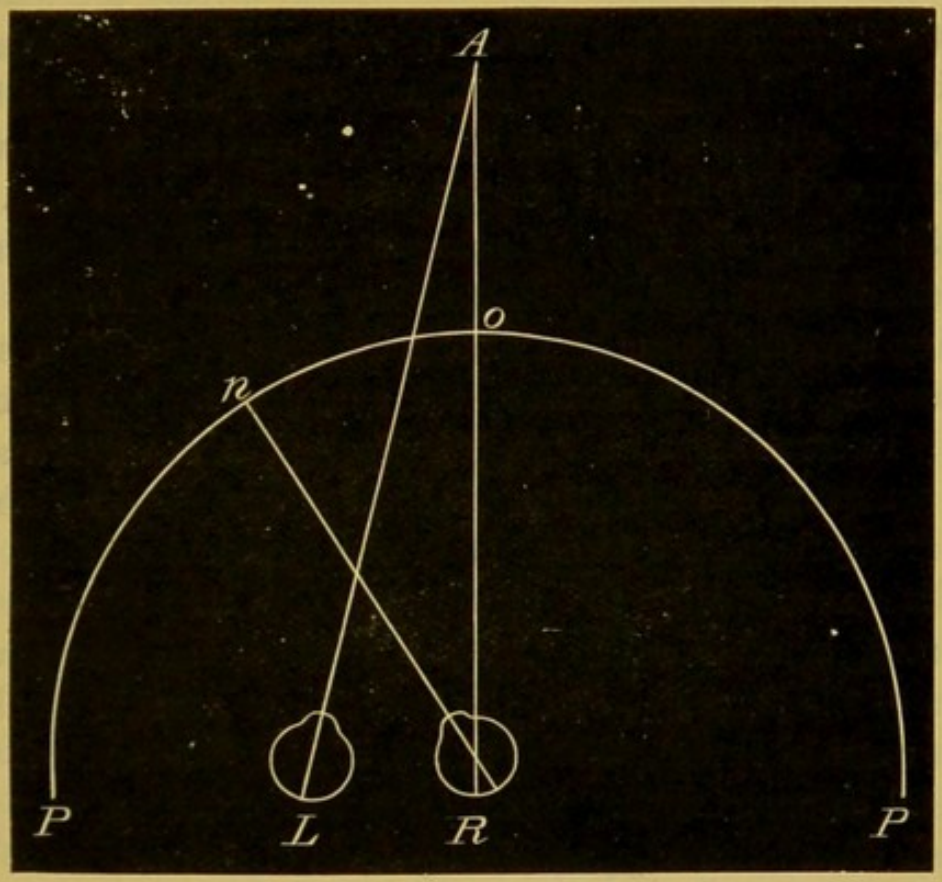


FIG. 186.

of the squint-angle may be read off there. This gives the optical axis of the eye; but, to be strictly accurate, we must remember that the position of the visual axis is what is required, and that it lies a few degrees farther inwards, according to the size of the angle γ.

4. Tangent Strabismometer.—Maddox's tangent scale can be used to determine the angle of strabismus subjectively, by means of the diplopia if it be present, and also objectively, by the observation of the corneal reflex; in the latter respect it is only a modification of Priestley Smith's method. The scale has two sets of figures,

large ones for a distance of five metres, and smaller ones for a distance of one metre. At the centre, or zero point, a candle is fixed, and also a string one metre long for adjusting the distance of the patient. The figures on one side of the zero are red, and on the other black.

When diplopia is present, the patient is merely asked to indicate the figure opposite to which the false image of the candle appears.

In the objective method, the surgeon stands with his head below the zero of the scale, facing the patient; he then notes the eccentric position of the corneal reflex of the candle in the deviating eye; and, estimating the amount of the squint, directs the patient to look at this figure on the scale. If the estimate be correct, the reflection will be in its proper position on the cornea; if it be not, the patient is directed to look at other figures higher or lower, as the case may be, until the position of the reflex is correct.

* *Mobility of the Eye in Convergent Concomitant Strabismus.*—In cases of long standing, the mobility is often defective in the squinting eye, and sometimes also in the fixing eye. The method of measuring the excursions of the eyes has been described on p. 467. In strabismus we simply compare the outward mobility of the squinting eye with that of the good eye, to ascertain how much, if anything, the former lacks of its normal amount.

Before undertaking the treatment of a case of convergent strabismus, in addition to the points mentioned, the power of fixation of the squinting eye, the presence or absence of diplopia and the sense of fusion, the refraction, and the acuteness of vision, should all be ascertained. For testing the vision in very young children, Worth has suggested ivory balls of different sizes which are thrown on the floor and which the child is asked to pick up.

Treatment of Concomitant Convergent Strabismus.—

(*a*) *Optical Treatment.* The total hypermetropia, and the astigmatism, if any, must be corrected, and the glasses must be worn constantly. In young children, atropine must be used to determine the refraction, and it should be continued until the glasses have been worn for some time. Some surgeons order glasses for infants of twelve months or even less. The glasses frequently diminish or remove the strabismus while being worn. They act by removing the strain on the accommodation and also by improving the vision.

(*b*) *Orthoptic Treatment.*—To Javal is due the credit of devising

this method. It consists in preventing the development of amblyopia, and in training the sense of fusion. To attain the first object, complete occlusion of the fixing eye for a certain period every day is necessary. Instillation of atropine in the fixing eye is also very serviceable and may replace the bandage, it frequently causes the strabismus to change over to this eye, especially when the originally squinting eye is used for near vision. When the vision is sufficiently improved, the training of the fusion sense should be undertaken. If diplopia be not present spontaneously it must be developed; and it is usually possible, when the sight in the squinting eye is not too defective, to give the patient diplopia—*i.e.* to make him continuously conscious of the presence of the image belonging to the squinting eye. This may be done by means of exercises with a prism, base downwards, before the deviated eye, or by coloured glasses, and with a candle flame used as visual object. The exercises are to be repeated daily, until diplopia without a prism is established.

Double vision having been established, we proceed to enable the patient to fuse the double images—*i.e.* to obtain binocular vision—by exercises with the stereoscope, convenient forms of which are Priestley Smith's heteroscope, and Worth's amblyoscope, or a modification of the latter, in which the electric illumination of the images can be varied at will. The training of the fusion sense should be carried out during that time of life which is the period of normal development of this sense. After six years of age the results are unsatisfactory, and involve great trouble and patience, yet cases have been recorded recently in which binocular vision has been restored in patients of 9 and 10 years of age.

As the patients are children, simple images, which require mere superposition without recognition of the third dimension, are generally sufficient at first; later on, pictures of geometrical drawings involving perspective can be used. Worth, however, believes that this treatment should be carried out by the surgeon, and that a child old enough to carry out stereoscope exercises himself is far past the age when the fusion sense might have been developed. This method of treatment is useful, too, in completing the cures which have been commenced by operative measures. But the method makes great demands on the patience and intelligence both of the patient and of his parents.

(c) *Operative Treatment.*—According to some, operative procedures should not be undertaken, unless fusion training has failed, or is too slow and tedious, while the majority of surgeons still depend mainly on operative treatment, with or without the aid of the orthoptic method. Opinions differ as to the best age for operation, the majority of surgeons preferring to wait until the patients are over five or six years of age, while those who have studied the subject from the orthoptic side consider, that when an operation is indicated, the earlier it is done the better.

Since concomitant strabismus is the result of faulty innervation, and not a muscular defect, rules which will ensure in every case, with absolute certainty, the desired degree of operative effect cannot be laid down. Indeed, all that is required in those cases in which binocular vision can be established is an approximate correction, as the patient's fusion sense will complete the cure.

Formerly the operations in use consisted in tenotomy of one or both internal recti, supplemented if need be by advancement of the external recti. But within the past few years advancement of the external recti has begun to take the place of tenotomy of the internal recti, which has been almost completely abandoned by many surgeons. As Landolt pointed out years ago, the disadvantages of tenotomy are serious. Tenotomy of the internal rectus by allowing the eye to come slightly forwards and the muscle to retract, weakens the power of convergence, and to a less degree the power of lateral movement, without producing any increase of mobility in the opposite direction. Again, even when no over-correction of the strabismus is produced by the operation, the eye after some years often becomes divergent. Advancement of the external recti, on the other hand, keeps the eye back in the grip of the muscles; and, while it increases the outward mobility, it does so without weakening the internal recti, in fact the total range of movement is enlarged. Furthermore there is little or no danger of over-correction, as long as the operation is not combined with tenotomy of the internal recti. If a double advancement should still leave a convergent strabismus of say 15° or more, then a careful tenotomy limited to the tendon alone, without interfering with its lateral capsular attachments, may be performed.

* **Mode of Operating for Strabismus.** *Tenotomy.*—The instruments required for this operation are a spring-stop speculum, a

small-toothed forceps, blunt scissors somewhat curved on the flat, and two strabismus hooks (Fig. 187).

The eye having been thoroughly cocainised, and a few drops of 2 per cent. cocaine solution injected under the conjunctiva over the site of the tendon, the patient is placed on his back, the surgeon standing in front of him and on his left side, if the left eye is to be operated on, or behind him if it be the right eye. The speculum is then applied, and the conjunctiva over the insertion of the tendon of the internal rectus is seized with the forceps, and incised with the scissors between the forceps and the eye. Into the opening thus made the points of the closed scissors are inserted, and, with a snipping action, a passage is made through the subconjunctival tissue, from the conjunctival opening to the upper border of the tendon in case of the left eye, or to its lower border in the right eye. The scissors are now laid aside, but the conjunctiva is still held in the forceps; and, with the right hand, the point of the hook is passed through the opening and along the passage until the edge of the tendon is reached. The point of the hook being kept in contact with the sclerotic, the instrument is then turned rapidly round and under the tendon, and is brought close up to the insertion of the latter into the sclerotic, care being taken that the whole breadth of the tendon lies on the hook. The forceps are now laid aside, and the hook carrying the tendon is transferred to the left hand. One blade of the scissors (held in the right hand) is now inserted between the globe and the tendon, and the latter is completely divided at its insertion. It is better to cut towards the handle of the hook than away from it, as there is then no tendency to push any fibres of the muscle off the hook. The second hook is then employed for searching, above and below, for any strands of the tendon which may be left undivided, the test for complete division being that the hook can be brought up without obstruction to the margin of the cornea. If even a small segment of the tendon be left undivided, the result of the operation is apt to be unsatisfactory. Immediately after the operation, a marked diminution in the mobility of the eye inwards should be looked for, as this motion can now only take place by aid of any remaining connective tissue attachments of the muscle to the



FIG. 187.

eyeball and capsule of Tenon. If this defect in motion be not present, or to only a slight degree in comparison with the supposed extent of operation, it may be concluded that the tendon is imperfectly divided, and a new search with the hook for undivided filaments must be made. To estimate this loss of motion it is necessary before the operation to note the degree of mobility of the eyeball inwards, and to compare it with the inward motion of the other eye.

The effect of the operation may be diminished, if necessary, by drawing the edges of the conjunctival wound together with a suture, the tendon being thus prevented from uniting with the globe so far back. The more conjunctiva we include in the suture at each side of the wound the more will the effect of the tenotomy be reduced. This restricting suture should be applied, when the immediate result of the tenotomy is greater than expected or desired.

Conjunctival sutures should also be used when an extensive loosening of the sub-conjunctival tissue has been performed, in order to prevent sinking of the caruncle or the formation of a granuloma on the, otherwise exposed, sclera.

The Sub-conjunctival Operation for Strabismus is performed as follows :—A fold of conjunctiva is seized close to the lower margin of the insertion of the muscle, and incised with blunt-pointed scissors, so as to expose the tendon. A strabismus hook is passed through the opening and under the tendon. The scissors are now inserted and opened slightly, one point being kept close to the hook, while the other is passed between the tendon and the conjunctiva, and the tendon is divided at its insertion. This method is very generally adopted by English surgeons, but that of von Græfe, previously described, is preferable, as it much more readily admits of modifications of the effect.

In von Arlt's Method, instead of a hook being passed under the tendon in the first instance, the latter is seized with the forceps with which, just previously, the conjunctiva had been raised. In other respects the proceeding is the same as von Græfe's, than which it is said to be less painful.

The immediate and ultimate effects of a tenotomy are by no means identical. Immediately after the operation the effect is marked, owing to the loosening of the tendon from its insertion. In a few days, when the tendon becomes re-attached, the effect diminishes, and in the course of some weeks there is again an increase in the

effect, and this increase continues for about a year, as above stated.

The ultimate result may, with tolerable certainty, be estimated immediately after the operation by testing the power of convergence. If the patient be directed to look with both eyes at the surgeon's finger held in the middle line, and it be approached to within 12 or 15 cm. of his nose, and if the convergence of the eyes can be maintained at that distance, the effect will not be too great. But if, at a distance of from 18 to 20 cm., the operated eye should cease to converge, or begin to diverge, or if even at 12 cm. the convergence, although accomplished, cannot be maintained for more than a few moments, and that then the operated eye deviate outwards, ultimate divergence may be expected, even though the actual position of the visual axes be correct. A restricting suture must be applied in such cases.

Sometimes, although the patient converges up to 12 cm. satisfactorily, and maintains the convergence at that distance for some moments, the eye will then rotate inwards. In such cases there is apt to be a recurrence of the strabismus.

* *Advancement.*—An opening is made with scissors in the conjunctiva immediately over the insertion of the external rectus, and as long as the breadth of the tendon. The band of conjunctiva between the opening and the cornea is separated up with the scissors from the sclerotic, for to it the tendon has to be fastened later on. A strabismus hook is now passed under the tendon, and brought well up to its insertion, care being taken that the whole width of the tendon is held on the hook. A needle carrying a fine silk suture is introduced from its upper margin between the tendon and sclerotic, and passed through the tendon at its middle line. In the same way another suture is passed behind the tendon from its lower margin, and through it, close to the first suture. Each of these sutures is knotted firmly on the tendon, a long end being left to each suture (Fig. 187). The tendon is separated off with the scissors from the sclerotic close to its insertion. The sutures are passed through the conjunctival flap in the direction of the muscle, and are respectively tied with their own ends. In order to obtain a better hold for the sutures some fibres of the sclerotic parallel to the corneal margin should be taken up on the needle, but this must be done with great care and with strict asepsis. A greater or less effect is produced,

according as the sutures are placed farther or nearer to the insertion of the tendon, and according as they are drawn more or less tightly. The effect can also be increased by excision of a portion of the tendon previous to suturing.

There are many modifications of the advancement operation. Some of them consist in different methods of applying the sutures. A few operators merely make a tuck in the tendon without dividing it, others divide the tendon longitudinally and suture each portion separately above and below the corneal margin. In capsular advancement the muscle is advanced along with the capsule of Tenon, the tendon being folded over on itself when the sutures are tied.

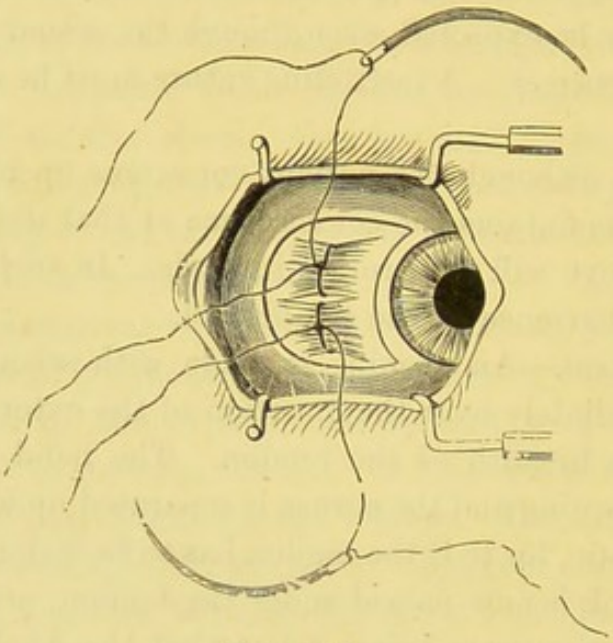


FIG. 188.

We have tried many of these methods, and find the above described operation as reliable as any.

After a tenotomy, a light dressing and bandage are applied on the operated eye only, but in cases of advancement, even if but one eye has been operated on, the bandage should be applied to both, and should not be removed, except for dressing purposes, for several days.

* *Dangers of the Strabismus Operation.*—Severe inflammatory reaction after a strabismus operation is very rare, and should not occur, even after an advancement. Puncture of the sclerotic with the scissors while the tendon was being divided has occurred in the hands of some operators; but except with sharp-pointed scissors,

or want of care, this cannot occur. It is also stated, that eyes have been lost after squint operations through orbital cellulitis, which, beyond doubt, must have been brought about by the introduction of septic matter upon the instruments.

Occasionally, a small arterial branch may be divided during the operation, and this, bleeding into the capsule of Tenon, may cause rather alarming exophthalmos. The protrusion goes back in a few days with use of a pressure bandage.

Sinking of the caruncle, some months after the tenotomy, when it does occur, can be remedied in the following way :—The conjunctiva is divided vertically about 6 mm. from the caruncle. The inner lip of the wound is raised, scissors curved on the flat passed in, and the sub-conjunctival tissue as far as under the sunken caruncle separated. The sub-conjunctival tissue under the outer lip of the wound, and as far as the corneal margin, is loosened in the same way, and the two flaps are brought together with a suture, which includes a sufficiency of conjunctiva to draw the caruncle well forwards.

Treatment subsequent to Operation.—It is generally necessary for the patient to wear the correcting spectacles for his hypermetropia either constantly or for near vision only, according as the result of the operative measures makes it more or less desirable to suspend the accommodation. After some months, it is usually possible to leave off the spectacles, except for near vision.

A cure of the strabismus, in the sense of removal of the deformity, can be attained by operation, and by itself affords ample indication for the operation. But a cure, in the true sense of the term, involves restoration of binocular vision, and this is very rarely obtained by operative measures alone. To this end the operation must be followed up by orthoptic treatment as already described (p. 514).

Divergent Concomitant Strabismus.—This form of strabismus is not so common as convergent squint. Two-thirds of the cases are due to myopia, which is generally more than 5 or 6D. It also occurs apart from myopia, and is then most frequently neuropathic.

In myopia two causes contribute to weaken the power of convergence for near vision. In the first place, little or no accommodation is required, and hence a tendency exists to relax the convergence. Furthermore, when the working distance is too close to the eyes, the increased effort of convergence which is necessary can-

not always be maintained. At first the weakness of convergence manifests itself only in near vision (insufficiency of convergence), but later on it results in absolute divergence for distance. Myopic divergent squint makes its appearance later in life than convergent squint, and the fusion sense is better developed than in the latter. Neuropathic divergent squint, on the other hand, is chiefly congenital, and the fusion sense is defective or absent. The degree of divergence is very liable to vary from time to time in these cases.

Treatment.—The correction of the myopia, by establishing the proper relations between accommodation and convergence, will cure the divergence in recent cases (see Insufficiency of Convergence, p. 529). The glasses should be worn constantly. In other cases, advancement of one or both internal recti should be performed, with tenotomy of the external recti if the power of abduction be greater than normal.

Non-paralytic divergent strabismus also occurs in blind eyes, and in high myopia. In the high degrees of myopia the movements of the eyes are more or less impaired, owing to their egg-shaped elongation. When the vision of one eye becomes defective, or when it becomes blind, there is always a tendency to divergence, unless the other eye be hypermetropic. If one eye be myopic and the other emmetropic, the myopic eye is often used for near vision, and then the other eye diverges, whereas the emmetropic eye serves for distance, and the myopic eye may then be divergent.

* **Latent Deviations (Heterophoria).**—When the orbital muscles are in a state of normal equilibrium, or orthophoria, and the eyes are fixing an object either distant or near, if one eye be covered, and thus excluded from the act of vision, it nevertheless continues to maintain its direction, and no deviation of the eye takes place behind the screen, or covering hand. But if the muscular balance be imperfect (heterophoria), there is a tendency for the eyes to deviate from the correct position, which tendency, however, under ordinary conditions, is kept in check by the desire for single vision. The deviation is suppressed by a special muscular effort, and only becomes manifest under artificial conditions ; namely, when the vision of the two eyes is dissociated, by such measures as render binocular vision difficult or impossible. This form of deviation is therefore said to be latent, and is sometimes known as suppressed squint.

Latent deviations, due to disturbance of the relation between

accommodation and convergence, occurring in errors of refraction (such as latent convergence with hypermetropia), are not to be regarded as heterophorias unless they persist after the optical correction.

If the fusion sense become impaired—by disease of one eye, for example—a latent deviation may become manifest and may lead to true strabismus.

Latent deviations may be in the direction of convergence (Esophoria), or divergence (Exophoria), or the eyes may tend to turn in opposite directions vertically, one eye being higher than the other (Hyperphoria), when the condition is called right or left hyperphoria, according to the eye which is the higher.

The muscular effort necessary to keep the tendency to deviation in control, sometimes leads to the development of asthenopic symptoms (muscular asthenopia). Special attention has been paid to this form of 'eye strain' in the United States, where it has been held accountable for nervous affections, such as neurasthenia, hysteria, migraine, chorea, and epilepsy. This view, however, is generally regarded as somewhat exaggerated. It is more probable that heterophoria merely acts as an additional exciting cause of nervous attacks, in those who are already subject to the conditions mentioned. Defects in the muscular balance are not more common in neuropathic than in healthy individuals, who do not suffer from asthenopia; and these defects may be present in the former, without giving rise to asthenopia.

* *Test for Latent Deviations.*—The best test object for distance (six metres) is a candle flame or frosted electric lamp, and for near vision a black dot or line.

1. *Test by Exclusion of One Eye.*—While the eyes fix the test object, one eye is covered by the surgeon's hand, and its position, as shown for instance by the corneal reflex, is observed immediately on withdrawing the hand, as also any movement which the eye may make to right itself. The latter movement indicates a deviation in the opposite direction—*e.g.* if the eye move inwards on being uncovered, it must have been deviated outwards when covered.[1]

[1] In the 'exclusion' test for *latent* deviations it will be observed that it is the position of the eye which is covered which is noted by the surgeon, whereas when the 'exclusion' test is applied to detect a *manifest* strabismus (p. 468) the uncovered eye must be watched.

Both eyes must be examined alternately. When a heterophoria is present, it generally exists in both eyes, and is of the same kind.



Fig. 189.

In hyperphoria (vertical deviation), the eye which is higher will rotate downwards, and its fellow will make a movement upwards; for example, in left hyperphoria the left eye will deviate upwards when covered, and will adjust itself by a downward movement when uncovered; the right eye, on the other hand, when screened will deviate downwards, and will rotate upwards on re-exposure. This test, however, is by no means so delicate as the following subjective tests, which depend on the production of diplopia.

2. *Tests with Prisms.*—(*a*) This test was first used by von Græfe for the examination of insufficiency of the internal recti. A prism is placed vertically before one eye, of such a strength that it cannot be overcome by the muscles; one of 10° is sufficient. A dot with a fine line drawn vertically through it (Fig. 189) on a sheet of white paper is given to the patient to look at, at his usual reading distance. If the prism be placed with its base downwards before the right eye, this, in the normal condition, both eyes fixing, would produce a double image of the dot and line, placed of course vertically, one over the other, and as the images of the lines overlap, the figure would seem to be a line with two dots, the upper dot being the image belonging to the right eye (Fig. 190). In insufficiency of convergence (exophoria), the image of the right eye would not only be higher than that of the left, but it would also stand to the left (crossed double images) more or less; so that here the picture is that of two lines, each with a dot, the upper line and dot standing to the left side (Fig. 191). This crossed diplopia indicates divergence. In this case the artificially produced vertical diplopia renders the latent deviation manifest, and a lateral diplopia is superadded.



Fig. 191.



Fig. 190.

In order to test for vertical deviations (hyperphoria), the prisms

must be placed horizontally, and with their bases inwards; because the external being much weaker than the internal recti, prisms of lower degrees can be used; but for this purpose the rod test described below is better.

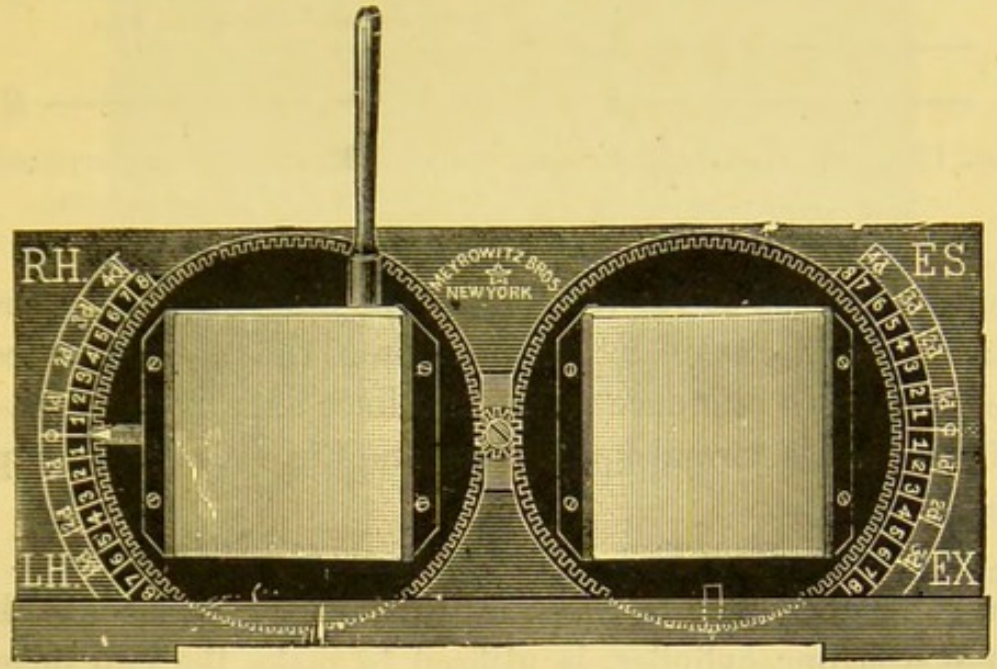


FIG. 192.—The prisms of Stevens' phorometer.

(*b*) Stevens' phorometer (Fig. 192) is a convenient instrument for applying the prism tests. The prisms can be placed either vertically or horizontally by the lever, and the degree of heterophoria can be measured by a rotation of the prisms, the amount of the deviation being indicated on the scales to the right and left.

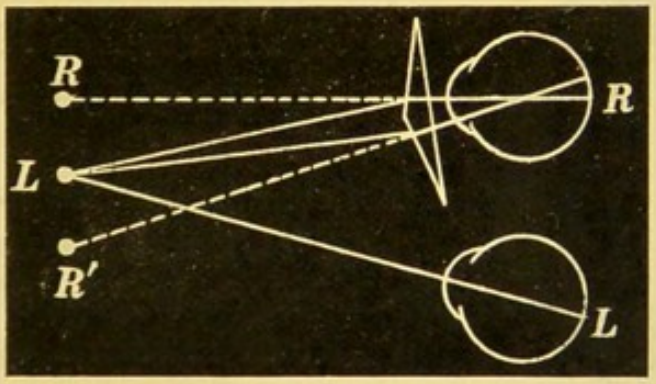


FIG. 193.

(*c*) Maddox's Double Prism is also useful. It is composed of two prisms, base to base, and is easily adjusted. When placed vertically before, say, the right eye, with the line of junction of the prisms opposite the pupil, this eye sees two images of the spot,

one vertically over the other, and, if the muscular equilibrium be normal, the spot seen by the left eye will appear to be in a line with the other two, and midway between them (Fig. 193). If a hori-

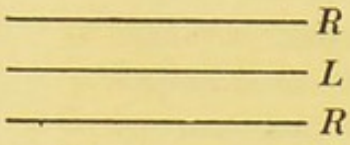


FIG. 194.—Normal equilibrium.

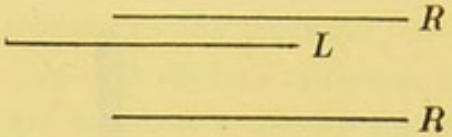


FIG. 195.—Right hyperphoria and esophoria.

zontal line be used as the test object, the different forms of heterophoria can be diagnosed by the position of the central line seen by the left eye, with reference to the two lines seen by the right—*e.g.*, Fig. 194 indicates normal equilibrium, and Fig. 195 right hyperphoria and esophoria.

3. Maddox's Rod Test.—This is probably the best test. The apparent lengthening of a flame into a line of light, when looked at through a strong cylinder, is utilised to make the two images so dissimilar, that no desire to unite them remains. The chief advantage of this principle is that slight malpositions do not, as with prisms, vitiate the result materially. The instrument consists of a number of parallel glass rods (Fig. 196) usually coloured red, which thus produce a red line of light, at right angles to the axis of the rods, when placed before one of the eyes, the other eye seeing the light or flame naturally. When the red line passes through the flame there is orthophoria (Figs. 197, 1).

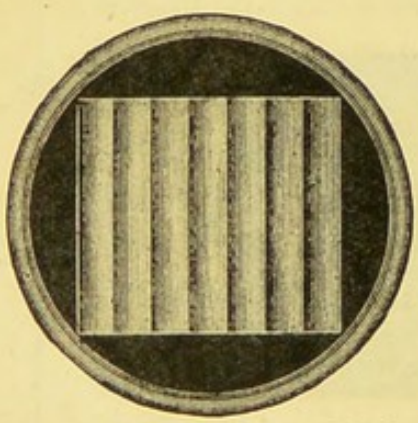


FIG. 196.—Maddox's Rods.

The line of light must be vertical, and therefore the rods must be placed horizontally for horizontal deviations (Fig. 197), and the opposite way for vertical deviations (Fig. 198). The defect is measured by the deviating angle of that prism, which brings the light and line together, or, preferably, by a tangent scale, placed with its zero just behind the flame, so that the figure crossed by the line of light gives the deviation in degrees. For vertical diplopia the scale should be vertical, and for horizontal diplopia, horizontal. In either case the axis of the

cylinder should be parallel to the scale. When the cylinder is vertical, it should be shaded from the light of the window. By placing the patient's head in different positions, the diplopia can

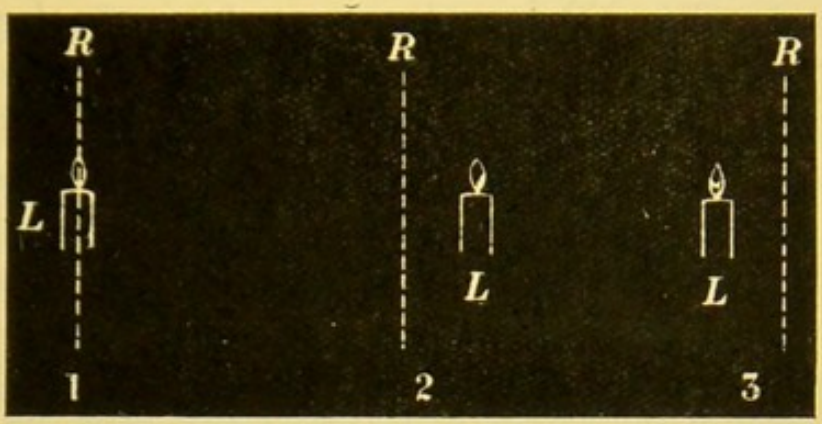


FIG. 197.—1. Orthophoria. 2. Exophoria or latent divergence. 3. Esophoria or latent convergence.

be measured in all parts of the oculo-motor field. Vertical and horizontal scales should, for this purpose, be fixed on the wall, with their zero points coinciding at the position of the flame. This test is most useful for distant vision (6 metres). For near vision the double prism is better.

In order to obtain accurate results when testing the muscular balance, any error of refraction must be corrected.

* *Symptoms of Heterophoria.*—Great difference of opinion exists as to the frequency with which heterophoria gives rise to asthenopia. In the United States it is said to be very common. There is no doubt

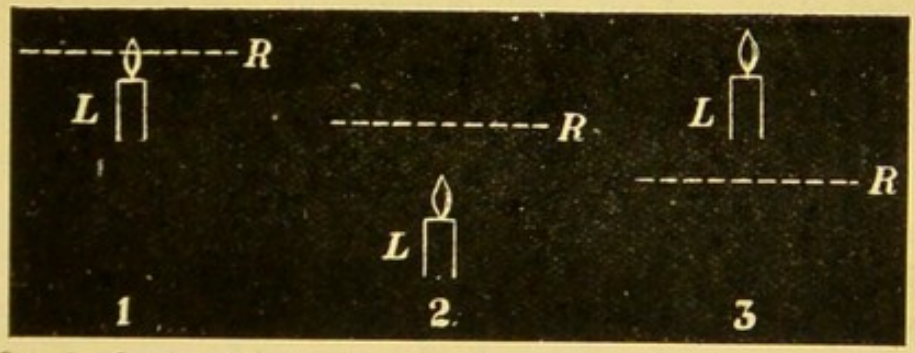


FIG. 198.—1. Orthophoria. 2. Left hyperphoria. 3. Right hyperphoria.

that heterophoria may be present without causing any inconvenience. Hyperphoria is the most troublesome form, esophoria the next most troublesome, while exophoria, unless combined with a diminished amplitude of convergence, causes little or no annoyance. The symptoms

are : headache and pains in the eyes—especially towards the end of the day, or following on long-continued close observation—giddiness and conjunctival hyperæmia. Narrowing of the palpebral fissure sometimes occurs in hyperphoria, in the eye which deviates upwards.

Treatment.—This will depend, not merely on the degree of the heterophoria, but also on the strength of the muscles, as measured by their power of overcoming the diplopia produced by prisms. Whether the heterophoria be present in near, or in distant vision, or in both must also be considered. In near vision at a distance of 12″ an exophoria of 2° to 4° is very common, and often causes no annoyance.

The treatment consists in the wearing of prisms with the base in the direction of the muscle to be relieved (p. 396), exercises with prisms, or operation. The first two will suffice in moderate degrees of the defect ; but it may be mentioned that the value of exercises with prisms is doubted by some surgeons. When only a prism of low degree is required, the desired effect may be accomplished by decentration of the lenses (p. 408), which correct the error of refraction, if there be one. In the higher degrees operation may be necessary, advancement of a muscle being preferred to tenotomy of the antagonist. In Europe, graduated tenotomies, by which is meant partial division of the fibres of the tendon, are not regarded with favour.

* *Cyclophoria* (*Latent Torsion*).—This consists in a tendency to abnormal rotation round the antero-posterior axis of the eyeball, so that the vertical meridians of the eyes are no longer parallel. The subject is not, as yet, well understood. A certain amount of torsion appears to occur physiologically in near vision. Latent torsion can be detected with the double prism, a horizontal line being used as the test object. If it be present, the line seen by the naked eye, between the double image, will not be parallel to the double lines seen by the eye clad with the prism. Fig. 199 indicates an inclination of the upper ends of the vertical meridians towards one another. The opposite is, however, the more common condition. Maddox's rod and Stevens' clinoscope are also used for testing cyclophoria.

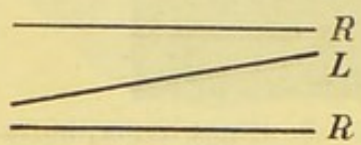


FIG. 199.

According to Savage, in astigmatism with oblique axes, torsion

is necessary to make the vertical meridians coincide with the nearest meridian of the astigmatism; and he believes that this accounts for the fact, that some astigmatic people are more comfortable without correction of their astigmatism, being unable to abandon the torsion to which they had become habituated.

Insufficiency of Convergence.—This has to a great extent been confused with exophoria (latent divergence) for near vision; indeed, von Græfe's test is really one for exophoria or esophoria existing in near vision, rather than for insufficiency of convergence. The two conditions may co-exist, but one does not involve the other. Either may be present alone; furthermore, a latent convergence (esophoria) may in some cases exist along with insufficiency of convergence. The essential point in the diagnosis of the latter condition is the presence of a diminution of the amplitude of convergence (p. 9) as measured by gradually approaching to the eyes, in the median line, a series of parallel fine lines, or an illuminated line or point, until one eye is seen to diverge, or until the patient gets crossed diplopia. The test should be made on several different occasions, as results are liable to vary with the state of health or available energy of the patient.

Causes.—Insufficiency of convergence usually depends on defective innervation, due to a central cause, which may be organic, as in locomotor ataxy, or more commonly functional, as in hysteria, neurasthenia, anæmia, and exophthalmic goitre (partly). Other causes are myopia (see Divergent Strabismus, p. 521), and perhaps sometimes anatomical defects in the internal recti.

Symptoms.—Patients complain of pains in the head and eyes, and fatigue after reading, sewing, etc., for any length of time; they are inclined to hold the book or work farther from them, and they sometimes get relief by closing one eye.

Treatment.—In neuropathic and debilitated patients, the general health requires attention both mentally and physically, and out-of-door exercise, with peace of mind, should be recommended. With regard to local treatment, exercises in convergence, with or without the aid of the stereoscope, should first be tried, any error of refraction being of course corrected. A full correction of myopia, and an under-correction of hypermetropia may render assistance, by making demands on the accommodation, and thus indirectly on the convergence. If exercises prove useless, prisms with bases

inwards may give relief, or, if glasses be worn, they can be decentred (p. 408).

Should these methods prove unsuccessful, advancement of one internal rectus, or of both if necessary, should be performed.

Spasm of the orbital muscles only occurs in convulsions, in conjugate deviations, and in hysteria. In the latter condition it is not uncommon to find spasm of the orbicularis, with convergent strabismus and contraction of the pupil due to spasm of accommodation.

Two very simple and useful instruments which have of late been applied to the observation of phenomena connected with binocular vision, including the detection of malingerers, are the Diploscope of Remy, and Harman's Diaphragm Test. These tests have the advantage over the stereoscope of being made under more natural

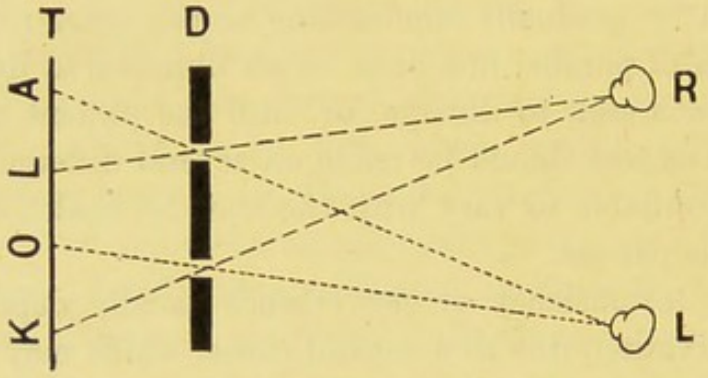


Fig. 200.—To illustrate the principle of the Diploscope.

conditions. We have found the instruments of great service in ascertaining the binocular effect of the reading-glasses ordered for presbyopia, etc.

The Diploscope consists of a screen with perforations through which test letters are seen. The holes may vary in number and position. In the simplest form of the test there are two holes placed horizontally through which a horizontal row of three or four letters is visible. Fig. 200 explains the principle involved. The letters on the test card T are seen through the two apertures in the screen D in such a way that the consonants only are visible to the right eye R, and the vowels to the left eye L. In normal vision the letters appear in their proper position as K O L A ; but if the eyes diverge, the resulting crossed diplopia will cause K L and O A to move away from each other so that the test will now read K L O A. Excess of convergence on the other hand will make the pairs of letters

approach each other so as to read O K A L, or in higher degrees O A K L. If there be a vertical deviation of one eye, one pair of letters will appear to be higher than the other.

In Harman's test, Fig. 201, the Screen D has only one aperture, through which the central portion of the test on the card T will be visible to both eyes, and the other portions to one eye only; for instance No. 3 is seen by both eyes, 1 and 2 by the right eye (R) only, and 4 and 5 by the left eye (L) only. It is found that, in order to obtain binocular vision, some persons require a larger area visible to both eyes than do others. According to Harman, the width of this area measures the intensity of the desire for binocular vision, and he has called it the 'ocular poise.' The size of the area common

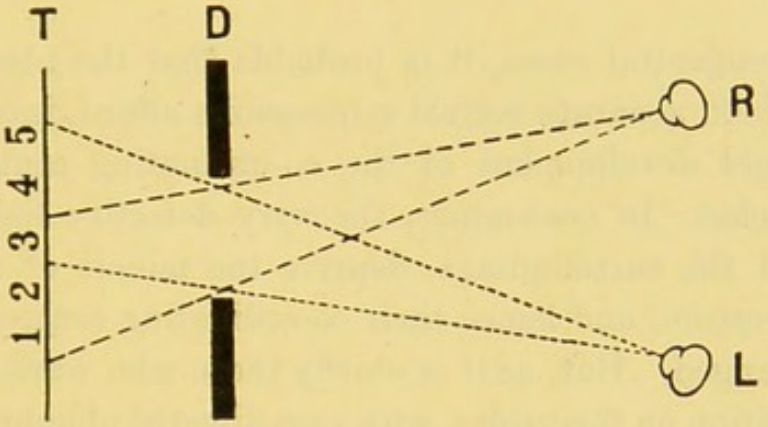


FIG. 201.—To illustrate the principle of the Diaphragm Test.

to both eyes depends on the width of the aperture, and in the newer model of the instrument this can be varied, and its measurement can be read off on a scale.

NYSTAGMUS.

This term indicates an involuntary rhythmical oscillation of the eyeballs laterally (the most common form), vertically, or with a rotary motion (caused by the oblique muscles). It is usually constant, but may increase or become visible in certain positions of the eyes only, while it may diminish in others. Sometimes it is accompanied by oscillation of the head.

It usually affects both eyes, but in rare cases it is unilateral.

It is most commonly found along with congenitally defective vision—microphthalmos, coloboma of the chorioid, albinism, etc.

—or in those whose vision suffered in infancy, *e.g.* leucoma of the cornea, anterior polar cataract caused by ophthalmia neonatorum, etc.; but it may be acquired, and is often seen in those employed in coal-mines. It occurs in many cases of disseminated sclerosis.[1] In rare instances it can be produced voluntarily; in one case of the kind that we have observed, the individual induced it by converging as much as possible. Nystagmus does not affect the excursive movements of the eyes, nor has it any direct effect on the acuteness of vision.

Temporary nystagmus, due to irritation of the vestibular nerves in the semicircular canals, can be produced by syringing the ear with warm or cold water or by rotation of the patient, and the variety of nystagmus thus induced is made use of for diagnostic purposes. (Barany.)

In the congenital cases, it is probable that the absence of the stimulus, which accurate retinal impressions afford, interferes with the functional development of the co-ordinating centres for the orbital muscles. In coal-mines, the very defective light, and the blackness of the surroundings, deprive the miners of any defined retinal impression, and hence their co-ordinating centres are apt to become deranged. But, as it is chiefly those who work in one constrained position on their sides, with eyes directed obliquely upwards, who become affected, it seems probable that this unnatural and long-continued direction of the eyeballs is an important factor in the production of the affection; indeed, it may be to a great extent a professional cramp, like writer's cramp. In fact, a case of acquired nystagmus in a compositor, due to working in a strained position, has been recorded by Snell.

Those patients, in whom nystagmus is due to a congenital defect of vision, do not complain of oscillation of the objects they look at; but individuals, who become affected with it in later life, are much troubled by that symptom, especially at the onset. In miners, the nystagmus is often accompanied by night-blindness, and a peculiar twitching of the eyelids.

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[1] According to Gowers (*Diseases of the Nervous System*, vol. i., 2nd Ed.), nystagmus occurs often in ataxic paraplegia, primary spastic paraplegia, and hereditary ataxia, sometimes in severe multiple neuritis and syringomyelia, but rarely in progressive muscular atrophy.

Treatment.—Congenital nystagmus is, as a rule, incurable, but in cases which admit of improvement of vision, a cure, partial or complete, is sometimes brought about when the vision improves. If strabismus be present it should be cured, after which a diminution in the oscillations may result. In miner's nystagmus, the all-important measure is a permanent relinquishment of mine work; and this is frequently followed by satisfactory results.

CHAPTER XVII.

DISEASES OF THE EYELIDS.

Erythema, erysipelas, phlegmonous inflammation, and abscess are all liable to attack the eyelids, but require no special observations in this work. It should merely be stated that erysipelas of the eyelids may extend to the connective tissue of the orbit, and ultimately give rise to atrophy of the optic nerve.

Eczema.—This is often seen on the skin of the eyelids, most frequently in connection either with general eczema of the face or with phlyctenular ophthalmia. The lacrimation in phlyctenular ophthalmia increases the eczema, which then, by causing contraction of the skin of the lower lid, often produces eversion of the inferior punctum lacrimale, and this, in turn, causes increased lacrimation.

Atropine infiltration of the eyelid, from use of atropine eye-drops in some persons, is frequently accompanied by a moist form of eczema of the lids and face.

Treatment.—Should the use of atropine be the cause it is necessary to discontinue it, and to substitute solution of Scopolamine (gr. j and ʒj). As an application to the affected skin the following ointment is useful :—Oil of Cade, ♏ iv, Zinci oxidi, gr. v, Adipis lanæ hyd. vaselin alb., aa. ʒij.

Marginal Blepharitis (*βλέφαρον, eyelid*), or **Ophthalmia Tarsi,** is nothing else than eczema of the margin of the eyelid. It is found either as **Blepharitis Ulcerosa** (Eczema Pustulosa), or as **Blepharitis Squamosa** (Eczema Squamosa). In blepharitis ulcerosa, small pustules form at the roots of the eyelashes, and these, having lost their covering, become ulcers, which scab over. The whole margin of the lid may then be covered with one large scab, in which the eyelashes are matted, and under which the lid will be found swollen, red, and moist, with many minute ulcers and pustules, the latter

due to suppuration of the hair follicles and of the sebaceous glands belonging to them. Many eyelashes come away with the scab when removed, and others are found loose and ready to fall out. Cicatrices resulting from the suppuration are also present, and there the hair follicles are destroyed, and the cilia do not grow again.

The disease is chronic, and is most commonly seen in strumous children. It is frequently accompanied by phlyctenular ophthalmia, or by simple conjunctivitis, which may have been its cause, or which promotes it by keeping the margin of the lid constantly wet.

If neglected, ulcerous blepharitis, by reason of the scars it produces, is liable to give rise not only to permanent loss of eyelashes, but to irregular growth (trichiasis) of those which remain. After a time, the continued congestion and inflammatory swelling of the lid margin leads to its hypertrophy, chiefly of the upper lid.

The margin of the lower lid is liable to become everted, owing to contraction of the skin of the eyelid. Involved in this eversion is the lower punctum lacrimale, and consequently lacrimation ensues, with resulting eczema of the eyelid, which in turn promotes the ectropion, while the exposure of the conjunctiva of the lower lid increases the already existing conjunctivitis.

The Treatment of Ulcerous Blepharitis consists, in the first place, in the careful removal of the scabs, without causing any bleeding of the delicate surface underneath. Bleeding indicates that newly formed epithelium has been torn away, and it is important, therefore, to soften the scabs by soaking the eyelid with olive oil, or with a warm saturated solution of bicarbonate of soda, before removing them. Any pustules found under the scab should be punctured, and all loose eyelashes, which act as foreign bodies, taken away. Also all diseased eyelashes should be drawn away. These are recognised by aid of a magnifying glass as shorter, thicker, straighter, and more highly pigmented than the normal ciliæ; and when removed their roots are found to be club shaped. The ulcers should be carefully touched twice a week with a fine point of solid mitigated lapis. The surface should then be well dried by pressure, not by rubbing, with cotton wool, and the following ointment rubbed in with the tip of the finger—Hydrarg. pracip. alb. gr. vj, Zinci oxidi gr. viij, Liq. plumbi subacet. ♏ vj, Adipis benzoat. ad. ℥iv. This ointment is to be continued by the patient, night and morning, after the lids have been washed, and all scabs and loose eyelashes

removed from them, and well dried, until healing is thoroughly established. In many mild cases a boric acid ointment (gr. ij ad ʒj of vaselin or of lanolin) will be found efficacious instead of the above. A creolin ointment suits many cases, if it do not irritate—viz. Creolin, 1 to 5 min. ; Aq., ʒij ; Lanolin, ʒvj.

Or, again, after the scabs and loose and diseased eyelashes have been removed as above, the margins of the eyelids may be freely bathed with a wash of ten to twenty minims of creolin to eight ounces of water, and after this the creolin ointment may be applied. A first principle of treatment in all these cases is that it be non-irritating.

All complications with conjunctival affections or lacrimal obstruction must be attended to, the patient's general system carefully improved, and errors of refraction corrected. In inveterate cases, the use of staphylococcus vaccine is indicated.

Squamous Blepharitis comes on after the ulcerous form has passed away ; or, it is found as a primary affection, especially in chlorotic women. The margin of the lid is somewhat swollen and red, and covered with loose epidermic scales. It is an extremely chronic affection, but, although disfiguring, it has no dangerous sequelæ.

The Treatment of Squamous Blepharitis. Boric acid ointment (gr. xx ad. ʒj).

Chlorosis, if present, should be treated with suitable remedies.

Phtheiriasis (*φθείρ, a louse*) **Ciliorum.**—The pediculus pubis occurs on the eyelashes. It gives rise to excessive itching and burning sensations, and the consequent rubbing produces excoriations of the margin of the lid. The lice occupy chiefly the roots of the eyelashes, to which they cling tenaciously, while the shafts of the cilia are covered with their brown egg-capsules ; and this gives to the cilia the peculiar appearance of being covered with dark brown powder, which enables the diagnosis to be easily made. The fully developed parasites, as well as the eggs, may be more readily seen by aid of a strong convex glass.

Treatment.—With a cilium forceps the pediculi as well as some of the eggs may be removed from the cilia. This proceeding repeated daily, along with the application of mercurial ointment, or of a weak red precipitate ointment, to the margin of the eyelids morning and evening, will soon effect a cure.

Hordeolum (*hordeum*, a grain of barley), or **Stye,** is a circum-

scribed purulent inflammation situated at the follicle of an eyelash. It commences as a hard swelling, with more or less tumefaction and œdema of the general surface of the lid, and often with some chemosis, especially if it be situated at the outer canthus. In its early stages there is much pain associated with it. It gradually suppurates, and may then be punctured or allowed to open of itself.

Styes frequently come in rapid succession, and then, probably, a constitutional disturbance exists as the cause. In the earliest stage cold applications may be successful in putting back a stye, but, later on, warm stupes will hasten the suppuration and relieve the pain. Habitual constipation is a common source of hordeolum, and should be met by the use of mild laxatives. Sulphide of calcium, $\frac{1}{10}$ gr. every hour, or $\frac{1}{2}$ gr. twice a day, for an adult, has been recommended as a specific in these cases. If there be troublesome recurrences, vaccine treatment can be adopted.

Chalazion (*χάλαζα, hail*), **Meibomian Cyst,** or **Tarsal Cyst,** is probably a granuloma in connection with a Meibomian gland, and not a mere retention cyst. The granuloma consists of round and epithelioid cells and sometimes giant cells. Chalazion has its origin in a slight chronic inflammatory process in the connective tissue surrounding the gland, which usually passes off without having attracted the attention of the patient, but occasionally, when the cyst has developed, acute inflammation with formation of pus comes on. The tumours vary in size from that of a hemp-seed to that of a hazel-nut, causing a marked and very hard swelling in the lid without any redness of the latter. They occasionally open spontaneously on the conjunctival surface, giving exit to contents which are usually viscid or grumous, and sometimes purulent.

Treatment.—No application can bring about absorption of these tumours. Local anæsthesia having been produced by an acoine, or by a cocaine and adrenaline injection, the lid is everted, and the tumour is opened by an incision from the conjunctival surface, and its contents thoroughly evacuated by aid of a small curette. Difficulty is sometimes experienced in finding the point in the conjunctiva corresponding with the tumour, but it is usually indicated by a dusky or greyish discoloration. Immediately after the evacuation, bleeding into the sac often takes place, and causes the tumour to remain for a day or two as large as before—a fact of which the patient should be warned. The operation may occasionally require to be repeated.

The interior of the sac should not be touched with nitrate of silver; and the incision and evacuation should not be made through the skin, unless in rare instances when the capsule is exceptionally thick, as more or less disfigurement from the scar may result.

More than one chalazion is often present at a time, and some people become liable to them periodically during a number of years, especially those who suffer from acne of the face.

* **Milium** (*milium*, a millet seed) presents the appearance of a perfectly white tumour, not much larger than the head of a pin, in the skin of the eyelid. It is a retention tumour of a sebaceous gland, and can readily be removed by puncture and evacuation.

* **Molluscum,** or **Molluscum Contagiosum.** — This is a white tumour in the skin of the eyelid, which may attain the size of a pea. At its summit is a depression, which leads to an opening into the tumour, through which the contents can be pressed out. It is probably a diseased condition of a sebaceous gland, and contains altered epithelial cells, and peculiar bodies, termed molluscum corpuscles, which are of a fatty nature. Many such tumours may form in the lids at the same time. It is held by some observers that this affection is contagious, although in what way is not clear, inasmuch as experimental rubbing of the contents of a molluscum into the skin has not given rise to the tumours.

Treatment.—Each separate tumour must be evacuated by simple pressure, or after it has been opened up with a knife or scissors.

Teleangiectic Tumours, or **Nævi,** of the eyelids occur congenitally.

Treatment.—Small tumours of this kind may be destroyed by touching with nitrate of silver or hydrochloric acid, or by performing vaccination on them in the case of infants, instead of on the arm. Larger tumours may be ligatured or treated with the galvano-cautery, or with ethylate of soda, or carbonic acid snow, and electrolysis is a very effectual method in many cases.

* **Xanthelasma** (*ξανθός, yellow*; *ἔλασμα, a layer*) is the term applied to yellowish plaques raised slightly over the surface of the skin of the eyelid, with very defined margins. Women are more liable to it than men. The patches are generally bilateral and symmetrical, and are most frequently situated in the neighbourhood of the inner canthus. The shape of these plaques is extremely irregular, and they may attain the size of a shilling or larger. The appearance

is caused by changes in the middle layers of the corium, consisting of aggregations of large epithelioid cells, with development of connective tissue, and of yellowish brown pigment in and about the cells, with fatty degeneration of the connective tissue.

Treatment.—Removal by careful dissection is sometimes employed, but can hardly be recommended unless under exceptional circumstances; the growth, moreover, is liable to recur. But good, and apparently permanent, cures have been effected by means of radium. Electrolysis too can be used. A platinum needle is passed about 5 mm. under the growth and parallel to the skin and allowed to remain a few seconds, five or six such insertions being made fairly close to each other. A scab forms and comes away in a few days, and thus in a few sittings the entire growth will have been attacked. Care must be taken to destroy the whole growth, or a recurrence will take place.

* **Palpebral Chromidrosis** (*χρῶμα, colour*; *ἵδρωσις, sweating*).—The phenomenon of an exudation of pigment upon the eyelids, of which a good many cases are recorded, has given rise to much discussion. The opinion held by many is that these cases are always the result either of deception in hysterical individuals, or of accidental circumstances, such as the exposure of a patient with seborrhœa palpebrarum to an atmosphere loaded with coal-dust or pigmentary matter, in some manufacturing district. Of the fact that the appearance has occurred under both of these conditions there can be no doubt. There would seem also to be evidence that some genuine cases of colour-sweating on the eyelids have been observed; but they must be extremely rare. The discoloration is blue or black, and occurs in the form of fine powder upon the skin of one or both eyelids of both eyes It can be wiped off, and is said to begin to reappear after a short interval. The subjects of it have been chiefly young girls, but it has also been seen in women of advanced years, and even in middle-aged men.

The Treatment in a genuine case may consist in the application of a lotion of liq. plumbi and glycerine; and, internally, iron, quinine, and arsenic, along with the regulation of the general system, particularly in respect of any uterine derangement.

Herpes Zoster Ophthalmicus is a herpetic eruption of the skin in the region supplied by the ophthalmic division of the fifth nerve of one side.

Occasionally, in the same case, the second division of the fifth nerve may be affected, and, yet more rarely, the third division as well. One or two cases, too, have been published in which the zoster affected each side of the face.

But by far the most common case is the simple herpes zoster ophthalmicus, in which only the region supplied by the ophthalmic division of the fifth nerve is affected ; and of this region it is usually that portion alone which pertains to the supra-orbital and infra-trochlear branches that is involved, as is represented in Fig. 202. The number of vesicles varies much ; there may be but one, or there may be several, or they may be so numerous as to become confluent.

The appearance of the eruption is often preceded by a feeling of general discomfort, gastric disturbance, and high temperature. Yet more commonly is the eruption preceded by supra-orbital neuralgia, which is often of intense severity. This pain usually continues, but may cease, after the eruption comes out, and sometimes it persists even for many months after the eruption disappears. Photophobia, due to the irritation of the fifth nerve, is not uncommon at the commencement of the affection. Along with the appearance of the herpes the skin of the forehead becomes red and swollen, and the appearances are often mistaken for erysipelas, but the strict limitation of the eruption by the vertical middle line of the forehead is of itself sufficient to indicate the diagnosis. The upper lid is somewhat œdematous and red, and droops over the eye, and this is much more marked when the skin of the eyelid itself is the seat of vesicles.



FIG. 202.

The contents of the vesicles soon become purulent and hæmorrhage may take place in them. They then gradually dry up, and form crusts, which conceal more or less deep ulcers, and as these ulcers often penetrate to the corium they are liable to leave permanent scars behind, which at first are red, and later become of a glistening white. The entire eruptive process lasts about three weeks ; and, when it is completed, the sensibility of the affected skin

remains dull for a considerable time. Herpes zoster ophthalmicus is more common in advanced life than in youth, but it may appear at any age, and has been observed as early as the sixth month after birth.

The disease is not associated with danger to the eye, unless keratitis come on, or, what is much more rare, unless iritis, cyclitis, or chorioiditis appear. The conjunctiva is almost always slightly chemotic and injected, or there may be true conjunctivitis; but vesicles are not often seen on it.

There is considerable variety in the forms of keratitis liable to occur in herpes zoster ophthalmicus—viz. herpetic vesicles, phlyctenulæ, bullæ (any of which may go on to ulceration), superficial opacity without loss of substance, and parenchymatous opacity, either diffuse or punctate. The superficial opacities without loss of substance may disappear completely. Parenchymatous opacity either clears away completely, or remains as a slight nebula; while ulceration leaves, at the least, some opacity; or, if it become septic, may seriously endanger the eye. Anæsthesia, more or less well marked, attends the corneal affections, and remains for a long time after they recover.

Iritis is very uncommon in herpes zoster ophthalmicus, and is usually of a mild type, and irido-cyclitis and chorioiditis are still more uncommon.

Herpes zoster ophthalmicus is due to an inflammatory process in the Gasserian ganglion, as Head and Campbell have shown, and in the opinion of these authors the skin eruption is caused by intense irritation of the ganglion cells. The lesion in the Gasserian ganglion is similar to that found in the posterior root ganglion in zoster of the trunk and limbs. Head and Campbell believe the affection to be an acute specific disease—a view suggested by the facts that it occurs in the course of recognised infective diseases, that it occurs endemically and epidemically, and that it rarely occurs a second time. It is probable that the affection may also have a toxic origin, as when arsenic has been taken for a long time, and in carbonic oxide poisoning.

Treatment.—It is doubtful whether treatment has any influence in curing or in controlling the severity of an attack of herpes zoster ophthalmicus. Quinine in full doses should be given, and a 1 per cent. cocaine ointment made with equal parts of vaseline and lanolin

should be smeared lightly over the affected part. Complications in the cornea or uveal tract are to be dealt with on the principles laid down in the chapters on diseases of those organs. The patient, unless the attack be a very mild one, should be confined to bed.

* **Syphilitic Affections of the Eyelids.**—*Primary Syphilitic Sores* occur on the eyelids, usually near the margin of the upper or lower lid, or at the inner or outer canthus, or may occupy the conjunctival surface of the eyelid. The first appearance is generally a small red swelling which the patient calls a 'pimple,' and which ulcerates and becomes characteristically indurated about its base. The margin of the ulcer is clean-cut, and its floor somewhat excavated, and covered with a scanty greyish secretion. Or, without any ulceration, the lid is swollen, greatly indurated, purple, and shiny; and in these cases the diagnosis may be somewhat difficult. The pre-auricular and sub-maxillary glands are almost always swollen; and this is a valuable, although not altogether positive, diagnostic sign, as it is seen also in tubercular diseases of the conjunctiva. The presence of spirochætes in the secretion, or a positive Wassermann test, will determine the diagnosis. The occurrence of the sore is followed by the usual constitutional symptoms of syphilis. Very rarely is there any permanent damage done to the eyelid.

The most common modes of infection are by a kiss from a syphilitic mouth, or by a finger.

In view of the rarity of this affection, as also of interstitial keratitis in acquired syphilis, quite a number of cases have been recorded, in which interstitial keratitis followed in the eye the lid of which had previously been the seat of a primary syphilitic sore.

Treatment.—Locally, iodoform ointment, dusting with finely powdered iodide of mercury, or the black wash may be used; while salvarsan, or the usual general mercurial treatment is employed.

Secondary Syphilis gives rise to ulcers on the margins of the lids, to loss of the eyelashes, and to the secondary skin affections which attend it in other parts of the body.

In *Tertiary Syphilis* a gummatous infiltration of the tarsus—so-called Syphilitic Tarsitis—may occur, but it is a rare affection. One or both eyelids, in one or both eyes, may be attacked. Without pain the lid becomes slowly and gradually hypertrophied, and the integument tightly stretched and hyperæmic. On palpation, which gives no pain, the tarsus can be felt to be enlarged and of cartila-

ginous density. The palpebral conjunctiva is somewhat swollen, but through it the yellowish-white colour of the gummatous infiltration can be seen, if it be possible to evert the lid. Ptosis results, and the lid may be so hard and stiff as to render eversion impossible. The eyelashes fall out, and the pre-auricular gland is swollen. Although, as stated, the process is remarkable for its freedom from pain, yet severe pain may be experienced, should a rapid increase in the gummatous infiltration take place. Under treatment—which consists of iodide of potash and mercury—the infiltration disappears, and leaves a normal eyelid behind, or the tarsus may be somewhat atrophied as a result.

* **Vaccine Vesicles on the Eyelids** are produced by accidental inoculation at the intermarginal part of the lid; or on the outer surface of the lid, if the skin be abraded by a finger-nail or otherwise. Sometimes the vesicle develops into a large ulcer with yellowish floor and hard and elevated margin. There is much pain, much swelling of the eyelid, and chemosis.

Although distressing for a week or so while it lasts, the affection is not a dangerous one, further than that a cicatrix in the skin is left behind, and the eyelashes at the affected part are lost.

Treatment.—A warm chlorate of potash lotion (gr. v ad ℥j) is the best application.

Rodent Ulcer (Jacob's Ulcer).—This disease commences as a small pimple or wart on the skin near the inner canthus, or over the lacrimal bone, as a rule; but it may also originate in any other part of the face. The scab or covering of the wart is easily removed, and underneath is found a shallow ulcer with a well-defined indurated margin, the skin surrounding the diseased place being healthy. The progress of the disease is extremely slow, extending over a great number of years, and in the early stages the ulcer may even seem to heal for a time, but always breaks out again. In mild cases the ulceration may remain superficial; but more usually it strikes deep, in the course of time eating away every tissue, even the bones of the face and the eyeball. The latter is often spared until after the orbital bones have gone.

The disease is an epithelial cancer of a non-malignant or purely local kind. There is no tendency to infiltration of the lymphatics. It is rarely seen in persons under forty years of age.

Treatment.—Extirpation of the diseased part with the knife,

followed by the application of chloride of zinc, or of the actual cautery, used formerly to be employed; and Bergeon's treatment, with the internal administration of chlorate of potash, and its local application as a lotion, was also used with benefit for the time.

But all other measures have here given way to the Röntgen Ray treatment, which now enables brilliant cures to be effected in the majority of these terrible cases. Dr. W. S. Haughton, who is in charge of the Röntgen Ray department of the Victoria Hospital, has given us the following description of the method which he finds to be the most successful in the treatment of rodent ulcer:—When the ulcer is large, lumpy, or prominent, it is advisable to remove as much as possible of its floor and margin by excision or cautery, so as to expose its growing base directly to the Röntgen Rays. The ulcer is exposed to the rays, at a distance of not less than six inches, through an accurately shaped window in a mask of lead foil. A layer of cotton-wool or other non-conducting material is placed between the patient's skin and the lead foil. The affected part is given two minutes' exposure to the rays every second day, until definite signs of reaction appear. For superficial ulcers a soft X Ray tube gives the best results, when deep tissues are affected a hard tube is preferable. From 10 to 20 sittings, according to the extent and depth of the ulcer, are usually necessary to effect a cure. Early cases are of course the most favourable for treatment, but in far advanced cases—even when the eyeball was gone, and the bones of the orbit extensively destroyed, with visible pulsations of the brain through the roof of the orbit—the growth of the disease has been arrested, and all pain and hæmorrhage have been stopped.

In rodent ulcers of small extent radium is capable of effecting good cures. Two or three 5 mg. tubes of first quality radium are applied to the ulcerated surface for about half an hour, at intervals of ten days to three weeks, and to a different part of the ulcer at each sitting, until gradually the whole surface is brought to heal. The cicatrix left is soft and skin-like. The application for a few seconds of the carbonic acid snow gives rise to healing in some cases.

* The condition known as **Solid Œdema, Elephantiasis Lymphangioides,** or **Elephantiasis Nostras of the Eyelids,** is well represented in the accompanying picture (Fig. 202 [1]) of a case under the care of

[1] *Trans. Ophth. Soc. U.K.*, vol. xix.

Sir A. Critchett. It is a chronic tumefaction of the eyelids. The skin covering the swelling is smooth and pale, and resembles the skin of an œdematous lid; but on palpation the swelling is found to be more resistant than simple œdema. There is, almost invariably, a history of recurring attacks of facial erysipelas. These give rise to a permanent alteration of the lymph channels, and, each attack leaving its trace, an ever-increasing hypertrophy of the tissues of the eyelids takes place.

Treatment.—Operative measures have been adopted in many instances with satisfactory results, both cosmetically and as regards the functions of the eyelids; but, unfortunately, in those cases which have remained under observation sufficiently long, the former



FIG. 203.

condition gradually returned, as in Sir A. Critchett's case (Fig. 203), in the picture of which the cicatrices of the operations can be seen. Multiple punctures, collodion, pressure, etc., and many internal remedies have been tried in vain.

* **Plexiform Neuroma,** or **Neuro-fibroma** is a rare disease of the eyelids. It is seen as a congenital growth which slowly increases in size. The tumour in general is soft to the touch, but contains many hard strings and knobs. Pressure on it is painful in some cases. It may attain great size, and may extend to the supra-orbital, temporal, and malar regions, giving rise to much disfigurement. Operation is indicated only if the tumour be markedly progressive, as a satisfactory result is not very easily attainable,

and gangrene has followed in some cases, while in others, where the growth had to be followed deeply, severe hæmorrhage has occurred. In some instances the tumour has invaded the orbit, and even the cavity of the skull, after absorption of the orbital roof.

* **Lymphoma** or **Lymphadenoma** of the eyelids usually occurs as a bilateral and symmetrical disease, but it does occur, in rare instances, on one side only. It is frequently associated with leucæmia, or pseudo-leucæmia, or it may be found in apparently healthy individuals. It often invades the orbit, and its growth is exceedingly slow and quite painless.

* **Epithelioma, Sarcoma,** and **Lupus** are all seen in the eyelids, but require no special description here.

* **Gangrene of the Eyelid** is a rare condition. It may occur as a consequence of an infected wound of the lid, or from some general infection of the system, even in influenza, and has been seen as a result of excessive use of iced compresses.

Clonic Cramp of the Orbicularis Muscle, or of a portion of it, is often seen, and is popularly known by the name of 'life' in the eyelid. It is frequently due to over-use of the eyes for near work, especially by artificial light, or if there be defective amplitude of accommodation.

Treatment should consist in the regulation of the use of the eyes for near work, and the correction by glasses of any defect in the accommodation.

Blepharospasm, or **Tonic Cramp of the Orbicularis Muscle,** is commonly the result of irritation of the ophthalmic division of the fifth nerve by reflex action, as in phlyctenular ophthalmia (p. 104) and some other corneal and conjunctival affections; or from foreign bodies on the conjunctiva or cornea, etc.; or it may continue for some time after the relief of any such irritation. It occurs, also, independently of such causes, and is then difficult to account for, unless as a hysterical symptom. Yet, even in these obscure cases, the spasm is probably often a reflex from the fifth nerve (*i.e.* teeth, or nose), and it will be found that pressure upon the supra-orbital nerve at the supra-orbital notch may arrest the spasm; or, if not there, then pressure on the infra-orbital, temporal, malar, or inferior alveolar branch may have the desired effect.

Treatment.—If the cause of the reflex cannot be ascertained, or if it have passed away, and if the cramp be still very distressing,

stretching or resection of the branches of the fifth nerve, from which the reflex proceeds, may be tried. The operation of spino-facial anastomosis has been successfully employed in some obstinate cases.

Ptosis (πτῶσις, *a fall*), or **Blepharoptosis,** is an inability to raise the upper lid, which then hangs down over the eyeball. It is either congenital or acquired; and in the latter case is most usually the result of paralysis of the branch of the third nerve supplying the levator.

Persons affected with ptosis involuntarily endeavour to raise the eyelid by an over-action of the frontalis muscle. The drooping lid and elevated eyebrow give a peculiar and characteristic appearance.

Paralytic Ptosis—*The Causes of Paralytic Ptosis* are similar to those of paralysis of other branches of the third pair, more especially exposure to cold draughts of air while the body is heated, and syphilis or rheumatism affecting the branch to the levator palpebræ in its course. It may also be due to cerebral disease (p. 496). The branch to the levator may be paralysed alone, or in conjunction with other third-nerve branches, especially to the superior rectus, and the loss of power may be partial or complete.

Some cases of bilateral ptosis in elderly people due to primary atrophy of the levator palpebræ muscles have been recorded. The eyelids were elongated and thinned, so that the eyeball showed plainly through them. The loss of power had in each case been very slowly increasing for many years.

The Treatment of a recent case of ordinary paralytic ptosis depends upon its cause. If this be syphilis, then a course of mercurial inunctions or of iodide of potassium; if rheumatism, salicylate of soda or iodide of potassium—with, in either case, protection of the eye and side of the head by means of a warm dressing and bandage. Cases in which these remedies have failed, and which have become chronic, often demand operative treatment. Attempts have been made, with success in some cases, to obviate the inconvenience of ptosis by giving support to the lid by wire splints worn like an eyeglass, or attached to the upper edge of spectacle-frames.

Ptosis due to a cerebral lesion rarely comes within the scope of treatment.[1]

[1] The value of ptosis as a localising symptom in cerebral disease is treated of in chap. xvi.

* Operative treatment is indicated in cases of paralytic ptosis—where other measures have produced no result—in ptosis adiposa, and in congenital cases. A very common proceeding consists in the excision of a sufficiently large oval piece of integument, its long axis lying in the length of the lid, with the subcutaneous connective tissue and fat, and, in paralytic cases, a small portion of the orbicular muscle. The fold of integument to be abscised is seized by two pairs of forceps—one of them held by an assistant—at the inner and outer ends of the lid, and by this means the necessary size of the fold is estimated. The abscission of the fold is performed with a pair of scissors, the margin of the wound lying close to the points of the forceps. The subcutaneous tissue, etc., is then removed, and the edges of the wound drawn together by a few points of suture.

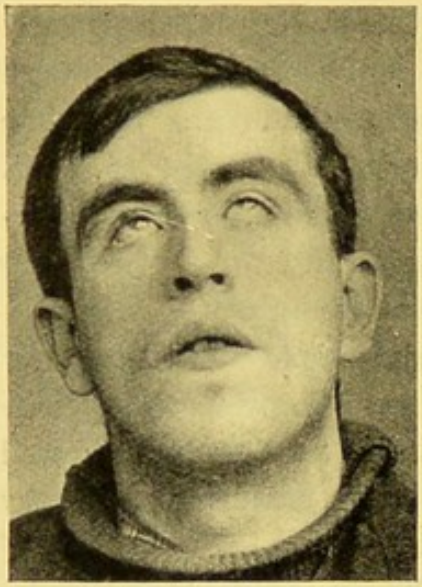


FIG. 204.—Result of Motais' operation in right eye.

* *Motais' Operation.*—This operation has for its object the transplantation into the upper lid of a flap taken from the superior rectus muscle; consequently it is only suitable for cases of ptosis in which there is no paralysis of the superior rectus. In such cases the result is very satisfactory, and the movements of the lid follow those of the eyeball better than they do after other operations for ptosis. Fig. 204 shows the perfect elevation of the lid on looking up.

The upper lid is everted, and the upper fornix is stretched between two sharp hooks, one being inserted into the sclerotic above the cornea, and the other into the ciliary margin of the everted lid. The conjunctiva is then divided over the insertion of the superior rectus, the incision being carried beyond the lateral limits of the tendon, which is exposed by separating the sub-conjunctival tissue, and capsule of Tenon. The tendon is raised on a large strabismus hook passed under it from the inner side, and it is seized at its centre about 4 mm. from its insertion with a double-toothed forceps, so that an incision may be made with scissors in its centre in front of the forceps, quite close to the sclerotic, and 4 mm.

in width. The sectioned portion of the tendon is then seized with a broad-ended fixation forceps, so as to stretch it out well; and with straight scissors two parallel incisions are made upwards, one at each side of the tendon, so that a flap 1 cm. long may be formed in the tendon. A catgut suture with two curved needles is passed through the flap near its free margin, and tied firmly on the flap. The central part of the conjunctival fornix is incised with the curved scissors, and the blades are passed between the tarsus and the soft tissues of the eyelid as far as the ciliary margin, so as to make a path for the flap of tendon. One of the needles carrying its end of the suture is then passed along the path thus made, and caused to emerge through the skin near the ciliary margin. The second needle is passed in the same way, its point of exit being a few millimetres from that of the first. The ends are tied over a pledget of lint, and by this means the lid will be drawn up and the ptosis relieved. The conjunctival wound is united with catgut. To prevent lagophthalmos, the lower lid is raised until it comes in contact with the upper lid, by means of a suture passed through the former near its ciliary margin, and then through the skin of the eyebrow where it is tied.

* *Birnbacher's Operation.*—An incision, with its convexity upwards, is made in the skin corresponding with the upper edge of the tarsus. Three sutures with a needle at each end are passed through the upper border of the tarsus, so as to form three loops, one central and two lateral; the two needles of the central loops are passed vertically upwards under the skin, and are brought out quite close to one another in the eyebrow. The lateral loops are treated in the same way, but are made to diverge on each side from the central one, instead of being parallel. The ends of the threads are tied over a small roll of lint, and tightened until the edges of the lips just touch when the patient closes the eye. They may be left in from twenty to twenty-five days.

CONGENITAL PTOSIS is generally present in both eyes. It is due in some cases to an imperfect development of the levator palpebræ, and in others to an abnormal insertion of this muscle, its tendon being attached to the tarsus too far back. Birnbacher's operation may be employed, and Eversbusch has proposed the following proceeding more particularly for congenital ptosis:—

* *Eversbusch's Operation for Congenital Ptosis* (Figs. 205 and

206).—The object of the operation is to increase the power of the levator by advancing its insertion, or rather by doubling it down over the tarsus, to which it forms fresh adhesions. Knapp's lid-clamp is applied, the plate being passed well up into the fornix; and, before the ring is screwed down, the skin of the lid is drawn down, so that its prolongation just under the eyebrow may be forced into the instrument. The skin and the underlying orbicularis are now divided in the entire width of the lid, parallel to its free margin, and at a distance half-way between this margin and the eyebrow. The skin and subjacent muscle are then separated up, both upwards and

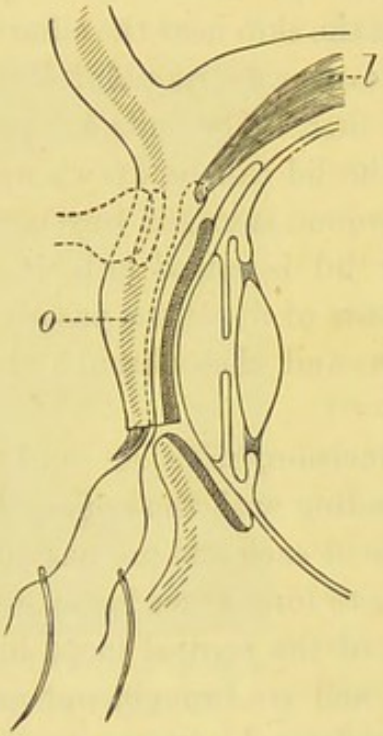


FIG. 205.

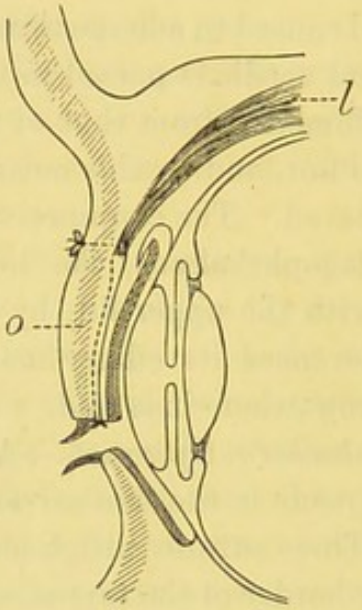


FIG. 206.

l, levator palpebræ ; *o*, orbicularis.

downwards, for 4 mm. in each direction, so that the insertion of the levator may be well exposed. A suture with a small curved needle at either end is then introduced, by means of one of these needles, horizontally into the tendon at its insertion, and near the centre of the latter, in such a way that about 2½ mm. of the tendon may be included in the suture. Each needle is now passed vertically downwards between the tarsus and orbicularis, and brought out at the free margin of the lid at a distance from each other of about 2½ mm. Two more such double sutures, one in the temporal, the other in the nasal, third of the tendon, are similarly applied. The margins of

the horizontal skin and muscle wound are now drawn together, and then the three sutures are closed tightly. It is desirable to slip glass beads over the ends of the sutures before tying them, to prevent cutting into the margin of the lid. Both eyes are bandaged, and the sutures are left in for a week or more.

While the foregoing and other operations relieve the ptosis, they are liable to give rise to some unsightly cicatrices, and are sometimes not permanent in their effect. With a view to obviate these drawbacks, Carl Hess has devised the following operation.

Hess' Operation.—The eyebrow having been shaved, an incision (*a a*, Fig. 207) is made in its whole length, and carried through the skin and subcutaneous tissue ; and, starting from this incision, the skin of the lid is separated with the scalpel from the underlying orbicular muscle nearly as far as the ciliary margin (dotted line in Fig. 207). When the hæmorrhage has ceased, three silk sutures, each armed with two needles, are introduced, one at the centre and one towards either end of the eyelid, and about half-way between the eyebrow and lid margin (*b*, Fig. 207), or somewhat nearer the latter. The needles of each suture are inserted about 5 mm. apart, and, being passed from without inwards through the skin, they are brought out in the space made by the skin dissection. The needles are now passed deeply under the upper border of the incision in the eyebrow, and brought out a few millimetres above it (at points represented by three pairs of dots in Fig. 207). The two ends of each suture are tied over a small roll of lint or a bit of rubber drainage tube, and drawn tightly enough to relieve the ptosis by producing a fold in the skin flap. The wound in the eyebrow is united by some points of suture. The sutures are allowed to remain for eight or ten days. The permanent result depends on the union and cicatrisation of the extensive raw surfaces in their new position. The operation causes little or no disfigurement, as the artificial fold falls in about the same situation as that which is present in the normal eyelid ; while the cicatrix in the eyebrow is concealed by the hairs when

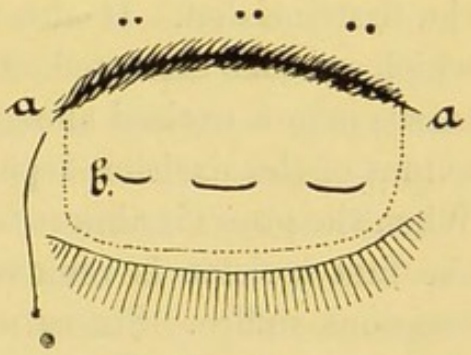


FIG. 207.

they have grown again. In Figs. 208 and 209 a section of the eyelid before and after tightening of the sutures is represented.

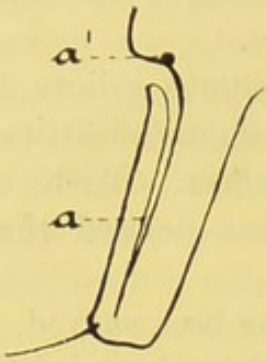


FIG. 208.

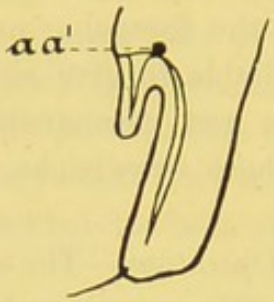


FIG. 209.

FIG. 208.—The needles are passed in at *a* through the skin of the lid, and brought out at *a'* through the skin and subcutaneous tissue above the eyebrow.

FIG. 209.—When the sutures are tightened *a* is closely approximated to *a'*.

Freeland Fergus' Operation.—This operation is employed by Mr. Fergus for all cases of ptosis. It can be performed painlessly by infiltration of the eyelid with a weak solution of eucaine. The eyelid is stretched upon a spatula inserted under it, and an incision is made parallel to, and a few millimetres distant from, the edge of the lid. The incision extends from end to end of the eyelid, and is carried through the skin and muscle. A second incision is made, extending nearly in a semicircle from one extremity to the other of the first incision. It also is carried through the skin and muscle, which are then dissected off the face of the tarsus. A portion of the tarsus is now excised along with the conjunctiva adherent to it, the extent of this excision depending upon the amount of effect desired. When the ptosis is almost total, nearly the whole of the tarsus above the first incision is removed. In lesser degrees of ptosis smaller excisions suffice. Six sutures are finally inserted, three deep and three superficial. The deep sutures are best made of absorbent sterilised catgut. The superficial ones can be of this material or of silk. The three deep sutures are used to unite the tough fibrous membrane which passes from the occipito-frontalis to the eyelid with that portion of the tarsus wnich remains in the lid below the level of the first incision. The superficial sutures are employed to

unite the edges of the skin wound. The operation gives great mobility to the eyelid.

* A remarkable and rare condition is *Congenital Ptosis, with Associated Movements of the Affected Eyelid, during the action of certain muscles.* It is most commonly the left lid which is affected, and the paralysis may be congenital or acquired. Three conditions have been observed—viz. (1) elevation of the drooping lid when the eye is adducted, (2) when the eye is abducted, or (3) when the mouth is opened. A synchronous contraction of the pupil has been noticed in some cases, while in some the elevation of the lid occurs also with a lateral motion of the jaw, and with deglutition. Gower's explanation is that in these cases the levator is not wholly supplied by the third nerve, but partly also by nerve fibres which take their origin in the nucleus of the fifth pair, and which also supply the external pterygoid and digastric muscles. But this theory does not hold good in all cases, for Bull describes a case in which the lid was raised when the head was bent back, thus stretching the digastric, and he regards these as associated or reflex movements. In some instances the lid can be raised voluntarily on closing the other eye. Needless to say, no remedy can be applied for relief of this condition.

The term ptosis is also given, although not very correctly, to cases in which increased weight of the lid causes it to droop, as in conjunctival affections, or where a tumour has formed in the eyelid, or where there is a hyper-development of the subcutaneous fat.

* **Lagophthalmos** (λαγώς, *a hare*, as it was supposed that this animal sleeps with its eyes open; ὀφθαλμός), or inability to close the eyelids, is most commonly due to paralysis of the portio dura, and is then associated with the other symptoms of the latter affection. On an effort to close the lids being made, the eyeball is rotated upwards under the upper lid, owing to the associated action of the superior rectus; and in sleep this upward rotation also occurs—a fact which explains, to a great extent, the immunity of the cornea from ulceration in many of these cases. Lagophthalmos may also be due to orbital tumours pushing the eyeball forwards, to exophthalmic goitre, to staphyloma, or to intra-ocular growths distending the walls of the eyeball—in all of which conditions the eyelids are often mechanically prevented from closing over the eyeball, or can be closed only by a strong effort of the will. The danger to the eye

depends upon the tendency to ulceration of the cornea from its dryness, caused by exposure to the air, and from foreign substances not being removed from it by nictitation.

In cases of non-paralytic lagophthalmos, protection of the cornea by keeping the eyelids closed with a bandage, or by inserting a few epidermic sutures in the margins of the eyelids to draw them together, should be our first care. Tarsoraphy may be employed in those cases where circumstances indicate that it would be useful—*e.g.* in some cases of exophthalmic goitre, or of staphylomatous eyeball.

In paralytic cases, the primary cause of the paralysis (syphilis, rheumatism, etc.) must be treated so long as there is a prospect of restoring power to the muscle. Locally, galvanism and hypodermic injections of strychnia may be employed. During cure the cornea should be protected as above. In incurable cases, the opening of the eyelids must be reduced considerably in size by an extensive tarsoraphy, or by the method proposed by Pflüger.

The Operation of Tarsoraphy consists in uniting the margins of the upper and lower lids in the neighbourhood of the external commissure, so as to reduce the size of the opening of the eyelids. The commissure should be caught between the finger and thumb, and the edges of the lids approximated, so as to enable the operator to form an estimate of the required extent of the operation. A horn spatula is then passed behind the commissure, and the necessary length of the margin of each lid, including the bulbs of the cilia, is abscised with a sharp knife. The raw margins are then brought together with sutures.

Pflüger's Method consists in passing one, two, or even three double sutures subcutaneously around the eyelids, about 5 mm. from their margins. The ends are drawn together, so that the eye is concealed by the pouch thus formed, and tied. From time to time the sutures are tightened, until finally they cut through, and by this means a subcutaneous ring-cicatrix is produced. Should the first ring-cicatrix not sufficiently close the eyelids, the operation can be repeated even more than once again. The method is tedious and painful.

Symblepharon (*σύν, together ; βλέφαρον, the eyelid*) is an adherence, partial or complete, of the eyelid to the eyeball. It is usually the result of burns of the conjunctiva by fire or caustic substances (p. 96). The shortening of the conjunctival sac, which

is seen as the result of pemphigus or of granular ophthalmia, and which is described (p. 88) under the heading of Xerophthalmos, is not properly termed symblepharon. If the symblepharon interfere seriously with the motions of the eyeball, or if it cause defect of vision by obscuring the cornea, it becomes desirable to relieve it by operation. Should it consist of a simple band stretching from lid to eyeball, it may be severed by ligature, and if the band be broad, two ligatures may be employed, one for either half. A symblepharon which occupies a considerable surface cannot be got rid of in this way; and for such cases a transplantation procedure like that of Teale may be employed, the great difficulty in dealing with these cases being the tendency there is to re-union of the surfaces, unless one or both of them be carpeted with epithelium.

* In *Teale's Operation*, if we suppose the case to be similar to that represented in Fig. 210, an incision is carried along the line of the margin of the cornea at *A*, through the whole thickness of the symblepharon, and the lid is dissected off from the eyeball as far as

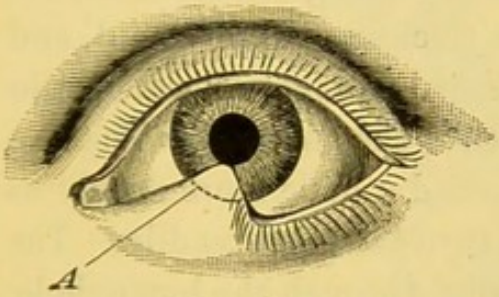


FIG. 210.

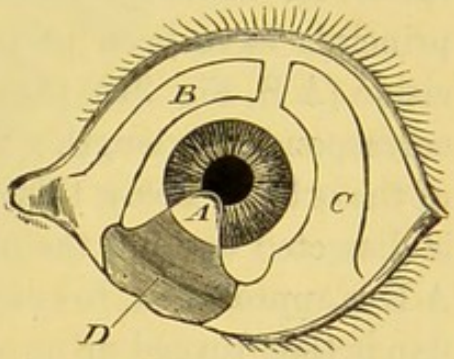


FIG. 211.[1]

the fornix. Two conjunctival flaps are now formed, as at *B* and *C* in Fig. 211, and one of them (*B*) is turned to form a covering for the wounded surface of the inside of the eyelid, while the other (*C*) is used to cover the bulbar surface (Fig. 212), the flaps being held in their places by fine sutures. That part of the symblepharon which is left adherent to the cornea soon atrophies and disappears. No great tension of the flaps should exist as they lie in their new positions.

Teale, again, has suggested the formation of a bridge-like conjunctival flap above the cornea, and the removing of it across the

[1] Mr. Teale now makes his flaps, as in Fig. 211, wider than he originally did. He has been so kind as to alter this drawing with his own hand for this work.

latter to cover the loss of substance situated below. After the sutures which keep the flap in its place have been introduced, the latter is separated at its bases.

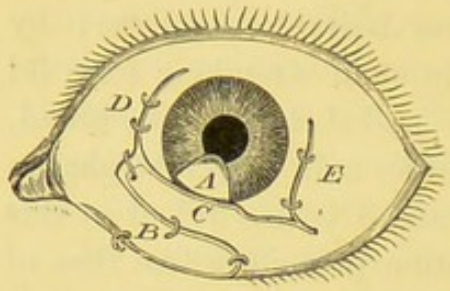


FIG. 212.

A simple plan, which would be applicable to such a case as that depicted in Fig. 210, where the adhesion is not very extensive, and perhaps even to some more extensive ones, consists in dissecting the conjunctival process off the cornea, and then turning it down on the raw inner surface of the under lid, and fastening it there with a suture or two. We have done this with complete satisfaction.

* *Harlan's Operation.*—This is specially applicable to extensive symblepharon of the lower lid, and differs from the foregoing operations in that it provides a covering of skin, and not of mucous membrane, for the raw surface of the under lid. Operations on the same principle have been proposed by Snellen and by Kuhnt. An incision (A B, Fig. 213) through the whole thickness of the eyelid, and corresponding in length with the latter, is made along the lower margin of the orbit. Below this a skin flap (C D) is then formed. The flap is dissected up, and the incisions are carried a little more deeply as A B is approached, to enable the flap to turn the more readily. The flap is then turned up as on a hinge, slipped through the buttonhole, and sutured securely to the inner surface of the under lid. After a time the skin surface turned towards the eyeball becomes considerably modified, so as to be somewhat like mucous membrane. The bare space left by the removal of the strip of skin is covered without strain by making a small horizontal incision (D E) at its outer extremity, and forming a sliding flap.

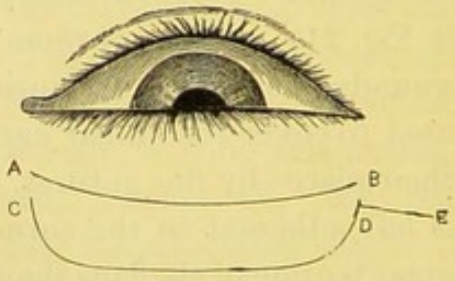


FIG. 213.

* *Transplantation Operations.*—The transplantation of mucous membrane from the lips or cheek has been used in extensive symblepharon, but the drawback to mucous membrane flaps, where two opposing surfaces have to be covered, is that when the superficial

epithelium of the mucous membrane is thrown off there is danger of the surfaces uniting. Thiersch and other skin flaps are preferable.

Blepharophimosis (*βλέφαρον, eyelid ; φίμωσις, narrowing*) is a contraction of the outer commissure of the lids, with consequent diminution in size of the opening between the latter ; and is commonly due to shortening of the skin, from long-continued irritation, caused by the discharge in a case of very chronic conjunctivitis.

It is remedied by a *Canthoplastic Operation*. The outer commissure is divided in its entire thickness, in a line which is a prolongation of the line of junction of the lids when closed, by a single stroke of strong straight scissors, one blade of which has been

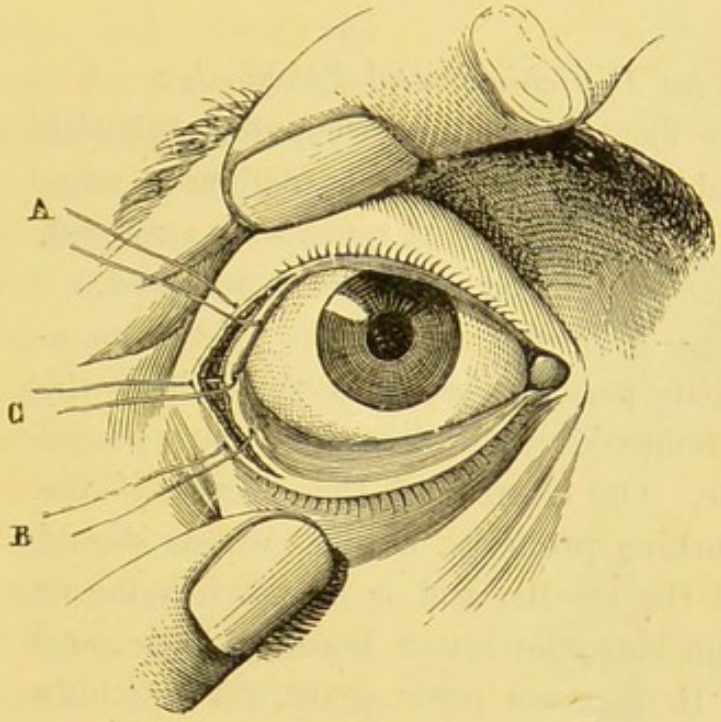


FIG. 214.

passed behind the commissure. The integumental incision should be made a little longer than that in the conjunctiva. An assistant then draws the upper lid up and the lower lid down, so as to make the wound gape. The conjunctival margin and the dermic margin are now united in the centre by a point of suture (C, Fig. 214), while two more sutures (A and B) are applied, one above and the other below the first. This operation is also employed in cases of granular ophthalmia and of purulent conjunctivitis, when it is desired to relieve pressure of the eyelid on the globe.

Distichiasis (*δίς, twice ; στίχος, a row*) and **Trichiasis** (*τρίχος, a hair*).—The first of these terms indicates the growth of a row of

eyelashes along the intermarginal portion of the lid in addition to the normal row; while trichiasis indicates a false direction given to the true cilia. Both conditions are often found co-existing, and often, too, they are present along with entropion. They may both be produced by chronic blepharitis (p. 535), or by chronic granular ophthalmia (p. 72). Some cases of congenital distichiasis and trichiasis have been recorded. The symptoms the false cilia produce, and the dangers to the eye attendant on them, are due to their rubbing on the cornea, which causes pain, blepharospasm, and opacity of the cornea, or even ulceration of it.

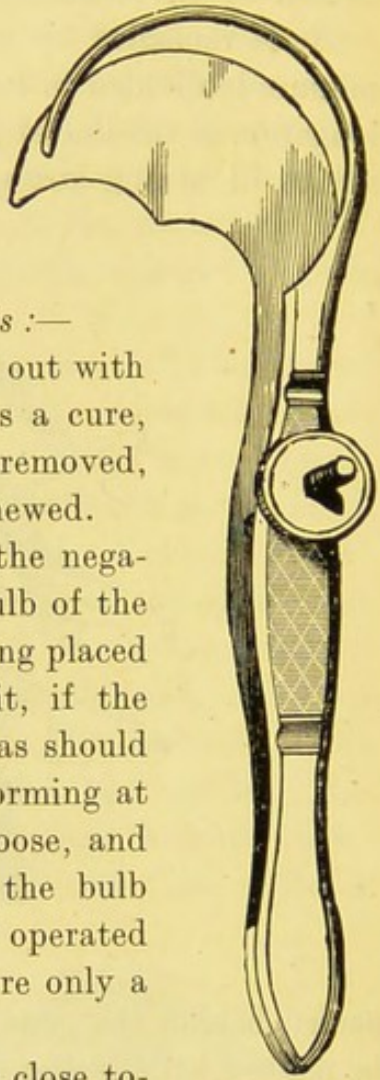


FIG. 215.

Operations for Distichiasis and Trichiasis :—

Epilation.—The false cilia may be pulled out with a forceps; but this cannot be regarded as a cure, as the hairs grow again; yet, if repeatedly removed, they grow finer and finally cease to be renewed.

Electrolysis.—A needle is attached to the negative pole, and its point passed into the bulb of the eyelash to be removed, the positive pole being placed on the temple. On closure of the circuit, if the battery be working properly, bubbles of gas should rise up round the needle, and a slough forming at the root of the hair, the latter becomes loose, and is removed. It does not grow again, for the bulb is destroyed. Each hair must be separately operated on. The proceeding is very valuable where only a few cilia are to be dealt with.

Excision.—When some half-dozen hairs close together are growing wrong, the simplest and best plan is to completely remove them by excision of the corresponding portion of the ciliary margin. A fine knife is passed into the intermarginal region at the place corresponding with the hairs to be dealt with, and a partial division of the lid into two layers, as in the Arlt-Jaesche operation (*vide infra*), is effected. A V-shaped incision in the skin of the lid is then made, including the erring hairs, the whole flap is excised, and the margin of the loss of substance is drawn together with sutures.

Transplantation, or *Shifting*, of the marginal portion of the integument containing the hair bulbs, true and false. One of the oldest and most valuable operations of this kind is that of Jaesche, modified by Arlt. It is performed as follows :—Knapp's, or Snellen's, clamp (Fig. 215) having been applied to prevent bleeding, the lid in its whole length is divided in the intermarginal part into two layers (Fig. 216), the anterior containing the orbicular muscle and integument with all the hair bulbs, the posterior containing the tarsus and conjunctiva. The incision in the intermarginal portion is about 5 mm. deep. A second incision is now made through the integument of the lid, parallel to its margin, and from 5 to 7 mm. removed from it. This incision also extends the whole length of the lid. A third incision is carried in a curve from one end to the other of the second incision. The height of the curve is proportional to the effect required, varying from 4 mm. to 7 mm. The piece of integument included between the second and third incisions is dissected off with forceps and scissors, without any of the underlying muscle being touched, and the margins of the loss of substance are brought together by sutures. By this procedure the lower portion of integument, containing the hairs and their bulbs, is drawn up and away from contact with the cornea. After this operation the condition is more liable to relapse than after the following.

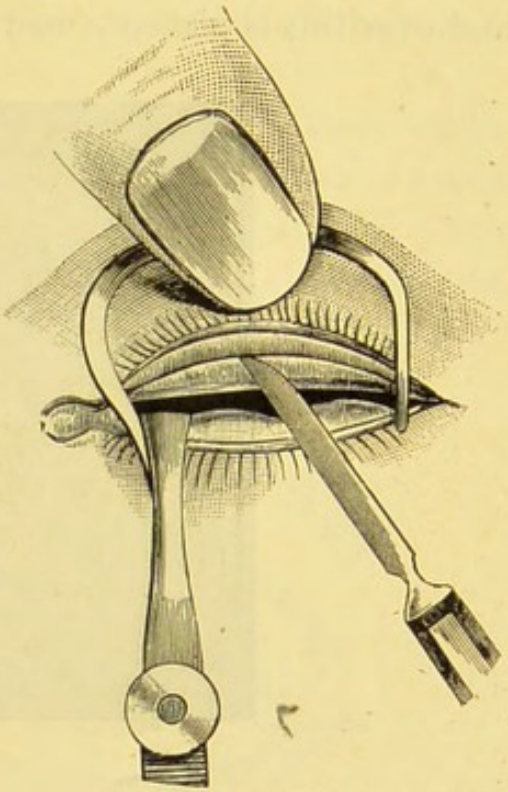


FIG. 216.

Van Millingen's Operation consists in splitting the eyelid, as in the Arlt-Jaesche operation, from end to end, sufficiently to produce a gap (*B*, Fig. 217) 3 mm. in width at the central part of the lid, and gradually becoming narrower towards the canthi. The gap is kept open by sutures passed through folds of skin on the upper lid (*a a a*), by means of which also the lid is prevented from closing for twenty-four hours at the least. As soon as the bleeding has ceased, a strip of mucous membrane of the same length as the incision in the lid,

and 2 to 2½ mm. in breadth, is cut out with two or three snips of a curved scissors from the inner surface of the patient's under lip, on which an eyelid clamp has been placed to prevent bleeding, and is introduced at once into the gap in the intermarginal space. It should then be pressed into position with a probe. According to Van Millingen, sutures are superfluous; but they are desirable for the sake of security, and do no harm. It is important, in order to obtain a neat effect, to clean the fat and submucous tissue from the flap before applying it; and while this is being done the flap should lie on a warm porcelain plate. The eyelid is then covered over with a piece of lint, on which is spread a thick layer of xeroform vaseline, and over this is placed a wad of cotton-wool and a bandage.

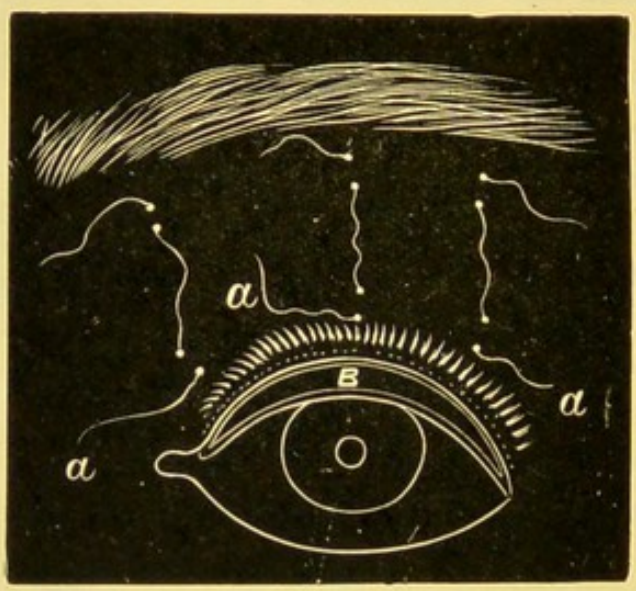


FIG. 217.

It is not advisable to transplant small strips of mucous membrane if the trichiasis be partial, as partial trichiasis is often only the commencement of complete trichiasis, and therefore, in these cases, the filling up of the entire length of the intermarginal space with a flap of mucous membrane should be effected. One or two fine sutures, which serve to unite the margins of the wound in the lip, arrest the bleeding at once, and accelerate union of the part, which is generally completed in twenty-four hours.

This method is very effectual in permanently providing a good intermarginal space, and in thus definitely relieving the condition.

Entropion (*ἐν, in; τρέπω, to turn*), or **Inversion of the Eyelid,** is due to organic change in the conjunctiva or tarsus, or to spasm

of the palpebral portion of the orbicular muscle. A large proportion of the former class of cases is the result of chronic granular ophthalmia, and is most common in the upper lid. Spastic entropion occurs in the under lid only. It is frequent in old people (senile entropion) from relaxation of the skin of the eyelid, and is also produced by the wearing of a bandage after operations.

Treatment.—If the tarsus of the upper lid be not distorted, organic entropion can often be corrected by one of the methods described for trichiasis and distichiasis. But many of these cases are accompanied by, or rather are due to, abnormal curvature with hypertrophy of the tarsus.

In such cases the operation must include an attack on the tarsus itself.

Snellen's Operation.—An eyelid clamp is applied. About 3 mm. from the margin of the lid, and parallel to it, an incision is made through the skin alone, extending the whole length of the lid. The orbicular muscle is exposed by dissection of the skin upwards, in

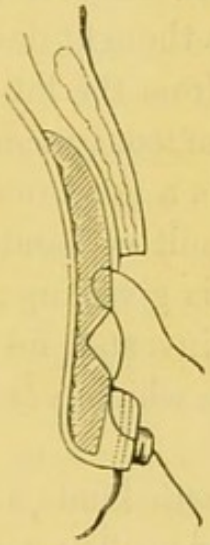


FIG. 218.

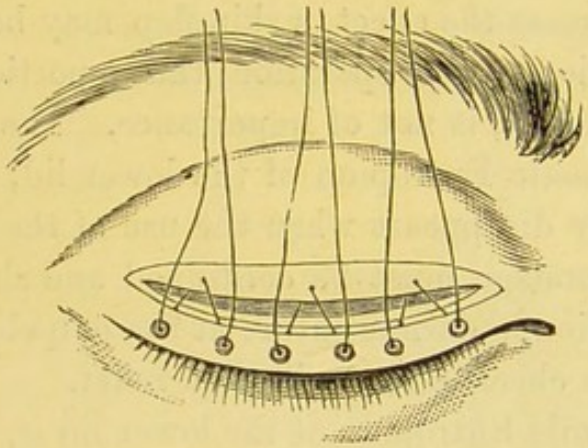


FIG. 219.

order to promote retraction of the latter, and along the edge of the lower margin of the wound a strip about 2 mm. broad of the orbicular muscle is removed, and the tarsus to the same extent is exposed to view. A wedge-shaped piece, corresponding with the exposed part of the tarsus, is now excised from it with a very sharp scalpel, the edge of the wedge pointing towards the conjunctiva, which latter, however, is left intact. The hypertrophy of the tarsus, which is always present, facilitates this procedure. A silk suture carrying a needle on each end having been prepared, one needle is passed from within

outwards through the band of muscle and integument left at the margin of the lid. The second needle is also passed from within outwards through the upper lip of the tarsal loss of substance, and then from within outwards through this same marginal band, at a distance of about 4 mm. from the point of exit of the first needle. The ends of the suture are now tied together, a small bead having first been strung on each to prevent it from cutting through the skin. Three such sutures are employed. The accompanying figures (218 and 219) make the foregoing description more intelligible.

Berlin's Operation.—An eyelid clamp is applied. The first incision lies 3 mm. above the margin of the lid, extends its whole length, and divides it in its entire thickness, including the conjunctiva. The skin and muscle at the upper edge of the wound are pushed or dissected up so as to expose the tarsus. The upper edge of the tarsal incision is now seized at its centre with a finely toothed forceps, and an oval piece with the adherent conjunctiva, about 2 to 3 mm. wide in its widest part, and in length corresponding with that of the eyelid, is excised from it with a fine scalpel. The wound is closed with three sutures through the skin. If it be thought desirable to increase the effect, a skin-flap may be excised from the lid. The objection to this operation, that a portion of the mucous membrane is removed, is not of importance. The method is a good one.

Spastic Entropion of the lower lid, as the result of bandaging, usually disappears when the use of the bandage is given up; or, if the bandage must be continued and should the inverted lid cause irritation, a dermic suture at the palpebral margin which is fastened to the cheek below will give relief.

Senile Entropion of the lower lid is, of the spastic kinds, the one which most commonly needs operative interference. The methods in general use for it are :—

The Excision of a Horizontal Piece of Skin, with a portion of the underlying palpebral part of the orbicular muscle, so as to give rise to sufficient cicatricial contraction to draw the margin of the lid outwards.

The foregoing, and other such measures, produce a good result at the time, but are sometimes followed by recurrence of the entropion. Hotz, believing the cause of this to be that the cicatrix, whether dermic or dermo-muscular, upon which the result depends, has no *point d'appui*; and consequently, while it may draw the

eyelid out, is liable to draw the skin of the cheek up, and thus to neutralise its desired effect, has proposed the following ingenious operation :—

Hotz's Operation.—A horn spatula is inserted under the lid, and, at 4 to 6 mm. below the margin of the latter, a horizontal incision is made through the skin from the inner to the outer end of the lid. This incision is at the boundary between the palpebral and orbital portions of the orbicular muscle, and just over the lower margin of the tarsus. An assistant then draws the upper edge (*a*, Fig. 220) of the wound upwards with a forceps, while the surgeon draws the lower edge (*b*) downwards, in this way exposing and stretching the orbicular muscle. A few strokes of the knife in the direction of the incision are now sufficient to separate the palpebral portion (*l*) of the muscle from the orbital portion (*p*), and to lay bare the lower edge of the tarsus (*t*), which is of a yellowish tendinous appearance. That part of the palpebral portion of the muscle which covered the lower edge of the tarsus, and which was drawn up with the palpebral edge of the first incision, is now removed with forceps and scissors, to the extent of about 2 mm. in width, through the whole length of the lid. All such muscular fibres, also, which may still adhere to the lower third of the tarsus must be carefully cleaned off, and now the palpebral skin may be brought into union with the tarsus. Four sutures are generally applied, about 5 mm. apart. The needle is passed through the palpebral skin, close to the margin of the wound (at *a*). The bare tarsal edge is then seized in the forceps, the needle placed perpendicularly on it (at *d*), and carried through it by a short downward curve until its point appears (at *c*) below the tarsus in the tarso-orbital fascia (*f*). The needle is now passed out through the lower edge of the incision (at *b*), care being taken that none of the fibres of the orbital portion of the muscle are included in the suture. Upon the suture being tightly closed, the edges of the skin wound are drawn into the tarsus, and become

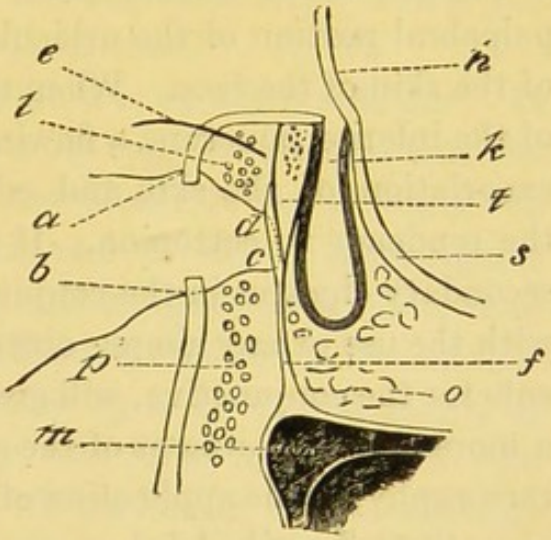


FIG. 220.

adherent to it. The sutures may be removed about the third day. If the first incision be placed too far from the margin of the lid, there will be no result, as the traction upon the palpebral skin will be too slight. If the incision be placed too close to the margin, the traction may be so great as to interfere with the union of the skin and tarsus. In this operation the tarsus affords the fulcrum, which Hotz thinks is wanting in other methods. The tarsus of the lower lid is sometimes badly developed, and the result of the operation may then be disappointing.

Ectropion or **Eversion of the Eyelid.**—Of this there are three kinds: (1) Muscular, or Spastic. (2) Cicatricial. (3) Paralytic.

Muscular Ectropion occurs only in the lower eyelid and may have its starting point in œdema of the conjunctiva, which everts the edge of the eyelid, and this eversion becomes increased and encouraged by spasm of the palpebral portion of the orbicular muscle, so that the term palpebral paraphimosis might be given to the condition. In the recent stage it may generally be remedied by suitable conjunctival measures. In chronic cases operative measures are usually required.

Muscular ectropion is often seen in old people, and is then given the name of Senile Ectropion. Here it is due to atrophy of the palpebral portion of the orbicularis of the lower lid, and relaxation of the skin of the face. When these have resulted in slight eversion of the inferior punctum, a flowing of tears is produced, causing some excoriation of the skin and edge of the lid, which then increase the tendency to ectropion. If the condition be not extreme, with secondary changes in the conjunctiva, slitting up of the canaliculus, with the use of any simple ointment for the lids, and mild astringents for the conjunctiva, will give much relief. In pronounced cases, a more active treatment of the conjunctiva, and the performance of tarsoraphy, or the application of Snellen's sutures, or one of the other operations described below, are demanded.

The following operations are amongst the best for the correction of muscular ectropion :—

Snellen's Sutures.—A silk ligature is threaded at either end with a needle of moderate size and curve. The point of one of these needles is passed into the most prominent point of the exposed and everted conjunctiva, and brought out through the skin 2 cm. below

the edge of the lower lid. The other needle is entered in the same way 5 mm. from the first, and made to take a nearly parallel course, the points of exit on the cheek being 1 cm. apart. Equal traction is applied to each end of the suture, while the lid is assisted into its place by the finger. The suture is tied on the cheek, a small roll of sticking-plaster having been inserted under it to protect the skin from being cut. Two, or even three, such sutures may be required, and they are allowed to remain for several days.

Freeland Fergus' Method.—Fergus points out that the two-thirds of the exposed conjunctival surface of the lower eyelid, from the fornix towards the free margin, are usually comparatively healthy, the marginal third alone being diseased. He has devised the following procedure, which consists in excision of the diseased tissue. An incision is made through the conjunctiva from the inner to the outer canthus, demarcating its healthy from its diseased portion. With forceps and scissors the conjunctiva covering the healthy portion of the eyelid is freed from the underlying structures right down to the region of the retro-tarsal fold. The hypertrophied tissue is next excised throughout its entire extent, so as to restore as it were the original margin of the lid, and finally the conjunctiva is drawn up and secured by a few points of suture to the margin. The success of the operation depends on the thoroughness with which the excision of the hypertrophied tissue is effected.

Kuhnt's Operation for Senile Ectropion is an admirable one. It consists in splitting the lower eyelid in its central third, so that the conjunctiva and tarsus are left in the posterior layer, while the anterior layer contains the orbicularis and the skin. A triangular piece, the base of which is formed by the margin of the lid, is then excised from the posterior layer, and the margins of the loss of substance in the latter are brought together by three or four points of suture. Lest they should give way too soon, it is necessary to place these sutures very securely. A puckering of the anterior layer, opposite the line of sutures in the posterior layer, is produced, but subsequently disappears, and a suture which unites the most prominent point of the pucker with the margin of the tarsus assists in this. Or, if the lid be split, say, to an extent twice as long as the base of the triangular piece to be excised, the puckering can be distributed at either end of the incision. It is by reason of the shortening of the posterior layer of the split eyelid that the

eversion is corrected. We frequently use this operation, and always with gratifying results.

Kenneth Scott's Operation.—The external canthus and the tissues beyond it are thoroughly divided by a pair of strong scissors. The lower eyelid, which is usually the affected one, is then seized, and its margin stretched sufficiently outwards, parallel to the border of the other lid, so as to restore the palpebral aperture to its proper appearance ; the portion of eyelid margin thus made to extend beyond the site of the external canthus is removed, along with its contained eyelashes, by slicing it with a sharp knife. The upper and lower eyelids are then brought together, so that the original outer extremity of the upper eyelids approximates exactly to the new extremity of the lower eyelid. They are secured in this position by passing a silver wire suture vertically downwards through the substance of the upper lid, continuing it out through that of the lower one, and then twisting the ends firmly together. Two of these retaining stitches may be introduced close together if necessary. The edges of divided skin, along with the deeper muscular tissues, including that part which recently formed the outer end of the affected eyelid, are simply stitched together with a continuous fine silk suture.

No dressing other than a repeated dusting with some fine antiseptic powder need be used. The silk stitches may be removed in six days' time, the silver ones being left in for five or six days longer. Scott states there is never any puckering apparent beyond the newly formed canthus, and the small linear cicatrix is lost amongst the other lines often found there.

Cicatricial Ectropion is caused by chronic blepharitis with dermatitis of the skin of the eyelid (p. 535). It is also caused by scars in the eyelid from caries of the orbit, or from wounds or burns, which destroy the integument of one or both eyelids. Cicatricial ectropion caused by burns of the face and eyelids in epileptics or children who have fallen into the fire is not uncommon. The burnt skin of the eyelids is replaced by a granulating surface ; and, when cicatrisation of this surface commences, the free margin of the upper lid is drawn up towards the eyebrow, and that of the lower lid down towards the cheek, the conjunctival surface of the eyelids in consequence becoming everted, and the cornea exposed, as the eyelids cannot now be closed.

For the higher degrees of ectropion due to chronic blepharitis

—or, as it is called, Blepharitis Ectropion—in the lower lid, *Kuhnt's Operation* consists in the splitting of the eyelid in its whole extent into two layers, an anterior (skin-muscle) and a posterior (tarsus-conjunctiva) and the shifting of the layers on each other so that the anterior one is elevated while the posterior one is lowered. It is performed as follows :—

The lower eyelid is stretched in a lid-clamp. An incision is made through the skin (Fig. 221) immediately below the eyelashes. The roots of any eyelashes which may be exposed should be removed without injury to the skin. An incision is now made from end to end in the intermarginal portion of the lid (dotted line in Fig. 221),

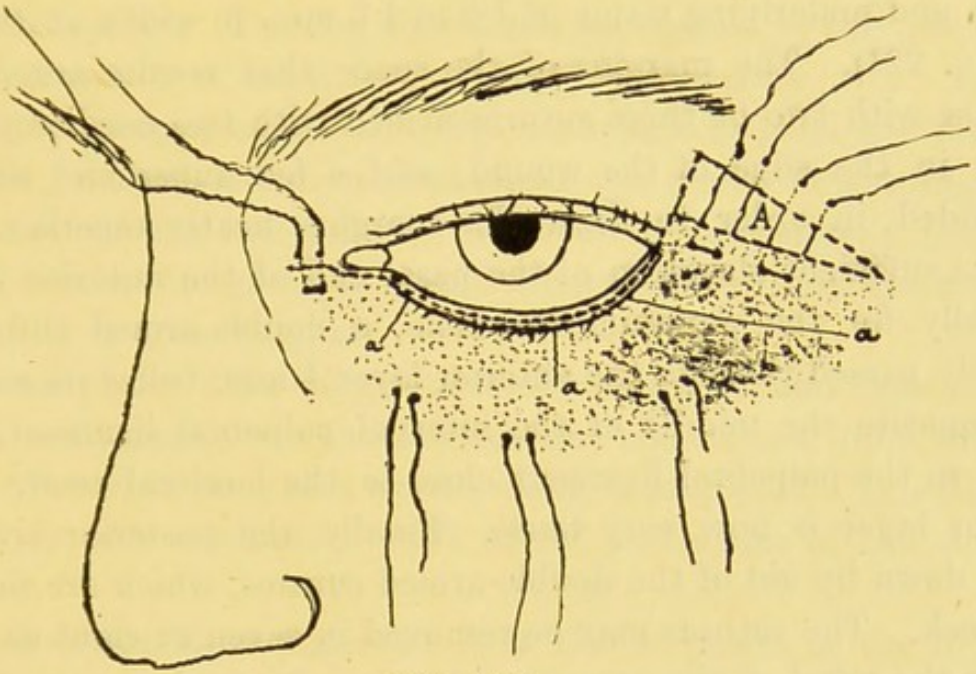


FIG. 221.

and as deep as the inferior orbital margin in the temporal and nasal directions. The intermarginal incision is continued in the nasal direction as far as the anterior crista lacrimalis, with a depth of 1·0 to 1·5 cm., care being taken not to injure the canaliculus. The temporal extension of the intermarginal incision is made to pass steeply upwards and outwards, and then rectangularly outwards and downwards (compare Fig. 221). If the anterior (skin-muscle) layer be now tightly stretched, the further splitting of the lid below the inferior orbital margin can easily be accomplished, and without injury to the tarso-orbital fascia. (In Fig. 221 the punctated portion represents the undermined region.) At the external canthus the tarso-conjunctival layer is then divided as though for a cantho-

plastic operation (p. 557). In order to lower the posterior layer, from three to five sutures, each with two needles, are passed through it, being entered between the lower margin of the tarsus and the conjunctival fornix into the space between the anterior and posterior layers of the split lid. They are then passed through the anterior layer so that they may appear through the skin 1 cm. below and concentrically to the orbital margin. The suture which lies in the most nasal direction should be placed about 2 mm. to the outside and below the punctum lacrimale, so that the nasal half of the posterior layer may be well drawn down. In order to raise the anterior layer at its temporal end, there is removed from the outer end of the upper lid a wedge-shaped piece of skin and underlying tissue of 1·0 to 1·5 mm. in width at its base (*A*, Fig. 221). The margins of the space that results are drawn together with two or three sutures armed with two needles placed deeply in the edge of the wound, and a few superficial sutures are added, in order to draw the margins neatly together. To secure a sufficient elevation of the nasal end of the anterior layer, especially for the punctum lacrimale, a double-armed suture is similarly passed through the anterior layer 4 mm. below its margin and opposite the middle of the internal palpebral ligament, and is tied to the palpebral ligament close to the lacrimal crest. The anterior layer is now very tense. Finally, the posterior layer is drawn down by aid of the double-armed sutures, which are tied on the cheek. The sutures may be removed in seven or eight days.

For the relief of the extreme ectropion due to burns of one or both eyelids, the best method is that of Wolfe by *Skin Transplantation*. It is performed as follows :—

In the first place the eyelid—let it be the upper eyelid—is dissected down into its place to the utmost limit, so that the most extensive raw surface possible may be obtained. The margin of the lid, having been drawn over the lower lid, is fastened to the cheek with three points of suture. A portion of skin, suited as regards shape, and about one-third larger (to allow for shrinkage) than the raw surface of the eyelid, is then taken from the inside of the arm, and having been carefully freed of all its subcutaneous fat and connective tissue, is laid upon the raw surface, and secured to it by a large number of fine interrupted sutures around the margin. Or, if the margin of the skin surrounding the raw surface

be dissected up, the edge of the graft can be slipped under it, and secured in its place by this means. A non-irritating dry dressing, or an ointment dressing, is applied, and the graft usually heals on in the course of a few days. This method of grafting was introduced by Wolfe and Lefort, and it may be employed in all these cases with most satisfactory results.

It is important to preserve and utilise any part of the skin of the eyelid which remains, especially its ciliary border with the eyelashes. The thorough cleaning of the flap from its subcutaneous fat and connective tissue is also important, as otherwise an unsightly and lumpy effect is produced when the flap has healed on. While this cleaning is being done, the flap should lie on a warm sterilised porcelain plate. The flap should not be applied to the raw surface until all oozing of blood from the latter has ceased.

The transplantation of a flap with pedicle from the forehead, temple, or cheek is also used to repair an eyelid ; but, owing to the thickness of the integument, the result is cosmetically less satisfactory than that given by a graft from the arm, while the tendency to shrink is quite as great.

Some prefer Thiersch grafts to dermic grafts, and state they are more easily applied to the raw surface, and do not differ in colour from the surrounding skin when healing is completed. It is desirable to obtain one continuous graft of the whole size of the wounded surface.

Paralytic Ectropion is due to loss of power in the orbicular muscle in cases of paralysis of the seventh nerve. It occurs in the lower lid only, which falls outwards by its own weight when not kept in contact with the eyeball by the tone of the muscle. The condition is remedied by a tarsoraphy (p. 554) when all hope of recovery of the paralysed nerve has to be abandoned.

* **Ankyloblepharon** (*ἀγκύλη, a string ; βλέφαρον, an eyelid*) is a uniting of the upper and lower eyelids along their margins. It may be partial or complete, and often goes with symblepharon. Like the latter, it is usually caused by burns and ulcers.

The condition can only be relieved by operation, of which the result is often unsatisfactory, owing to the difficulty of preventing re-union taking place at the canthi. To avert this, it is always necessary to cover the wounded surface with conjunctiva or skin.

Injuries of the Eyelids.—All kinds of injuries of the eyelids (contusions, incisions, burns, etc.) are common.

In consequence of the looseness of the integument, œdema and ecchymosis, one or both, are often seen in a marked degree as the result even of slight injuries.

Owing to the direction of the fibres of the orbicularis, an incised wound of the eyelid, if in the vertical direction, will gape, while a similar wound in the horizontal direction will not do so. Hence the scar left after the former wound is apt to be very visible, but that after the latter may be almost imperceptible. If the eyelid be divided vertically in its entire thickness, unless union by first intention can be obtained, a deep furrow is left in the eyelid, and, perhaps, at its margin an unsightly coloboma.

The result of burns of the eyelids has been treated of at p. 566.

Emphysema of the eyelids is sometimes seen after a blow on the eye, and is a sign of fracture of the orbit complicated with a communication between the subcutaneous connective tissue of the eyelids and the nose, the ethmoid sinus, the frontal sinus, or the antrum of Highmore. An emphysematous lid is swollen, soft, and crepitating to the touch.

Ecchymosis of the lower lid, usually with ecchymosis of the lower portion of the conjunctiva, after falls or blows on the head, is a sign of fracture of the base of the skull, the blood making its way along the floor of the orbit.

Simple ecchymosis of the eyelids from blows, commonly known as ' black eye,' never gives rise to further complication. It requires some fourteen days or more, according to the quantity of blood extravasated, before the eye recovers its normal appearance.

Treatment.—Injuries of the eyelids, of whatever kind, are of course treated upon general surgical principles. Incised wounds should be carefully and neatly drawn together with sutures as soon after the injury as possible, and with antiseptic precautions. Emphysema may be assisted in its absorption by the application of a rather tight bandage, and directions should be given to the patient to blow his nose as gently as possible, so as to avoid recurrence of the condition.

* **Epicanthus** is a congenital deformity, usually binocular, which, in the most pronounced cases, consists in partial paralysis of the levator palpebræ (ptosis), and of the rectus superior, with a narrow

palpebral fissure, and a fold of integument at the inner canthus which conceals the caruncle from view (see Fig. on p. 501), and gives the appearance of great breadth to the bridge of the nose. The term is also used for cases in which the integumental fold at the inner canthus is the only abnormal condition. This deformity can be somewhat diminished by the removal of an oval piece of skin from the bridge of the nose, its long axis being vertical and its width varying according to the effect required. When the margins of the wound are brought together, the abnormal epicanthal folds are diminished in width.

* **Congenital Coloboma** of the upper lid—sometimes associated with a dermoid cyst of the limbus of the cornea corresponding with the cleft in the lid—and even congenital absence of the eyelids, have been occasionally observed.

CHAPTER XVIII.

DISEASE OF THE LACRIMAL[1] APPARATUS.

Malposition of the Punctum Lacrimale.[2]—The punctum in the lower lid is more efficient for carrying off tears, than that in the upper lid, and a derangement of the lower punctum alone is sufficient to give rise to epiphora. Normally the punctum lies against the eyeball and cannot be seen, unless the observer draws the inner end of the lid away from the eye. Inversion of the punctum accompanies entropion of the lower eyelid, while eversion of it is present with ectropion of the lid. A slight eversion, quite sufficient to cause epiphora, may exist without any marked ectropion of the lid, and it is these cases which more properly belong to this chapter. They are the result generally of some chronic, although it may be slight, skin affection of the lower lid, which draws the inner end of the latter slightly away from the eyeball.

A prominent symptom of this and of all the following lacrimal affections is lacrimation, or epiphora (*ἐπιφορὰ δακρύων, a flow of tears*), a flowing of tears over the cheek.

Inversion of the punctum can only be relieved by an entropion operation on the eyelid.

Stenosis, and **Complete Occlusion of the Punctum Lacrimale.**—Either of these conditions may result from conjunctivitis, or from marginal blepharitis, although they may not appear for a length of time after those affections have passed away, and the original affection may have been so slight as to have escaped the observation of the patient. In stenosis the size of the punctum may become so extremely minute, that even the normal flow of tears is

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[1] *Lacrima*, a tear.

[2] In this chapter, and elsewhere in the book, the terms punctum lacrimale and canaliculus refer to the inferior passage, unless it be otherwise expressly stated.

too copious to pass through it. Complete occlusion is probably only a more advanced stage of stenosis.

The Treatment, in cases of eversion of the punctum without marked ectropion of the lid, of stenosis, and of complete occlusion, is similar, namely, the opening up of the punctum, and its conversion into a slit. This is done with a Weber's knife (Fig. 222), the probe-point of which is passed into the punctum in cases of eversion, forced into the small opening in cases of stenosis, or forced through the usually thin covering of the punctum in cases of occlusion. In doing this the lower lid should be stretched rather tightly by a finger of the surgeon's left hand placed near the external canthus. The probe-point having entered the punctum, the edge of the knife is turned slightly towards the eyeball, and the instrument is pushed on into the canaliculus, until 2 mm. of the latter has been opened up, and is then withdrawn. If the edge of the knife be directed outwards in this proceeding, the incision comes to lie on the outer edge of the intermarginal portion of the lid, and not in contact with the eyeball; consequently the result is unsatisfactory, for the tears are not carried away, and the disfigurement produced may be considerable. A slitting up of the whole, or the greater part, of the canaliculus in these cases is unnecessary, and interferes with the physiological action of the tear passage. For two or three days after the little operation, it is necessary to pass a probe along the portion of the canaliculus which has been slit up, to prevent union taking place.



FIG. 222

When, as sometimes happens in old people, and occasionally even in the middle-aged, from relaxation of the orbicularis, the inner end only of the under lid is everted, the excision of a small flap of conjunctiva somewhat after the manner of Fergus (p. 565) will restore the punctum to its normal position.

Obstruction of the Canaliculus.—The canaliculus may be diminished in its calibre, or entirely closed, by contraction, which is the result of inflammation that has extended to it from the con-

junctival sac. It is not possible to diagnose the presence of either of these conditions, which may be associated with stenosis or occlusion of the punctum lacrimale, except by the introduction of a very fine probe into the canaliculus. The passage may also be obstructed by an eyelash, a chalky deposit, or a mass of streptothrix.

The diagnosis of streptothrix in the inferior canaliculus—it rarely affects the upper canaliculus—is made by the following signs and symptoms :—Lacrimation ; the presence of a creamy-yellow discharge at the inner canthus, without dacryocystitis ; congestion of the caruncle and neighbouring parts of the conjunctiva. On everting the inner end of the lower lid, the region corresponding with the canaliculus is seen to be rounded and swollen on its conjunctival aspect. The lacrimal punctum is enlarged, stands out from the eyeball when the patient looks up, and is filled with creamy exudation. On palpation, a hard cylindrical mass can be felt in the canaliculus. At a later stage, severe purulent inflammation of the canaliculus comes on, with marked swelling of the eyelid in the neighbourhood, and pain. The greenish-yellow dacryolith contained in the canaliculus usually consists of a streptothrix, which some regard as actinomyces.

Treatment.—Where there is merely diminution in the calibre of the passage, the introduction of probes, increasing in size, is frequently sufficient to effect a cure. If dilatation fail, recourse must be had to slitting up the canaliculus ; but, if it can possibly be avoided—that is, if a less extended opening will answer—the passage should not be slit up in its entire length. At least 3 mm. of its median end ought to be left intact, as otherwise regurgitation of tears from the lacrimal sac is liable to trouble the patient ever afterwards. If the canaliculus be completely closed by adhesions, so that a fine probe cannot be pushed through it, it becomes necessary to rip it up with the point of any small knife, following the known course of the passage from the outside. If the canaliculus be closed as far as the opening into the sac, or if only at that point, the obstruction must be pierced with the point of a fine knife. A difficulty in all these cases is to keep the passage patent when once formed. A plan which affords tolerable certainty of this is the frequent passage of probes into the sac until the tendency to closure seems to have ceased ; but even under favourable conditions recurrences of the closure are apt to occur.

Streptothrix in the lower canaliculus is readily cured by slitting up the passage and evacuating its contents.

Stricture of the Nasal Duct is usually the result of simple acute swelling of its mucous membrane in a catarrhal attack, which has originated in the nasal mucous membrane. Or, it is caused by membranous or cicatricial contraction of the mucous membrane resulting from long-continued chronic catarrh. It also occurs in consequence of disease of the bones of the nose—*e.g.* in syphilis, acquired or congenital, and from blows which fracture the bridge of the nose.

Treatment.—It is desirable to commence the treatment by syringing the nasal duct, the fine point of an Anel's syringe being introduced into the punctum lacrimale and canaliculus. In some cases, where the obstruction is merely a plug of mucus, the syringe may at once effect a cure. Stricture due to acute inflammatory swelling of the mucous membrane should be treated by the injection of weak alum or other astringent solutions into the lacrimal sac, or through the nasal duct, by means of an Anel's syringe; and attention should be paid to the condition of the nasal mucous membrane. Probing here should not be attempted, lest it injure the delicate swollen mucous membrane of the duct.

Membranous or cicatricial strictures are best treated by means of probes in the manner proposed by Sir William Bowman. Probes as large as numbers 3 or 4 can be introduced into the canaliculus if the punctum be first dilated. Should there be any difficulty, or if larger sizes are needed, the inferior canaliculus is slit up to a slight extent so as to admit the point of one of Bowman's smallest probes, which has been given a curve to suit that of the nasal duct. With a finger of the left hand (Fig. 223), if it be the patient's left eye, the surgeon stretches the lower lid, and, entering the probe with the right hand into the canaliculus, he pushes it gently along its floor until the point reaches the lacrimal bone (Fig. 223, position No. 1). The point being kept pressed against this bone, the direction of the probe is now altered, by carrying its free end upwards towards the bridge of the nose, until the point which is in the lacrimal sac is directed towards, or aimed at, the sulcus between the ala of the nose and the cheek. The probe in this position (Fig. 223, position No. 2) corresponds with the prolonged axis of the nasal duct, down which it is pushed slowly and with gentle pressure. If it be

the right eye, the surgeon reverses his hands, or operates from behind the patient. Any obstacles met with are overcome, if possible, by an increase of the pressure; but if, at any part of the passage, much difficulty be encountered, rather than that any violence be used, further manipulation should be postponed to

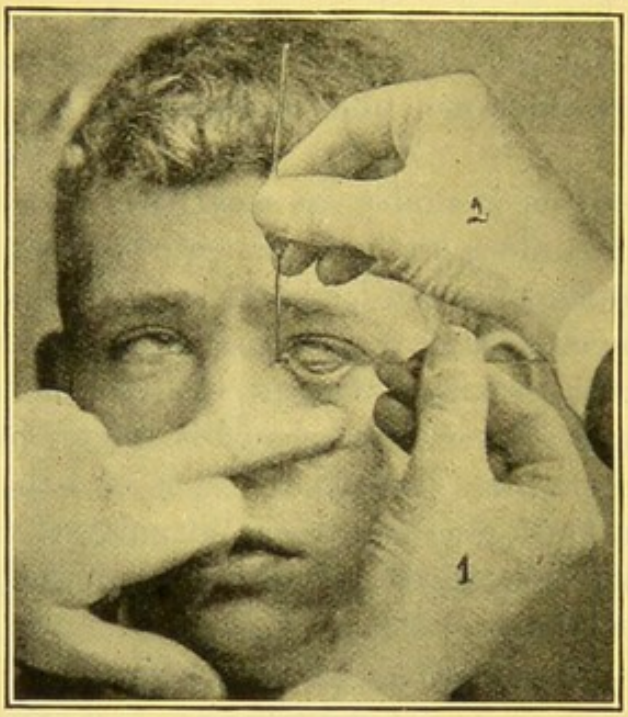


FIG. 223.

another day; and it will often be found that at the second or third visit the probe is passed with comparative ease. Thicker Bowman's probes are gradually introduced at successive sittings, until the largest size has been reached.

The most common seats for membranous or cicatricial stricture of the nasal duct are at the upper end, where it enters the sac, and where it is at its narrowest; and at the lower end, where it is mainly exposed to catarrhal processes spreading from the nostril.

Weber's probes are conical, and of very large calibre at their thickest part. The objection to such large conical probes is that when passed into the nasal duct, their thickest part, which is 3 to 4 mm. in diameter, corresponds with the upper end of the duct, which is its narrowest part, being only 3 mm. in diameter. Consequently, the probe becomes more or less impacted at this place at each operation, and this impaction, from injury of the mucous membrane and periosteum, is liable ultimately to give rise there to

hypertrophy of the periosteum, and finally to stricture; so that, while the immediate effect of their use is perhaps brilliant, the ultimate result is often the reverse. When used by the inferior canaliculus, their size makes it necessary to slit that passage in its entire length, and the entrance of the passage into the sac must be enormously dilated by so large an instrument, both of which circumstances are most undesirable. The same objection applies to the large probes introduced by other surgeons. Syringing the nasal duct should not be performed immediately after passing a probe, lest cellulitis be set up.

To prevent closure of the duct when once made free, Mr. Arthur Benson advocates the use of leaden styles, removable by the patient. He first divides the canaliculus (by preference the upper one), and dilates the stricture with probes in the ordinary way, and then introduces into the duct a piece of leaden wire 1·5 mm. to 2 mm. in diameter, cut to length, and smoothed off at the ends. The upper end is curved so as to lie out on the cheek. The style is at first removed daily, and the duct syringed, until any existing inflammation and discharge have almost ceased. The intervals are then increased; and as soon as practicable the patient is taught to remove the style and to replace it himself. When he is able to do this easily, he is directed to leave the style out for some hours each day, and finally to wear it only at night.

Very obstinate membranous strictures can sometimes be freed by electrolysis.

The cases of stricture which are the most favourable for cure are those due to inflammatory swelling of the mucous membrane, and next in order come those caused by membranous or cicatricial contraction, while strictures due to bony obstructions are incurable.

Now and then cases of persistent lacrimation will be met with, in which the nasal duct and the rest of the lacrimal apparatus seem to be in perfect order. These cases are often due to a catarrhal affection of the nasal mucous membrane, slightly involving the very lowest extremity of the nasal duct. Applications directed towards relief of the nasal affection are here indicated.

Blennorrhœa of the Lacrimal Sac, or **Chronic Dacryocystitis,** is commonly caused, in the first instance, by stricture of the nasal duct. In consequence of this stricture the tears and the normal mucous secretion of the lining membrane of the sac are retained,

and offer favourable conditions for the growth of micro-organisms, of which the pneumococcus is the one usually present.

But cases of lacrimal blennorrhœa are seen in which no stricture of the nasal duct is found. In many of these cases there has been a temporary stricture due to catarrhal swelling of the lining membrane of the duct, which has subsided without treatment, and the duct has again become free, while the lacrimal blennorrhœa, to which the stricture gave rise, continues. It is probable, however, that lacrimal blennorrhœa may occasionally come on where there has never been a stricture of the nasal duct, and merely as an extension of catarrh from the nostrils, especially in cases of ozæna, or as an extension of catarrh from the conjunctiva.

Tubercle is occasionally the cause of dacryocystitis, but it is not possible to make a clinical diagnosis between these and the more common cases, if the mucous membrane of the lacrimal sac alone be diseased. In many, but not in all cases, the tubercular infection of the sac extends from the nostril, or from the conjunctiva, one or other of which is the primary seat of the disease. The sac itself may be the primary seat of the tuberculosis, with quite healthy nasal and ocular mucous membrane.

Symptoms.—The patients as a rule complain merely of lacrimation. Some, more observant of themselves, may have noticed a swelling, known as a lacrimal tumour or mucocele, in the region of the lacrimal sac ; and also that the conjunctival sac, especially when the swelling is pressed upon, becomes now and then more or less filled with a somewhat viscid and opaque discharge, which obscures the sight until wiped away. Occasionally there is no lacrimal tumour, for the contents of the sac may not be copious enough to distend it markedly.

In order to ascertain in each case of epiphora whether lacrimal blennorrhœa be present, the surgeon presses with his finger over the lacrimal sac, when, if there be blennorrhœa, the discharge will be evacuated through the puncta into the conjunctival sac. But occasionally, where there is a deeply situated sac, owing to a prominent anterior lacrimal crest, although dacryocystitis is present, it may not be possible to express any discharge from the sac. Or, in those cases in which there is no longer a stricture of the nasal duct, the discharge may pass downwards into the nose, and the patient will feel it in his nostril, out of which he can blow it.

Conjunctivitis must sometimes be regarded, not as the cause, but rather as the effect of a lacrimal blennorrhœa, by reason of infection from the lacrimal sac. Blepharitis, too, is seen as a further result of infection from the discharge in old-standing cases.

The most serious complication, or consequence, of chronic dacryocystitis is the serpiginous ulcer of the cornea, caused through infection by the pneumococcus (p. 124).

Treatment.—It is important, in the first place, to ascertain whether there be a stricture of the nasal duct, and for this purpose water should be injected by means of an Anel's syringe through the canaliculus into the duct. If the fluid make its way freely into the nose or pharynx, it may be taken for granted that the nasal duct is not obstructed ; but if, instead of passing through—or only under high pressure—it distend the lacrimal tumour to a greater size, a stricture may be assumed. If stricture of the nasal duct be present, it should be relieved, if this can be done, by a few probings; excessive probing only aggravates the condition of the sac. Should there be no stricture, and also before and after any existing stricture has been relieved, the treatment consists in the very frequent pressing out of the contents of the sac by the patient, so that no distension of it may occur : and in doing this he should endeavour to cause the discharge to pass down the nose rather than into the eye. Frequent deep massage of the sac, which the patient can be taught to perform, is useful. Injections into the sac to relieve the catarrh should be made daily by the surgeon. Protargol, in a 15 or 20 per cent. solution, is a good application for introduction into the lacrimal sac. The latter should first be washed out with a physiological salt solution. Other fluids which have been recommended are Sol. Argyrol 25 per cent., Sol. Hydrarg. oxycyanat. 2 per cent., Sol. Potas. perman. 1 in 2500.

Any conjunctivitis or abnormal condition of the nasal mucous membrane should be treated. But there are many cases in which nothing short of extirpation of the lacrimal sac will bring about a radical cure of this troublesome, and even serious, complaint. Indeed, for chronic cases this operation is now commonly recommended at the first consultation, in view of the disappointing results obtained from other methods.

* *Extirpation of the lacrimal sac.*—For this Kuhnt's method is probably the best.

Prior to the operation, the contents of the sac should be expressed, and its cavity washed out with a sterilised salt solution. To render the sac more easily found, some surgeons fill it with paraffin prepared for surgical use with a melting point of 110°, which is injected through the lower canaliculus. The paraffin at once hardens, and the sac becomes outlined.

The patient should be deeply anæsthetised, or an effectual local anæsthesia may be obtained as follows:—About fifteen minutes before the operation a few drops of the following solution are injected subcutaneously: 1 c.cm. of a 1 per cent. solution of cocaine, to which is added 3 minims of a 1 in 1000 solution of adrenalin. After the injection the field of operation becomes of a waxy whiteness, when the operation can then be performed almost painlessly. By this means, too, the hæmorrhage, which is usually troublesome, is reduced to a minimum. As a result of the injection slight œdema of the region may be seen a few days after the operation.

An incision down to the bone and about 2·5 cm. in length is made over the anterior lacrimal crest. It begins about 4 mm. above the internal palpebral ligament, and ends about 5 mm. below the commencement of the bony lacrimal duct. As a rule the palpebral ligament is not divided by this incision, and has now to be separated with the scissors close to its insertion. Some surgeons consider it unnecessary and undesirable to divide the palpebral ligament, because it is likely to lead to some disfigurement, no matter how carefully the sutures may be applied, but this is not our experience. Müller's speculum is then inserted to draw aside the lips of the wound, and Axenfeld's speculum is inserted from the nasal side into the upper and lower angles of the wound as deep as the periosteum, to check the troublesome hæmorrhage which proceeds mainly from those angles (Fig. 224). If there be bleeding from the small arteries, they are, if possible, seized and twisted, while general oozing of blood is moderated by means of compresses soaked in solution of adrenalin with cocaine or hydrogen peroxide. The fibrous capsule of the sac is carefully incised along the crest, care being taken that the sac itself is not opened. The anterior wall of the sac, greyish blue and shining when no paraffin has been injected, then becomes exposed in the cavity. To remove the sac the surgeon separates its inner wall from the periosteum with the closed blunt ends of the scissors, or with a small elevator; then the fundus of

the sac, along with the strong fibrous capsule which is here adherent to it, is drawn forwards, and with a few strokes of the scissors is separated from its bed, and the scissors are passed behind the sac from above and the posterior wall similarly separated. The fundus of the sac is then drawn inwards and forwards, and the outer and what remains attached of the anterior surface are made free. Finally, the sac is cut off close to the bony canal, and, if there be no impervious stricture present, the mucous membrane of the duct is curetted with a suitable sharp spoon, or a fine olive-shaped electro-cautery is applied to it. The wound is closed by two or three

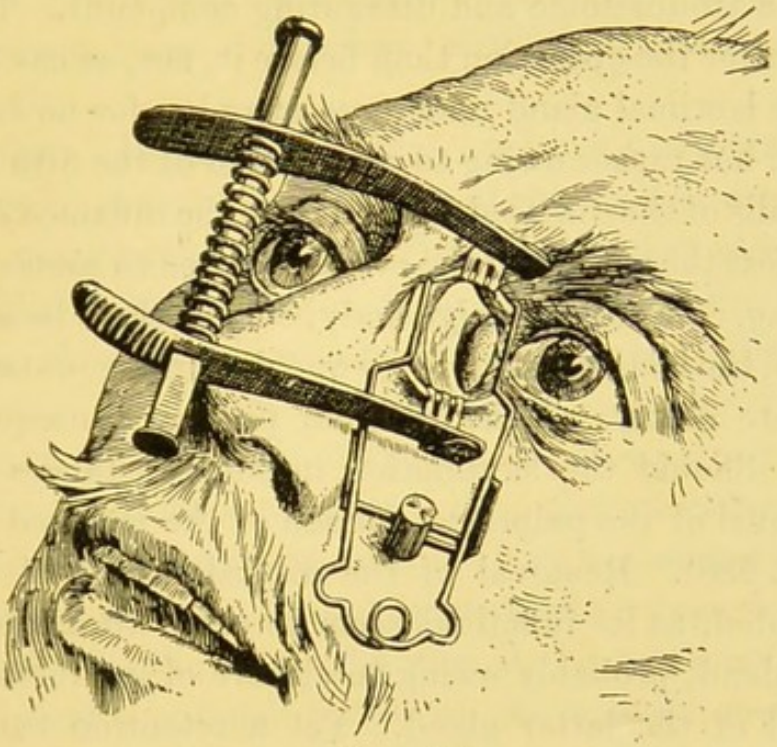


FIG. 224.

deeply placed sutures, special care being taken to secure the palpebral ligament to its insertion. A graduated dressing should be tightly applied to keep the walls of the cavity in contact.

Axenfeld performs a sub-periosteal operation, his first incision lying slightly in front of the anterior lacrimal crest, and the periosteum is then separated from the lacrimal bone, along with the wall of the sac. His object is to increase the security of a total extirpation, and to reduce the danger of injuries of the wall of the sac.

Should the sac be opened during the operation, its total extirpation will be rendered much more difficult; and if any portion

of the sac be left behind, the object of the operation is likely to be frustrated by a return of suppuration. If the sac be not excised in its entirety, the suspicious places must be destroyed by curetting. Where there is a fistula of the sac, or where there has been phlegmonous dacryocystitis, or where there has been excessive probing of the nasal duct, the operation is rendered difficult by reason of adhesions.

The wound heals rapidly by first intention, leaving a fine cicatrix which causes practically no disfigurement.

After extirpation of the suppurating lacrimal sac, a source of danger to the eye has been removed, and the patient has been relieved of a troublesome and disfiguring complaint. The lacrimation is less after the operation than before it, not, as has been stated, because the lacrimal gland undergoes atrophy, for no such atrophy takes place, but rather owing to elimination of the fifth nerve reflex from the walls of the diseased sac and from the inflamed conjunctiva. Indeed, unless the surface of the eye be exposed to some considerable irritation, *e.g.* cold wind, foreign body, etc., or there be some psychical emotion, the lacrimation is in no way disturbing, notwithstanding the complete closure of the lacrimal passage consequent on the operation. Should the lacrimation in some instances be troublesome, removal of the palpebral portion of the lacrimal gland is indicated (p. 586). Removal of the orbital portion of the gland is seldom needed, as its functions seem to cease after removal of the palpebral gland, probably owing to closure of its ducts consequent on removal of the latter gland. Yet a retention tumour of the orbital gland does not ensue.

It is desirable to instruct the patient that he should inform any surgeon he may subsequently consult for epiphora that his lacrimal sac has been removed, lest futile and perhaps harmful probing of the nasal duct should be attempted.

Acute Dacryocystitis (*δακρύω, to weep; κυστίς, a bladder*).—Acute inflammation of the lacrimal sac most usually comes on when chronic lacrimal blennorrhœa is already present. Caries of the nasal bones may cause it, and it occurs idiopathically, probably as the result of exposure to cold.

The region of the lacrimal sac and the surrounding integument become swollen, tense, and red, and these conditions often spread to the lids, giving an appearance which is sometimes mistaken for

erysipelas; but the history of the case, showing the previous existence of lacrimal obstruction, etc., will assist the diagnosis. Great pain accompanies the inflammatory process. Gradually the region corresponding with the lacrimal sac becomes the most prominent part of the swelling, and the abscess, pointing there, opens. When the pus has been discharged the inflammation subsides, and the opening through the skin may either close, the parts resuming their normal functions, or the opening may remain as a permanent fistula.

The difference between chronic blennorrhœa of the lacrimal sac and acute dacryocystitis, besides the fact that one is a chronic and the other an acute inflammatory process, is that the former process is confined to the mucous membrane of the sac, while in the latter the submucous tissue is involved, with phlegmonous inflammation as the result.

Treatment.—In the early stages poultices and purgatives should be employed. As soon as palpation of the sac indicates the presence of pus, it must be evacuated. This can be effected either through the canaliculus, by opening it up to its entrance into the sac, or by an incision through the integument over the sac. The latter is the better method, as it admits of free access to the interior of the sac. On the next day the walls of the sac are to be freely touched with solid mitigated nitrate of silver; or a plug of cotton-wool soaked in a strong solution of nitrate of silver may be inserted into its cavity, and left there for some hours; or various astringent solutions may be injected into the sac. The aim of the treatment, whatever it be, is to secure a rapid return of the mucous membrane to its normal condition. If stricture of the nasal duct be present, it must be treated *pari passu*. By these means the discharge from the sac is arrested, and the external opening gradually closes.

If a fistula should form, it may be brought to close, in many cases, by simply freeing an existing stricture of the nasal duct; or, it may be necessary to pare its edges, and bring them together by sutures; or, especially if there be a long fistulous passage, the galvano-cautery, in the form of a platinum wire, can be applied with advantage.

* **Dacryoadenitis** (*δακρύω, to weep; ἀδήν, a gland*), or **Inflammation of the Lacrimal Gland.**—This is a very rare affection. It occurs in an acute and in a sub-acute form, and is usually symmetrical in each eye. The acute form is characterised by swelling of the upper lid, especially in its outer third, by chemosis, by diminished mobility

of the eyeball upwards and outwards, with displacement downwards and inwards, by local pain often radiating into the frontal region, and by pain on pressure over the gland. On pressure, the tuberous and swollen gland may be felt, unless œdema of the lid should interfere. In the sub-acute form there is neither œdema nor chemosis, and little or no pain, and the diagnosis depends on the presence of a hard and lobulated mass under the outer third of the upper lid, which may displace the globe and interfere with its motion upwards and outwards.

Dacryoadenitis occurs in gonorrhœa, even long after the acute stage of the latter is passed, in epidemics of mumps with or without parotitis, in influenza, diphtheria, measles, and scarlatina. In all these instances it must be regarded as the result of toxic absorption, and having lasted from about three to fourteen days it undergoes resolution with complete recovery.

Dacryoadenitis may also be caused, without any conjunctivitis, by direct infection with the staphylococcus, streptococcus, or pneumococcus, each of which has been found in the inflammatory products, and these cases are liable to go on to suppuration, with formation of abscess. They are usually on one side only.

Finally, cases of tubercular dacryoadenitis have been recorded. The direct clinical diagnosis of these cases cannot be made—the suspicion only of their nature, from the presence of tubercular disease in other parts of the system, can be raised.

Treatment.—Treatment of any toxæmia which may be held to be present. Locally hot fomentations relieve pain and promote resolution. When abscess forms, it generally points in the conjunctival fornix, and is to be opened there. Should tubercle be suspected, removal of the entire gland is indicated.

* **Tumours of the Lacrimal Gland.**—Tumours of the lacrimal gland are rare. Sarcoma is the most common of the new growths here, with its mixed forms fibro-, myxo-, adeno-, and lympho-sarcoma. Adenoma is also common, and lymphoma, angioma, and some other varieties have been observed. In the beginning, the outer third of the upper lid seems swollen, but palpation shows this to be caused by a tumour behind the lid, but not in it, and also that the tumour originates in the orbit. Gradually, by pressure of this growing tumour, the eyeball becomes displaced forwards and inwards, and its motions are curtailed in the upward and outward

direction. In many instances the growth extends backwards into the orbit behind the globe, and then the direction of the displacement is more markedly forwards. The tumour may become fixed to the orbital margin, or the roof of the orbit may be involved and even perforated, and vision may be affected, if the optic nerve be pressed on.

Treatment.—Extirpation of the growth is indicated. If the case come under care at an early stage, the tumour can be reached and effectually removed, either through an incision made through the lid parallel to the outer half of the orbital margin ; or, the external commissure having been divided, and the upper lid turned up—through an incision made in the conjunctival fornix. In later stages, especially when the tumour has extended deeply into the orbit, Krönlein's operation (p. 609) is indicated.

* **Tubercular Tumour of the Lacrimal Gland.**—A few cases of tubercular tumour of the lacrimal gland have been recorded. The tumour presented itself as a very hard mass, about the size of an almond, freely movable under the skin, and unattended by pain. In some instances the history had extended over several years, and in others has lasted for some months only. In the majority of the cases there was tubercular disease elsewhere in the system, but in one instance there was none, nor was there any hereditary disposition to tubercle.

Treatment.—Extirpation of the gland.

* **Cysts of the Lacrimal Gland.**—These are rare. The most common of them is Dacryops, a term applied to a retention cyst, which occurs almost exclusively in the palpebral portion of the gland, and may attain the size of a hazel nut, and which appears as a more or less transparent bluish swelling in the outer part of the upper fornix.

Treatment.—Excision of a portion of the outer wall of the cyst.

* **Symmetrical Chronic Swelling of the Lacrimal and Salivary Glands.**—In this remarkable affection there is enormous swelling of each lacrimal, parotid, and submaxillary gland, while the sublingual glands, and small salivary glands in the cheek are also swollen, the whole producing a striking alteration in the physiognomy of the patient. The disease has an acute and a chronic form. The former may run its course, attended by some fever, in a week or ten days, and can be treated with hot fomentations locally, and saliclyate of

soda internally. The chronic form is reckoned by many to be a manifestation of leucæmia or of pseudo-leucæmia, and its treatment is in this way indicated.

* **Extirpation of the Lacrimal Gland.**—This operation is performed by making an incision through the integument under the outer third of the orbital margin ; the subjacent fascia is dissected up, the gland drawn forward with a hook, and dissected out with a scalpel. Or, if it be considered sufficient to remove the palpebral portion, this can be done from the conjunctival surface, by separating the lids widely at the outer canthus, while the patient looks well downwards and to the nasal side, when the palpebral gland will become prominent in the upper fornix (Fig. 225), and can be seized and cut out with scissors. This partial removal may be performed for persistent lacrimation when other means fail. As already stated, when a large tumour of the gland is present, Krönlein's operation is often needed. The absence of tears, which follows upon extirpation of the lacrimal gland, is not serious for the eye ; for normally the gland secretes very little, unless under the stimulus of a fifth nerve or psychical reflex. Under other conditions, the surface of the eye is kept moist mainly by the conjunctival secretion, which consists not merely of mucus, but of a watery fluid sufficient even if there be no secretion of tears—as in extirpation of the lacrimal gland where there is paralysis of the fifth nerve—to keep the surface of the eye moist.

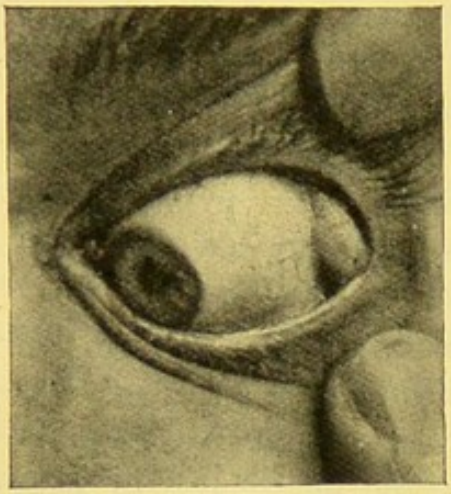


FIG. 225.

CHAPTER XIX.

DISEASES OF THE ORBIT.

The position of the eyeball in the orbit is subject to individual variations. As a rule the cornea projects very slightly beyond an imaginary line drawn from the upper to the lower margin of the orbit, so that a ruler placed in this position would touch the closed upper lid and exercise only slight pressure on it.

Exophthalmos or Proptosis.[1]—One of the most common signs in many diseases of the orbit is displacement of the eyeball forwards, which is usually accompanied by more or less lateral or vertical displacement. In slight degrees of proptosis the relative positions of the eyes can be best compared by observing the level of the cornea from behind and above the patient's head. Instruments (exophthalmometers) have been devised for the measurement of the amount of protrusion, and of these Hertel's is one of the best.

The causes of true exophthalmos are: increase in volume of the orbital contents, and diminution in the capacity of the orbit. The prominence of an enlarged eyeball due to high myopia, or to anterior staphyloma, as also the slight degree of exophthalmos which results from relaxation or loss of tone in the orbital muscles when several of them are simultaneously paralysed, are not reckoned as true exophthalmos. Again, the physiological forward position of the eyes sometimes present in very stout persons must not be misinterpreted. Retraction of the lids which follows the use of cocaine, and which also occurs in the early stage of exophthalmic goitre, and in other conditions (p. 613) may produce the appearance of proptosis, without any real displacement of the eyeball.

True exophthalmos from increase in the orbital contents may be brought about by inflammatory exudation, as in orbital cellulitis,

[1] *πρό, forwards; πτῶσις, falling.*

by new growths, by vascular diseases such as arterio-venous aneurism and cavernous sinus thrombosis, and by hæmorrhage or emphysema, the result of injury. Diminution in the capacity of the orbit as a cause of exophthalmos, is most commonly due to encroachment on it from disease of the nasal sinuses and in rare cases by the condition known as Tower Skull (oxycephaly) and the still more rare affection Leontiasis Ossium. Exophthalmos is most frequently met with as a unilateral affection, but it may be bilateral, as in exophthalmic goitre, in the later stages of thrombosis of the cavernous sinus, in pansinusitis, and also in symmetrical tumours of the orbit (lymphoma).

Orbital Cellulitis.—*The Symptoms* of this affection are: erysipelatous swelling of the lids, especially of the upper lid; serous chemosis; pain in the orbit, increased on pressure of the eyeball backwards; violent facial neuralgia; exophthalmos, with impairment of the motions of the eye in every direction; and high fever, sometimes with headache and vomiting.

Vision is not generally affected, but sometimes it is so from optic neuritis, and then, too, mydriasis is seen. The cornea is often completely or partially anæsthetic.

The surgeon, by pressing the tip of his fourth finger between the eyeball and the margin of the orbit, may feel a more or less resistant tumour. This gradually increases in some one direction, the integument in that position becomes redder, fluctuation becomes pronounced, and the abscess finally opens through the skin, or into the conjunctival sac, the pointing being usually at the upper and inner angle of the orbit. Restoration to the normal state, as a rule, comes about; but in some cases complete atrophy of the optic nerve supervenes. Other cases, however, recover without the formation of pus; while again, thrombosis of the cavernous sinus, or even meningitis or cerebral abscess may ensue.

In panophthalmitis (p. 197), as in orbital cellulitis, exophthalmos, loss of movement, swelling of the lids and chemosis also occur, but in panophthalmitis these symptoms are preceded and accompanied by purulent irido-cyclitis, or by suppuration of the cornea.

Causes.—(1) Idiopathic (*e.g.* cold); (2) traumatic (perforating injuries, foreign bodies); (3) extension of inflammation from surrounding parts (erysipelas, diseased tooth, ethmoidal cells); (4) metastasis (pyæmia, metria); (5) sequelæ of fevers (scarlatina,

typhoid, purulent meningitis, influenza). It is probable that the majority of cases of orbital cellulitis are due to infection from the neighbouring sinuses.

Treatment.—Locally, poultices or warm fomentations; and, when pus has formed, its earliest possible evacuation, followed by drainage and cleansing of the cavity with hydrogen peroxide or antiseptic solutions. The nasal sinuses should be treated if necessary. The general constitutional treatment suitable to each case need not be discussed here.

* **Tenonitis,** or **Inflammation of the Capsule of Tenon,** is an uncommon affection, the symptoms of which are those of a moderate cellulitis of the anterior part of the orbit. As in orbital cellulitis, the lids are red and swollen, there is slight exophthalmos, with restricted mobility of the eye, and chemosis, but no conjunctival discharge. The diagnosis (as distinguished from cellulitis) rests on the slight degree of exophthalmos, as compared with the great loss of mobility, and relatively well-marked chemosis. In the early stage, before the inflammatory symptoms have declared themselves, the patient complains of periorbital neuralgia, followed by a sense of pressure in the eye, and great pain on attempting to move it, so much so that the eyes are kept closed and immovable. One or both eyes may be affected, and relapses are common. Vision is not affected, and febrile symptoms are much milder than in cellulitis. The prognosis is good, recovery taking place in about a week. Sometimes suppuration occurs, and a small sub-conjunctival abscess forms, which generally opens upwards and inwards. In addition to the serous and purulent varieties, a chronic plastic form of the disease has also been met with.

Causes.—Chronic rheumatism (sometimes with effusion into a joint), influenza, and in rare cases tuberculosis. The suppurative form may be traumatic, or may follow measles or scarlatina.

Treatment.—Warm fomentations, and a light bandage, with salicylate of soda, antipyrin, or quinine internally.

Thrombosis of the Cavernous Sinus gives rise to symptoms which may be mistaken for those of an orbital process. It frequently spreads to the opposite side, and is accompanied by cerebral symptoms. The affection is described at p. 498.

Periostitis of the Orbit.—Acute periostitis of the orbit has many symptoms in common with phlegmonous inflammation of the orbital

connective tissue, which generally accompanies it; but it may usually be distinguished from the latter inflammation occurring independently, by the fact that, in it, pressure on the orbital margin is painful. The absence of this tenderness, however, is not always conclusive of the absence of periostitis, especially when the latter is restricted to the deep parts of the orbit. In periostitis the eyelids are not usually so swollen as in inflammation of the orbital tissues. Suppuration may take place, necrosis in consequence of detachment of the periosteum may come on, and communications with the neighbouring cavities may be formed.

In secondary syphilis, or in later stages of the disease, a syphilitic gumma of the orbital wall may form. This is accompanied by violent frontal neuralgia or headache, increasing at night. Proptosis occurs, with marked loss of motion in the eyeball in one or more directions. This early loss of motion is a very characteristic symptom, and serves to assist in the diagnosis between gumma and other orbital tumours. It is probably due to an extension of the inflammation to the connective tissue of the orbit, and to the muscles themselves.

The symptoms suggestive of gummatous periostitis of the orbit are :—A rapidly increasing proptosis, with displacement of the globe downwards and forwards, and much loss of motion of the eye, while on palpation the sensation is given to the finger of a tumour in the roof of the orbit, where gummata most commonly are situated. Also, thickening of the upper margin of the orbit, with pain on pressure of the roof of the orbit, and radiating periorbital pain at night.

Periostitis of a chronic form, and without tendency to suppuration, occurs most commonly in persons with a constitutional rheumatic tendency. It is accompanied by pain in and about the orbit, with increased tenderness on pressure backwards of the eyeball. Exophthalmos, and all other outward signs, are usually wanting.

The Prognosis depends much on the seat of the inflammation. If this be in the deep parts of the orbit, thickening of the periosteum may cause permanent protrusion of the eyeball; extension of the inflammation to the optic nerve may result in optic atrophy; the orbital muscles, or the nerves which supply them, may be implicated, with consequent paralysis; or, finally, the inflammation of the periosteum may strike into the meninges of the brain. When the

inflammation is near the margin of the orbit, early evacuation of pus, if it have formed, reduces the process within safe bounds; and this position is one of less danger in respect of its surroundings, than if the process be deep in the orbit.

Causes.—Periostitis of the orbit may be caused by blows or other traumata, by extension from neighbouring cavities, by syphilis, or by rheumatism.

Treatment.—Warm fomentations. Exit given to pus, if possible. Constitutional treatment. Incision along the orbital margin, and separation of the periosteum, with drainage, may shorten the process, if the foregoing measures do not give relief.

Caries of the Orbit is very frequently the result of periostitis, but often commences in the bone, and in either case is usually due to tubercular disease. It is also seen in very late syphilis. A trauma is sometimes the immediate cause of its onset.

Caries may attack any part of the orbital walls, its favourite seats being the margin above and to the outside, or below and to the outside. The latter situation is a common one for tubercular disease. When it is seated deeply in the orbit, it often causes exophthalmos and pain. At the margin of the orbit it produces œdema and swelling of the eyelids, with conjunctivitis; suppuration comes on, and the abscess finally opens through the integument or conjunctiva. A fistula is apt to remain for a length of time, and, the skin being drawn into this, ectropion of the lid is produced. If a portion of dead bone come away, the resulting cicatrix is liable to maintain the ectropion (p. 566).

Treatment.—The evacuation of purulent collections at the earliest possible moment—if they be deep in the orbit, by the careful introduction of a long bistouri parallel to the orbital wall—the insertion of a drainage-tube, and the regular washing out of the cavity with antiseptic solutions, until no more rough or bare bone can be felt with the probe. If the case be very tedious, Krönlein's operation may permit of the removal of sequestra with greater ease and security.

Injuries of the Orbit.—Wounds of the soft parts in the supra-orbital region, involving the supra-orbital nerve, were formerly held to be capable of producing a reflex amaurosis (p. 387), and many such cases have been recorded under the name of supra-orbital amaurosis. But the blindness in the cases recorded was brought

about in some other way—*e.g.* injury to the optic nerve in the optic foramen by the concussion, or by a fracture of the margin of the foramen, orbital periostitis, concomitant injury to the eyeball itself, facial erysipelas, intracranial lesions, and so on.

It may be, however, that a functional amblyopia, or amaurosis, similar to that occasionally seen after long-continued blepharospasm (p. 105), has sometimes been present.

Perforating injuries, more especially of the roof of the orbit through the eyelids, by prods of walking-canes, etc., and the lodgment of foreign bodies in the orbit are serious accidents. They are liable to be followed by phlegmonous inflammation; or, if a pointed weapon (stick, sword-cane, etc.) has been pushed into the orbit with some force, it may divide the optic or motor nerves, or injure the muscles, or it may even pass through the bony wall and perforate the brain, with fatal result.

It is remarkable what large foreign bodies may be concealed in the orbit. We have removed large pieces of wood, which had lain in the orbit, in one case for weeks, in another for several months without inflammatory symptoms. In the first there was even no exophthalmos.

Hæmorrhage into the Orbit may occur from injury, and may cause exophthalmos, or atrophy of the optic nerve from pressure. Such orbital hæmorrhages are sometimes met with at birth, as the result of complicated labour, especially when the forceps has been applied. Spontaneous hæmorrhages have been observed in old people with diseased arteries, in whooping cough, in hæmophilia, and in hæmorrhagic small-pox; and sub-periostea' hæmorrhages occur in Barlow's disease.

Hæmorrhage in the Eyelids, with ecchymosis of the conjunctiva, commonly known as a black eye, is usually the result of blows with large blunt objects, such as the closed hand. The object which causes the injury is arrested by the margin of the orbit, against which the tissues are bruised, while the eye usually escapes. On the other hand, when the object is small or sharp, it enters the orbit, and injures the eyeball, and there is less tendency to external bruising.

Deep Fractures of the Orbit, in the neighbourhood of the optic foramen, may cause atrophy of the optic nerve without any other symptom. The atrophy may not appear for some weeks, hence

the necessity for a cautious prognosis in cases of head injuries. Where the optic atrophy is the result of hæmorrhage into the sheath of the optic nerve, a dark greyish red ring may be visible round the margin of the optic papilla.

Emphysema of the orbit, or of the lids, or of both, sometimes occurs from injury of the ethmoid, or from rupture of the mucous membrane of the lacrimal duct. The emphysema develops after the injury when a strong expiratory effort, such as blowing the nose, is made. Emphysema also occurs in perforation of the ethmoid from disease, and even, although rarely, without previous disease.

Treatment.—Foreign bodies should be removed by dilatation of their wounds of entrance, or by the formation of a new passage through the conjunctival fornix—and great care should be taken to prevent the onset of inflammation, or to keep it within safe bounds. A pressure bandage, and the exercise of caution when blowing the nose for a little while, is all that is required in emphysema.

* **Enophthalmos,** or sinking of the eye back into the orbit, with apparent narrowing of the palpebral fissure, occurs to a certain extent in extreme emaciation, in Asiatic cholera, in paralysis of the sympathetic, and in facial hemiatrophy. But it has been observed to an extreme degree as a result of blows on the eye, or on the lower orbital margin; and in these cases atrophy, or cicatricial contraction of the retrobulbar cellular tissue, or paralysis of Müller's muscle, from injury of the sympathetic nerve, have been held accountable for the condition. In some cases, it is due to fracture or depression of a portion of the orbital wall.

Enophthalmos is sometimes congenital; it is also present, occasionally, in intermittent exophthalmos (p. 601), when the patient is in the erect position, and after removal of retrobulbar tumours.

* **Tumours of the Orbit.**—In the *Diagnosis of an Orbital Tumour* three questions present themselves :—First, Is a tumour of the orbit present? Secondly, Is the new growth confined to the orbit, or does it extend to neighbouring cavities? and Thirdly, Of what kind is the new growth? The diagnosis as regards any of these points does not often occasion much difficulty in advanced stages of the disease, especially where the growth occupies the anterior part of the orbit, or protrudes from it. It is rather in the early and middle

stages that difficulties in diagnosis present themselves, and attention will here be mainly directed to those stages.

Exophthalmos is, of the signs by which the presence of an orbital tumour is diagnosed in its early stages, by far the most important, because it is the most constant. In the earliest stages of a growth which commences in the deepest part of the orbit there may be, it is true, no exophthalmos, while other symptoms—defects of sight, pain, loss of motion—may already be present; but when the growth attains to certain dimensions, or if in the anterior part of the orbit there be even a small tumour, the eyeball must be pushed out of its place.

An important diagnostic point in connection with the exophthalmos caused by a tumour is that, unless it be within the muscular cone, its direction is almost always oblique and not straight forwards; for orbital tumours commonly tend to develop more along some one wall of the orbit than along the others, and hence the eyeball becomes pushed towards the opposite side as well as forwards. In cellulitis, œdema of the orbital tissues, Graves' disease, and paralytic proptosis, the exophthalmos has a direction straight forwards. Tumours growing from the apex of the orbit may, in their early stages, cause no obliquity of direction in the displacement of the globe, and some tumours do not do so even in an advanced stage of their growth; but these cases are exceptional. Tumours, too, situated altogether within the muscular cone, of which the most common are tumours of the optic nerve, need not cause any lateral displacement of the globe.

Again, the exophthalmos caused by an orbital tumour usually increases in degree slowly and gradually, differing in this respect from exophthalmos due to most of the other causes, in which either a sudden or a rapid development of the proptosis is the rule.

While tumours are sometimes present in both orbits, especially lymphoma or lympho-sarcoma, yet it is infinitely more common for one orbit alone to be diseased; and hence monolateral exophthalmos is suggestive of orbital tumour.

Palpation in the Orbit often provides a valuable sign, should the new growth have come within reach in the anterior part of the cavity. In many cases, indeed, there is no difficulty whatever in recognising the presence of an orbital tumour by this means, the sensation obtainable by the tip of the surgeon's finger pressed into

the orbit being very definite; in some the tumour can only be felt when the patient is anæsthetised; but in other cases the evidence is not so clear, and a reasonable doubt may exist as to whether any abnormal resistance is met with. By palpation we may gain some knowledge of the position, extent, shape, and consistence of the tumour, and whether it be adherent, either to the walls of the orbit or to the eyeball. It is important, when practicable, to compare the result of examination of the diseased orbit with the condition of the sound orbit; and this can be done to greater advantage, if palpation of the orbits be performed simultaneously with a finger of each hand.

The Röntgen rays have been successfully employed in some cases for the diagnosis of retrobulbar growths.

Derangements of Vision are often, but by no means always, present in the early and middle stages of the growth of an orbital tumour. Their occurrence depends frequently on the rapidity of the growth of the tumour, rather than upon its size. In an early stage of a rapidly increasing tumour, the sudden stretching of, and pressure on, the optic nerve may produce absolute blindness; while in another case, with an equal degree of proptosis, but which has been brought on by a slowly growing tumour, vision may be unaffected, by reason of the optic nerve becoming gradually accustomed to the change. Yet slowly growing tumours, which spring from the optic nerve or its neighbourhood, or from the deepest part of the orbit, are competent, by direct pressure on, or by implication of the optic nerve, to cause serious loss of sight, even in an early stage, and with but little exophthalmos. Optic neuritis, and, later on, optic atrophy, are occasionally discovered with the ophthalmoscope. Diplopia is often present when the globe is at first displaced, but disappears when the exophthalmos becomes extreme or the vision defective.

Pain is a symptom sometimes, but by no means always, present in cases of orbital tumours. It is especially liable to be complained of when the growth is increasing rapidly in size, even though it may not have attained to great dimensions. The pain is then often of a neuralgic kind, and very severe, from the unaccustomed pressure on branches of the fifth nerve in the orbit.

Loss of Power of Motion of the Eyeball is a very common symptom in cases of orbital tumours. It is caused in some cases by the

mechanical obstruction offered by the tumour, as a result of which motion of the eyeball becomes defective towards the side of the orbit on which the new growth is situated. In other cases the loss of motion is caused by stretching of the muscles from the exophthalmos, or by implication of them in the new growth, or by atrophy of their tissue, or by paralysis of the orbital nerves from pressure.

When there is little or no loss of motion, while the proptosis is marked, the conclusion may be drawn that the tumour lies within the muscular cone.

In the later stages the exophthalmos may become so great that the eyelids no longer cover the eyeball sufficiently, and a purulent keratitis may set in which may end in loss of the eye. The bulbar conjunctiva below the cornea becomes œdematous, bulges forwards, and becomes covered with crusts, and the lower lid becomes everted.

In every case the history, the rapidity of growth, and the age and general condition of the patient are important items for consideration.

Diagnosis of the Nature of an Orbital Tumour.—As regards the nature of the growth which may be present, it must be admitted that in many instances, in the early stages of a deeply seated tumour, we have to rest content with an indefinite or provisional diagnosis, unless an exploratory operation, with puncture or harpooning of the mass, is practicable.

Primary tumours of the orbit may be conveniently described under the following heads :—Cysts, solid tumours, pulsating exophthalmos, symmetrical tumours, tumours of the optic nerve, and tumours of the lacrimal gland.

Orbital Cysts are usually congenital (Dermoids, Encephalocele, Serous), but may be acquired (Hydatid, Cysticercus).

Dermoid Cysts are those most frequently found. Although congenital, they do not often grow to any size until the age of puberty or later, and may then for the first time give rise to troublesome symptoms. They are smooth rounded tumours which grow slowly, and finally reach very considerable size, and then bulge out between the eyeball and margin of the orbit. Pressure upon this protruding part causes it to diminish, while the exophthalmos is at the same time increased, and distinct fluctuation in the protruding part can be felt. The growth of the cyst is unaccompanied by pain or other inconvenience. It may adhere to the periosteum and cause

bony irregularities, or even perforate the roof of the orbit. The contents are generally either serous or honey-like, and occasionally hairs and other epidermic formations have been found in them.

Hernia Cerebri, either in the form of meningocele or of encephalocele, may invade the orbit. Its most common situation is the upper and inner angle of the orbit, to which it gains access through the suture between the frontal and ethmoid bones. It appears as a fluctuating, often transparent, pulsating congenital tumour. Sometimes the opening in the bones can be felt around its base. Pressure



FIG. 226.—A case of so-called anophthalmos, with a cyst in the left lower lid.

upon it causes it to disappear, but gives rise, at the same time, to symptoms of cerebral irritation, or pressure.

A congenital tumour in the upper inner angle of the orbit must be regarded with suspicion, lest it be a cerebral hernia, even though it do not pulsate, or on pressure cause cerebral symptoms. In the large cerebral herniæ, death in the first few days of life is the rule.

Cysts with Anophthalmos.—These appear as serous cysts, which project into the lower lid, giving it a slightly bluish tinge. They are associated with so-called anophthalmos (Fig. 226), in which, in spite of the name, a small or rudimentary eyeball is always found. The cavity of the cyst frequently communicates with the interior of the eye, and contains retina more or less altered and thrown into folds. These cases are regarded as encysted colobomata

(p. 230). Other cases are believed to arise from fœtal inclusion of a portion of the lacrimal sac.

Parasitic Cysts are usually caused by the echinococcus, while the cysticercus is much rarer in the orbit. Several cases of the former have been observed in England. The cysts are generally deeply situated, and the first symptom is severe pain in the head, like hemicrania. Their growth is very slow, and the presence of a hydatid thrill is very rare. The fluid obtained by aspiration may contain hooklets or scolices.

Treatment.—The cyst should be removed *in toto*, if possible. For this purpose, Krönlein's operation (p. 609) may be resorted to. Or, a horizontal incision may be made along the orbital margin through the eyelid, in order that the cavity of the orbit may be reached ; or two perpendicular incisions at either canthus through the upper lid may be made, and the latter turned upwards. With hooks or forceps, and scalpel or scissors, the cyst wall must then be carefully separated from all adhesions. If it cannot be removed entire, as large a portion of the wall as possible should be taken away, and the contents evacuated by gentle pressure backwards of the eyeball, and the sac washed out two or three times daily with an antiseptic solution, until all discharge has ceased. The above treatment does not, of course, apply to encephalocele, which should not be interfered with.

Solid Tumours of the orbit are in most instances malignant (sarcoma, endothelioma), but may be benign (exostosis, angioma, fibroma). They vary in consistency from the softness of the angiomata, to the dense hardness of the ivory exostoses.

Exostoses occur as the result of faulty development of the bones, and also without any apparent cause, and are usually of the kind known as ivory exostoses. Three-fourths of them begin before the twenty-fifth year of age. They spring most commonly from the ethmoid or from the frontal bones, and have a broad base, but are sometimes pedunculated.

All the bony tumours give, of course, the sensation of dense hardness to the touch ; but there are some malignant growths of such hardness that it may not be easy to tell them from the osteomata by palpation. And here a Röntgen ray examination will be necessary. The growth of an orbital osteoma is excessively slow, in many instances commencing in infancy, and lasting into advanced

life. In addition to the dense hardness of these tumours, the deciding points in the diagnosis are their smooth, usually globular, and somewhat nodulated surface, along with their immobility, and direct connection with the walls of the orbit, all ascertainable by the touch.

Operative interference, in cases of exostosis of the orbit, is only justifiable when the tumour does not grow from the roof of the orbit (as it then often involves the cranial cavity), and when there is reason to think that it is attached to the orbital wall by a narrow base or pedicle. Several instances are on record in which the growth has become spontaneously separated by necrosis of its pedicle. Beyond destruction of the eyeball there is no danger associated with these tumours, even if their growth take an intracranial direction; but they cause serious disfigurement, and often much pain.

Angiomata may be simple or cavernous. They are usually soft, compressible, and painless, are very slow in their growth, and do not give rise to pulsation or bruits. The teleangiectases, or simple tumours, are usually congenital, and are often merely extensions into the orbit of angiomata of the eyelid. The cavernous form is often encapsuled. A few cases of lymphangioma have also been met with in the orbit.

Sarcoma.—Malignant tumours of the orbit are nearly always sarcomata, many different varieties of which are met with. Sarcoma may develop in the connective tissue in any part of the orbit, most frequently, perhaps, in the periosteum and in the connective tissue about the lacrimal gland. Or it may arise from the endothelium of the vessels (endotheliomata), and if very vascular, it may pulsate, but without a murmur. These malignant tumours, after destruction of the eyeball by pressure, or by phthisis following ulceration of the cornea, attack the bony walls of the orbit and its surroundings.

The early extirpation of the tumour with complete evisceration of the orbital contents affords the only prospect, and that a slight one, of saving the patient's life.

Some forms of sarcoma, however, are non-malignant, especially those which lie free in the orbit and arise from the connective tissue. Indeed, Panas held that many cases of sarcoma, as also of lymphadenoma of the orbit, are due to infectious principles, toxins, or microbes, and are amenable to medical treatment by mercury, iodine, arsenic, or toxitherapy. So much certainly must be admitted—namely, that

cases now and then present themselves, with all the signs and symptoms of orbital tumour, which ultimately undergo a purely spontaneous cure, or one unexpectedly brought about by iodide of potassium.

Attention has recently been drawn to these pseudo-tumours by Birsch-Hirschfeld. In some cases no tumour is found in spite of the existence of exophthalmos, etc., while in others a chronic inflammatory condition of the connective tissue alone exists. We have ourselves seen a large sarcoma-like orbital tumour, which, on removal, proved to be merely a mass of inflammatory tissue.

Carcinoma of the orbit, unless originating in the lacrimal gland, is always secondary to carcinoma elsewhere in the body. We have seen it occur after removal of a carcinoma of the breast.

Symmetrical Tumours of the Orbits.—With the exception of tumours of the lacrimal glands, and possibly of rare instances of metastatic tumours, symmetrical tumours of the orbits are almost invariably lymphomata or lymph-adenomata, occurring in leucæmia or in pseudo-leucæmia.

Pulsating Exophthalmos.—This is most frequently due to arterio-venous aneurism in the cavernous sinus, which may be either traumatic or spontaneous. The symptoms are : proptosis ; the presence of peculiar bruits, which can be heard with the stethoscope over the orbit, and usually, also, over a more or less extensive portion of the skull ; engorgement of the veins of the eyelids ; pulsation, apparent in the eyeball, or at some point of the orbital aperture, and often a thrill which can be felt with the fingers placed on the upper lid. The pulsation and thrill may be diminished or abolished by pressure on the common carotid. The two latter symptoms are occasionally absent during the whole, or part, of the progress of the case. There may be retinal venous engorgement or even papillitis with defective vision. The same symptoms may be exceptionally caused by aneurism of the carotid in the cavernous sinus, aneurism of the ophthalmic artery at its origin or in the orbit, and by cirsoid aneurisms, or by very vascular malignant tumours. It is also possible that obstruction of the cavernous sinus from other intracranial causes may produce these symptoms.

Hæmorrhage is liable to prove fatal in these cases.

Treatment.—Ligature of the common carotid affords the best prospect of cure. Digital compression of the same vessel has pro-

duced cure in some cases. Spontaneous cure has been observed occasionally in cases of arterio-venous aneurism.

Intermittent Exophthalmos.—This is due to a varicose condition of the veins of the orbit. The exophthalmos only occurs on stooping, or on exertion, and can be produced by compression of the jugular vein in the neck. In the erect position there is often enophthalmos. Sometimes dilated veins are visible in the eyelids.

Tumours and cysts of the lacrimal gland also occur in the orbit (see p. 584).

Tumours of the Optic Nerve.—These are rare affections. They occur at all times of life, but the majority of the patients are under twenty years of age. The tumour usually commences about the middle of the course of the nerve, and does not reach the bulbar end. The symptoms are :—Slowly increasing protrusion of the eyeball, in a direction most usually directly forwards, or forwards and outwards (Fig. 227). The motions of the eyeball are not greatly restricted, and the centre of its rotation is not displaced, owing to the tumour being within the cone of the orbital muscles. The proptosis is unaccompanied by pain. The sight becomes very defective, or is quite lost at a very early stage, from interference with the functions of the nerve by the tumour or by the optic neuritis, or optic atrophy, to which it gives rise. The tumour is sometimes very soft, so that the eyeball can, as it were, be pushed back into it, and the pressure does not cause pain. The pupil reacts consensually. The tumour may often be felt by palpation in the orbit. The patient's health does not suffer.

The diagnosis between a new growth of the optic nerve and one of its sheath can hardly be made with certainty ; but the existence of fairly good vision, while other symptoms are as above described, long after the proptosis has appeared, would point to the sheath as the seat. Such a diagnosis is important, for it may be possible to remove, by Krönlein's operation, a tumour of the sheath of the optic nerve, while preserving not merely the eyeball, but good vision as well.

These tumours are either fibro-sarcomata (fibromatosis), or, less frequently, endotheliomata, and are usually intra-dural, i.e. encapsuled by the sheath of the nerve. Extra-dural tumours are more rare. Both varieties are benign, in the sense that they do not lead to glandular enlargements or to metastases, and they never

spread to the eyeball although the extra-dural tumours often surround the posterior half of the globe; but in some cases death occurs from extension of the disease to the cranial cavity, or from the sudden development of intracranial growths, which coexisted with the optic nerve tumour. An intracranial complication may occur many years after removal of the tumour of the nerve. Local recurrence is less common, but in one case a recurrence took place in the orbit twenty-six years after operation.



FIG. 227.—Tumour of the Optic Nerve.

Treatment.—To remove these tumours three methods are available, namely :—(1) Removal of the eyeball with the tumour; (2) Krönlein's operation, by means of which the optic nerve tumour, probably in the majority of cases, may be removed without the eyeball; and (3) Knapp's operation—also for removal of the tumour without the eyeball. It is unnecessary to describe the first of these procedures, which follows very much the lines of an ordinary excision of the eyeball, except that the optic nerve is divided as far back in the orbit as possible. Krönlein's operation is described on p. 609.



FIG. 228.—The same patient as in Fig. 227 after Krönlein's operation.

Knapp's operation is as follows :—The tendon of the internal rectus is divided so as to leave a portion adherent to the sclerotic of about 5 mm., the cut end being secured by a suture passed through it, to prevent it from retracting into the orbit. The eyeball is then forcibly everted outwards, strong scissors are passed into the orbit, and the optic nerve is divided as close to the optic foramen as possible. The globe is now further everted outwards, to expose its posterior surface with the tumour attached, and the latter is removed by dividing the optic nerve close to the eyeball. Finally, the eyeball is reposed,

the cut ends of the tendon of the muscle united, and the opening in the conjunctiva closed. A drawback to this operation is, that it is not always possible to be certain that the deep portion of the tumour is reached with the scissors.

Lagrange passes a ligature or loop over the tumour, divides the nerve as far back as possible, draws the tumour out, and thus exposes the back of the eyeball, from which the tumour is then removed. Fig. 227 represents a case of tumour of the optic nerve and Fig. 228 the same case after operation by Krönlein's method.

Implication of Neighbouring Cavities.—As regards the question whether the tumour be confined to the orbit, or involve one or more of the neighbouring cavities, it may be assumed that it is confined to the orbit, unless there are symptoms or signs which point in the opposite direction ; and in each case these symptoms and signs ought to be sought for. Tumours may either originate in one of these spaces and grow into the orbit, which is the more common event ; or, originating in the orbit, they may spread to a neighbouring space ; and it is often the history or progress of the case alone that can inform us which of these events has taken place.

When disease (mucocele, empyema, tumour) of the accessory sinuses of the nose involves the orbit, the symptoms which ensue may be due to the effect of the pressure exerted by the over-distended sinus, or to septic infection, or to a combination of these. The pressure effects are produced by the formation of a tumour-like projection of some portion of the orbital wall corresponding with the position of the affected sinus. This leads to displacement of the eyeball with exophthalmos and limitation of movement, and the sight may be impaired or lost from optic neuritis, or from atrophy of the optic nerve. If the sphenoidal, or posterior ethmoidal sinus be diseased, impairment of vision in one or both eyes may be the only symptom in the early stage. This is due to the fact, that the inner boundary of the optic canal sometimes forms a portion of the wall of these sinuses, and may be extremely thin on one or both sides, thus rendering the optic nerve particularly vulnerable. The nerve generally shows signs of inflammation or atrophy, but on the other hand it may be normal, as in retrobulbar neuritis from other causes (p. 343), and the defect of vision may only reveal itself as a central scotoma, or as an enlargement of the blind spot.

If septic infection take place, orbital cellulitis and its conse-

quences (p. 588) result. Infection is usually preceded by perforation of the orbital wall, but it may be carried into the orbit by emissary veins, or through small foramina, or congenital dehiscences in the bony walls.

Mucocele or empyema is sometimes indicated by a history of influenza, or post-nasal catarrh, followed by purulent discharge from the nose. In all cases, a careful examination of the nose ought to be made, aided, if necessary, by transillumination and the Röntgen rays. It should be remembered, however, that empyema of a sinus, with implication of the orbit, may sometimes exist without any appearance of nasal disease, if the channel of exit from the sinus be completely occluded.

In general, it may be stated that inflammation of the frontal and anterior ethmoidal sinuses gives rise to œdema and swelling of the lids, periostitis of the orbit, or peri-dacryocystitis; while disease of the posterior ethmoidal and sphenoidal sinuses is more apt to cause retrobulbar neuritis, optic neuritis or atrophy, or paralyses of orbital muscles.

The Frontal Sinus.—This sinus begins to form at about the seventh year of age, and continues to increase in size from that time onwards. Disease of this sinus, therefore, is only met with in adults. It frequently extends to the ethmoid, and sometimes leads to maxillary empyema. There may be some redness and swelling at the inner extremity of the eyebrow, with tenderness on percussion, and the patient sometimes suffers from paroxysmal attacks of frontal neuralgia, often worse in the morning; but again in this, as in the case of other sinuses, the pain may be diffuse, and not in any way characteristic. Œdema of the upper lid may be the only symptom of a frontal sinusitis. We have been consulted by patients, in one case for an œdema of the upper lid, and in another for morning ptosis, and in both cases the symptoms were the result of frontal sinus disease. A tumour then forms at the upper and inner angle of the orbit, and displaces the eye downwards and outwards. In some cases a fistula appears above the position of the lacrimal sac, and fluid may appear in the nostril on syringing it. Rarely, a frontal mucocele may form a subperiosteal collection in the roof of the orbit, and point at the outer side of the latter, as in a patient under the care of one of us. Osteoma of the frontal sinus shows itself as a slowly growing and

densely hard tumour, almost free from pain, situated along the superior margin of the orbit, extending into the latter and pushing the eyeball downwards and forwards. It may subsequently extend to the orbital plate of the ethmoid, and may be mistaken for an exostosis of the orbit. Bony growths originating in the orbit may invade the frontal sinus, and, whether originating there or in the sinus, are liable to produce absorption of the tables of the skull without any cerebral symptoms to indicate the occurrence.

The Ethmoid Cells.—Tumours of these cells, which encroach upon the orbit, are likewise most commonly either mucocele (empyema) or osteoma. Mucocele of the ethmoid cells presents itself in the orbit as a smooth hard tumour, on the inner wall of the orbit, giving rise to displacement of the lacrimal bone (with, perhaps, a sense of fluctuation and crepitation on palpation), and pushing the eyeball outwards and forwards. Epiphora may be an early symptom. There is sometimes a feeling of pressure on the bridge of the nose. Nervous symptoms, such as mental dullness, hypochondriasis, etc., may be present. Mucocele of the ethmoid cells encroaching on the orbit must also be distinguished from a dermoid cyst (p. 596). Osteoma of the ethmoid appears in the orbit as a hard round swelling at the inner canthus, followed by a swelling of the cheek and displacement of the eye outwards and forwards. It is apt also to extend into the nasal meatus, displacing the septum, and pushing the hard palate downwards, so that examinations of the nose and of the mouth should be made in aid of the diagnosis. Enchondromata and fibromata, too, sometimes spring from the ethmoid, and extend into the orbit, and malignant growths may be met with here.

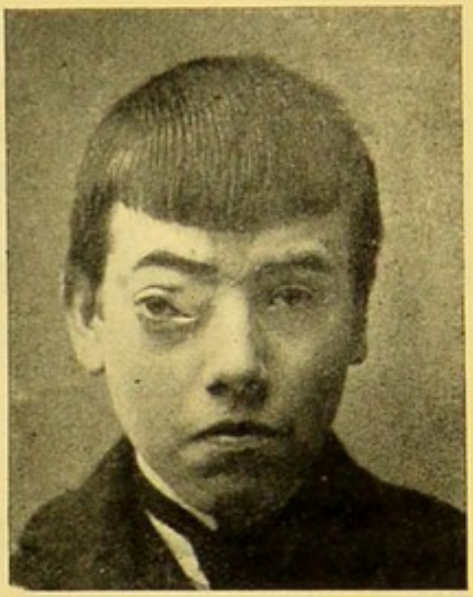


FIG. 229.—Anterior Ethmoidal Mucocele.

The Sphenoid Bone and Antrum of the Sphenoid.—Tumours originating here and encroaching upon the orbit are rare, and the diagnosis of their origin in an early stage may be impossible, except by radiography. They may cause pain in the occipital

region, and, as stated above, optic atrophy may be an early symptom. It is said (Stedman Bull) that an orbital tumour which soon causes blindness, commencing in the temporal side of the field, and leaving the fixation point unaffected to the last, while at the same time a growth appears in the naso-pharynx, is likely to be one having its origin in the sphenoid antrum. Bony tumours—osteoma, hyperostosis, and exostosis—polypi, and sarcomata, are the growths most frequently found to originate in the sphenoid antrum.

The Maxillary Antrum.—Tumours of the antrum sometimes push the floor of the orbit upwards, or erode it, and grow into that cavity, driving the eyeball upwards and inwards, or upwards and outwards. The breadth of the cheek is increased, the nose becomes pushed towards the opposite side, and the roof of the mouth is pushed downwards. Tumours of the antrum of Highmore sometimes cause pain in the teeth, or in the region of distribution of the infra-orbital nerve, and there may be a dull pain in the region of the antrum. In some cases there is a discharge of pus or of blood from the nostril. Empyema of the antrum may give rise to orbital cellulitis commencing at the lower part of the orbit, with swelling of the lower lid, and chemosis of the conjunctiva below the cornea.

We have seen two cases of malignant disease, one of the maxillary antrum, and the other in the nasal fossa, in which epiphora was the first symptom complained of by the patient.

Intracranial Tumours do not often invade the orbit. When they do so they originate in the middle fossa, and gain access through the sphenoid fissure and optic foramen. The diagnosis of the origin of the disease can only be made, if cerebral signs or symptoms, including defects in the field of vision, have existed prior to any sign of a new growth in the orbit. Tumours of the pituitary body may encroach upon the orbit by way of the sphenoid fissure, and are apt to be associated with polyuria and bitemporal hemianopsia, which assist the diagnosis.

A more common event, although not in an early stage of the growth, is the extension of a primary orbital tumour to the brain, either along the optic nerve, through the sphenoid fissure, or through the roof of the orbit by erosion of the bone. This occurrence is usually indicated by the presence of cerebral symptoms ; but cases have been met with where no such symptoms existed, although

the orbital growth had encroached upon the anterior or middle fossa of the skull.

* **Shrinking of the Conjunctiva (Xerophthalmos) and of the Sub-conjunctival Tissue of the Orbit, subsequent to Enucleation of the Eyeball.**—In some cases where the eyeball has been excised, and in due course a prothesis fitted, the conjunctiva and sub-conjunctival tissues shrink to such a degree, after some months or years, as to reduce the size of the orbital cavity so that the wearing of a glass eye becomes impossible. This is especially liable to occur amongst those hospital patients, who are careless in removing the prothesis at night, and in keeping the socket thoroughly clean at all times. The attempt is then often made to restore the orbital cavity, so as to render it possible to wear at least a small glass eye, by means of skin grafts, or of mucous membrane grafts, after the method either of Thiersch or of Wolfe. The success attendant on these procedures is usually a very moderate one, and often not permanent, owing to subsequent renewed shrinking of the sub-conjunctival tissue.

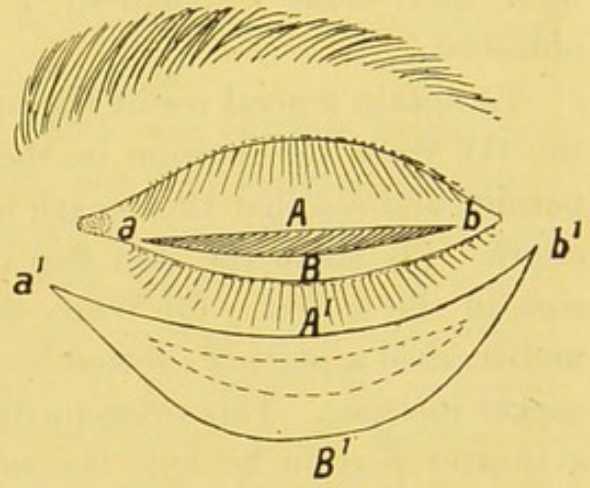


FIG. 230.

In these cases the lower sulcus is the most important part of the cavity, and if it can be made sufficiently deep, a small artificial eye will be retained. With this object in view, Mr. P. W. Maxwell, of Dublin, has devised the following operation (Fig. 230) :—

An incision is made in the floor of the socket, and carried downwards behind the lower lid. A semi-lunar flap, about 8 mm. in width at its widest part, is marked out on the skin of the lid, its upper concave border being about 5 mm. below the palpebral margin. The incision along the upper border of the flap is made to communicate with the bottom of the wound in the socket. The flap is now dissected up from the subcutaneous tissue, except an area represented by the dotted line in Fig. 230. The two ends of the flap (a' and b') are passed through the opening into the socket, and sutured to each end of the socket incision (a and b) ; and the

borders A' and B', being also passed through, are sutured to A and B respectively. The space on the cheek is closed, and the operation completed by inserting into the socket a temporary glass eye or shell. This should be as nearly as possible of the size and shape of the eye to be ultimately worn ; it prevents the new sulcus from being obliterated by contraction, and gives it a suitable shape. It cannot safely be taken out for at least a week, as the skin incision might perhaps be opened in so doing. If there be secretion, the space behind may be flushed out by a lacrimal syringe armed with a fine curved nozzle, which can be introduced under the edge of the eye at the inner or outer canthus. A glass shell with a hole in front is preferable to a glass eye, for it allows a syringe to be more easily used, and, being transparent, a view of the parts behind can be obtained.

To obtain a good result the following points should be attended to : (1) Make the incision in the socket as long as the space will permit, and see that this length is maintained throughout its entire depth. (2) Make the skin flap considerably longer than the incision in the socket. (3) When dissecting up the skin flap, leave undisturbed a portion (dotted line in figure) equal in length to the socket incision. This subsequently forms the fornix, or sulcus. If a shorter portion be left, the sulcus is apt to become V-shaped, which would require a specially made glass eye. (4) When closing the space on the cheek, as the lower border is longer than the upper, great care should be taken to equably distribute the excess, so as to avoid puckering. When this has been neatly done, the line upon the face becomes quite invisible after a few months.

In none of the cases, so far, has it been necessary to make a sulcus above. The same operation could, however, be performed on the upper lid, provided that, after dissecting up both the borders of the skin flap, the tendon of the levator were secured with one or two sutures before dividing it. After the skin flap is in its new position, the cut end of the levator could be attached to the tarsus. In closing the skin wound, the ends of these deep sutures should be allowed to project outwards, so that they may be pulled out when they ultimately become loose. If it were possible to obtain thoroughly aseptic catgut, the ends of the sutures might be cut short and buried.

In addition to providing a sulcus, the operation adds half the

width of the flap—viz. 4 mm. to the vertical diameter of the socket.

If there be much cicatricial contraction, the above operation is not sufficient, and it is better to transplant skin flaps (dermal or epidermal) from the arm to the spaces made by freeing the lids. The dissection of the lids should be deep, and all fibrous bands should be thoroughly divided. Either of two plans may be adopted. In the first, the conjunctiva is dissected from the lid margin, and the island of mucous membrane thus formed furnishes the covering for the central, or apical portion of the new socket, while the lids and artificially made fornices are clothed with the flaps from the arm. Or, secondly, the conjunctiva may be divided horizontally in the centre, and dissected up, except where it covers the tarsus; and the skin flaps may be used to cover the back of the orbit, and posterior surfaces of the newly made fornices.

The great difficulty in all these operations consists in keeping the flaps in close apposition with the soft and yielding tissues of the orbit, and therefore it is necessary to support the flaps, and retain them in position, with some solid material, such as gutta-percha or lead, which can be cut and moulded to fit the orbital cavity and fornices. The flaps may, if necessary, be wrapped round the artificial support, raw surface outwards, and fastened to it with sutures. After the insertion of the flap and shell, the edges of the lids are temporarily sewn together, and opened again in about a week.

Grünert adopts the first method, and then divides the outer canthus and frees both lids, so that they can be fully everted. The lids are then well everted, and sutured respectively to the brow and cheek. The skin flaps are thus easily applied, and good contact can be ensured by pressure of a bandage. After a couple of weeks the lids can be replaced, and the outer commissure re-united.

* **Temporary Resection of the Outer Wall of the Orbit (Krönlein's Operation).**—This operation was devised by the late Professor Krönlein, of Zürich. It is well suited for the removal of tumours of the optic nerve, and other new growths and cysts in the posterior part of the orbit, as well as foreign bodies, without sacrificing the eye-ball, or perhaps even the sight. It may also be employed to reach purulent foci in the orbit, and has been used to remove some of the retrobulbar fat in cases of exophthalmic goitre.

The eyebrow and the scalp in the temporal region are shaved, and the skin of the whole region of the operation is rendered aseptic.

The First Stage of the operation consists in making a curved incision on the temple through the skin and soft parts. This incision commences on the temporal ridge, at a point where the latter would be intersected by a horizontal line running 1 cm. above the supra-orbital margin. The middle point, or apex, of the incision lies in the centre of a horizontal line, which unites the external canthus with the outer orbital margin. The end of the incision lies on the zygoma, in the centre of a horizontal line uniting the external canthus with the tragus. The length of the incision in adults is 6 to 7 cm., and the direct distance between its two ends is about 5 cm. Smaller incisions are inconvenient. In that portion of the incision which runs along the margin of the orbit it goes to the bone, through the periosteum.

The Second Stage consists in raising the periosteum from the inner surface of the outer wall of the orbit with a slightly curved and somewhat pointed elevator, which is introduced at the exposed outer orbital margin. The periosteum is separated upwards as far as 1 cm. above the fronto-malar suture, downwards as far as the spheno-maxillary fissure, and posteriorly until well behind the spheno-zygomatic suture. This proceeding is not difficult, as the periosteum is closely adherent along the orbital margin only, and at the sutures. The point of the elevator is now passed directly downwards, and carefully introduced into the spheno-maxillary fissure a few millimetres behind the sphẽno-zygomatic suture. The handle of the instrument is then turned over gently towards the nose, thus pressing the periosteum and all the contents of the orbit somewhat inwards, and exposing the bared inner surface of the outer orbital wall. The object of passing the point of the elevator into the spheno-maxillary fissure—where it remains during the next stage of the operation—is to fix the point towards which the osseous incisions are to be made to converge. Some surgeons prefer to omit this act, and the proximity of the infra-orbital nerve, and of the infra-orbital vessels, must be borne in mind.

The Third Stage includes the resection of the bony wall by three incisions, two horizontal and one oblique. The upper horizontal bony incision is made with a thin, sharp chisel, which should divide the external angular process of the frontal bone close to its base.

The soft parts having been previously drawn aside, the periosteum over the seat of the proposed bony incision is divided, and the orbital periosteum and the lacrimal gland are drawn aside.

The oblique bony incision passes from the deepest part of the previous incision downwards and backwards behind the spheno-maxillary suture, through the greater wing of the sphenoid bone, to a point about 1 cm. behind the anterior end of the spheno-maxillary fissure, where the point of the elevator has been kept all through.

The lower horizontal bony incision divides the frontal process of the malar bone close to its base, the soft parts having been drawn aside, and the periosteum divided. The incision ends at the anterior extremity of the spheno-maxillary fissure.

In making the bony incisions there is the danger of splintering to be contended with, and in the oblique incision there is some danger of luxating the spheno-maxillary suture. The chisel must be very sharp and thin, and it is well to apply its corner rather than its full edge to the bone, while only light taps with the mallet are used. It is important to make the bony incisions in the above order ; or, at any rate, the oblique incision should not be the last to be made, for, if it be, the thin outer wall of the orbit is liable to become severely splintered during the chiselling of the second bony process.

The Fourth Stage is the turning backwards of the flap of bone and soft parts, and the exposure of the interior of the orbit. After the flap has been turned well back, the separated periosteum is divided with blunt-pointed scissors, from before backwards. It is sometimes necessary, in order to reach the focus of disease, to divide the tendon of the external rectus near its sclerotic insertion, and possibly other orbital muscles must be severed ; but this should be avoided, if possible.

When all manipulations required in the orbit have been completed, any muscles which may have been divided are sutured to their insertions, the periosteum is replaced in its normal position, the flap of bone and soft parts turned forwards into its place, and secured there by a few catgut sutures through the periosteum. A drain is then placed in the lower part of the wound, and the rest of the wound is accurately closed with fine silk sutures, and an aseptic dressing and bandage applied. The catgut sutures through the periosteum, and the drain, are regarded by several operators as unnecessary.

We have performed the operation for tumours of the optic nerve (Fig. 228), and other tumours of the orbit, for a mucocele of the frontal sinus which extended out under the roof of the orbit, and for diagnostic purposes in a case of pulsating exophthalmos, and have found it very satisfactory. The resulting scar is not disfiguring (Fig. 228).

Exophthalmic Goitre (Graves' Disease, Basedow's Disease).

Symptoms.—The three cardinal symptoms of this disease are: increased rapidity of the heart's action, which may reach two hundred beats per minute; tumefaction of the thyroid gland; and exophthalmos, which is nearly always bilateral. Of these the cardiac symptom is the most constant, and usually the first to appear; either, or both of the others, may be wanting. There is often also great emaciation (Fig. 231), with outbursts of sweating and diarrhœa. A venous murmur may be heard in the neck, and a thrill can often be felt over the enlarged thyroid. In females there is very commonly irregularity or suppression of menstruation.

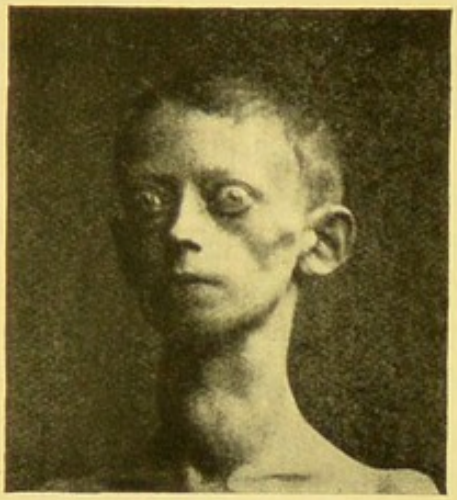


FIG. 231. — Exophthalmic goitre, accompanied with great emaciation, in a young lad.[1]

The disease, which is much commoner in women than in men, has been observed at all ages, but is most common in early adult life.

Von Græfe's Sign is a very early, tolerably constant, and almost pathognomonic one: it consists in an impairment of the consensual movement of the upper lid in association with the eyeball. When, in the normal condition, the globe is rolled downwards, the upper eyelid falls, and thus its margin is kept throughout in a constant relation to the upper margin of the cornea. In Graves' Disease the descent of the upper lid does not take place, or does so imperfectly; and, consequently, when the patient looks down, a zone of sclerotic becomes visible between the margin of the lid and the cornea. This

[1] We are indebted to Dr. Martin Dempsey for the photograph of this patient.

symptom is often present prior to any exophthalmos, and hence its great diagnostic value. It may also continue after the latter disappears—although it is perhaps more common for it to disappear before the proptosis—and it is not seen, or but very rarely so, in protrusion of the globe from other causes. But the sign is not so absolutely pathognomonic as it was held to be by von Græfe; for it may be absent in Graves' Disease, although very rarely so, in the early stages, and it is sometimes present in other diseased states, and even in health.

Stellwag's Sign, namely, incompleteness and diminished frequency of the act of involuntary nictitation, is also very constant. This act occurs sometimes only once in a minute: or several rapid nictitations take place, and then a lengthened pause. The nictitation each time is incomplete, the margins of the lid not being brought together. The result may be that the lower third of the cornea becomes covered with pannus vessels, owing to the constant exposure; for even during sleep the eyelids remain partially open.

Dalrymple's Sign consists in an abnormal widening of the palpebral aperture, due to retraction of the upper eyelid. It is this gaping of the eyelids which gives the characteristic staring aspect to the patient. This sign is often erroneously attributed to Stellwag, or is included in his sign.[1]

Insufficiency of convergence has been observed by Moebius and is called Moebius' Sign, but it is not always present and is, we think, merely indicative of general nervous debility, and not of importance as a sign of Graves' Disease.

Probably the first three 'signs' are due to the one cause—namely, loss of power in the orbicularis, rather than over-action of the levator.

Spontaneous pulsation in the retinal arteries is said to occur, but it is exceptional. The vision—unless when corneal complications supervene—and the condition of the pupil are unaffected by the disease. In some cases there is an increased flow of tears, but most of the patients complain of a dryness of the eyeballs. The sensi-

[1] Other conditions which produce widening of the palpebral aperture or "Staring Eye," are:—(1) Orbital Tumour (mechanically). (2) Stimulation of the Cervical Sympathetic. (3) Cocaine (in slight degree, probably by reason of 2). (4) Women after child-birth (hysteria). (5) In tetanus (spasm of occipito-frontalis). (6) In complete amaurosis.

bility of the cornea is diminished. Ulcers of the cornea are not common, but are said (von Græfe) to be more frequent in men than in women. The exposure of the eye and dryness of the cornea are the chief causes of ulceration, when it occurs; but Sattler inclines to the belief that it is also largely due to paralysis of the nervous supply of the cornea.

The patients are often hysterical; and even marked psychical disturbances have been noted, such as a peculiar and unnatural gaiety, rapidity of speech, and great irritability; or, on the other hand, extreme depression, and even attempts at suicide have been observed. Also loss of memory and inability to make a mental effort. The motions of the eyeball have in some cases been defective—a fact for which the exophthalmos does not account. Well-marked muscular tremors are frequently present and Trousseau's Cerebral Macula is often seen.

The Progress of the Disease is, as a rule, very chronic, extending over months or years, but liable to fluctuations in the intensity of its symptoms. A few cases have been recorded in which it became fully developed in the course of some hours or days. After a lengthened period, and many fluctuations, the symptoms usually slowly disappear. Occasionally a slight permanent swelling of the thyroid may remain, and very often more or less exophthalmos. About 12 per cent. of the cases go from bad to worse, and end fatally from general exhaustion, organic disease of the heart which may have come on, cerebral apoplexy, hæmorrhage from the bowels, or gangrene of the extremities.

Causes.—Anæmia and chlorosis are general conditions very often present, as are, also, irregularities of menstruation; but it is probable that the latter should be regarded rather as a concomitant symptom than as a cause. Severe illnesses are recorded as having gone before the onset in many cases, and also excessive bodily or mental efforts. Great sexual excitement has been known to be followed by Graves' Disease, and depressing psychical causes are not unfrequent forerunners of it. In many instances, however, the patients have been perfectly healthy, and no cause could be assigned.

The Enlargement of the Thyroid is due in the first instance to dilatation of its vessels; but in a late stage hypertrophy of the gland tissue may be produced, and increase of its connective tissue, and even cystic degeneration. The Exophthalmos is due to hyper-

æmia of the retro-bulbar orbital tissues, as is demonstrated by a vascular bruit often present, and the fact that steady pressure on the globe diminishes the protrusion. Hypertrophy of the orbital fat may be found *post mortem*, but it is, doubtless, secondary to the hyperæmia.

With regard to the nature of the disease, very many theories have, from time to time, been put forward. It is most probable that the disease is due to the excessive or altered secretion of the thyroid gland.

Treatment.—A principal part of this consists in the careful regulation of the patient's general health and functions. Freedom from mental anxiety and excitement, regular hours, much resting with moderate exercise on the flat, and change of air are the most important items.

The fluctuations, which occur in the intensity of the symptoms, render it difficult to arrive at definite conclusions with regard to the efficacy of remedies, a vast number of which have been tried and lauded from time to time. In mild forms of the affection, and especially if the anæmia be well marked, iron internally is beneficial, but in severe cases it has the opposite effect. Quinine in moderate doses has been employed with benefit in some cases. Trousseau recommended digitalis in large doses, but its effect must be watched. The beneficial action of iodide of potassium in ordinary goitre has suggested its use in this disease ; but under its influence the symptoms are sometimes aggravated, and it is doubtful whether they are ever relieved by it. Aconite has been praised highly, and so has belladonna. Ergotin internally has been tried, and with advantage in some instances. Sattler warmly recommends a well-regulated hydropathic treatment, when the patient is not too excitable. Paroxysms of cardiac palpitations, etc., are best combated by ice applied to the head, heart, and goitre. The sympathetic theory has induced the trial of a galvanic treatment of the cervical sympathetic. Thyroid extract has proved beneficial in some cases, also antithyroidin and the milk of thyroidectomised goats.

Gauthier recommends antipyrin before everything else. Extract of the thymus gland has been occasionally employed, and with encouraging results.

Partial extirpation of the thyroid has been performed in recent years with success in some cases.

The great number of remedies which have been proposed for the disease demonstrates its intractable nature. Yet a considerable proportion of the cases do undergo cure, in so far as quieting of the heart's action, and reduction, or, possibly sometimes, complete disappearance, of the goitre and exophthalmos, are concerned. It is common, however, even in the best recoveries, to see some exophthalmos remain permanently.

In cases where the exophthalmos is so great that the cornea is exposed even during sleep, it is desirable to perform tarsoraphy (p. 554); and the same operation is indicated when, the disease having subsided, the exophthalmos still remains to a degree which gives the patient a disagreeable expression.

APPENDIX.

REGULATIONS AS TO DEFECTS OF VISION WHICH DISQUALIFY CANDIDATES FOR ADMISSION INTO THE CIVIL, NAVAL, AND MILITARY GOVERNMENT SERVICES, THE ROYAL IRISH CONSTABULARY, AND THE MERCANTILE MARINE.

Candidates for Commissions in the Army (including the Royal Army Medical Corps) and Special Reserve.—Squint, or any morbid condition of the eyes or of the lids of either eye liable to the risk of aggravation or recurrence, will cause the rejection of the candidate.

The examination for determining the acuteness of vision includes two tests: one for distant, the other for near vision. The Army Test Types will be used for the test for distant vision, without glasses except where otherwise stated below, at a distance of 20 feet: and Snellen's Optotypi for the test for near vision, without glasses, at any distance selected by the candidate. Each eye will be examined separately, and the lids must be kept wide open during the test. The candidate must be able to read the tests without hesitation in ordinary daylight.

A candidate possessing acuteness of vision, according to one of the standards herein laid down, will not be rejected on account of an error of refraction, provided that the error of refraction, in the following cases, does not exceed the limits mentioned, viz.: (*a*) in the case of *myopia*, that the error of refraction does not exceed 2·5 D; (*b*) that any correction for *astigmatism* does not exceed 2·5 D; and, in the case of myopic astigmatism, that the total error of refraction does not exceed 2·5 D.

Subject to the foregoing conditions, the standards of the minimum acuteness of vision with which a candidate will be accepted are as follows:—

Standard I.

Right eye.	*Left eye.*
Distant vision.—V = 6/6.	V = 6/6.
Near vision.—Reads 0, 6.	Reads 0, 6.

STANDARD II.

Better eye.	*Worse eye.*
Distant vision.—V = 6/6.	V, without glasses, = not below 6/60; and, after correction with glasses, = not below 6/24.
Near vision.—Reads 0, 6.	Reads 1.

STANDARD III.

Better eye.	*Worse eye.*
Distant vision.—V, without glasses = not below 6/24; and, after correction with glasses, = not below 6/6.	V. without glasses, = not below 6/24; and, after correction with glasses, = not below 6/12.
Near vision.—Reads 0, 8.	Reads 1.

In Standard III., the standard for the test for distant vision, without glasses, for officers of the Special Reserve, will be not below 6/36.

Inability to distinguish the principal colours will not be regarded as a cause for rejection, but the fact will be noted in the report and the candidate will be informed.

The degree of acuteness of vision of all candidates for commissions (including preliminary examinations) will be entered in their reports in the following manner:—

Sufficient	Right eye V = ...	Reads.....
	Left eye V = ...	Reads.....
Defective	Right eye V = ...	Reads.....
	Left eye V = ...	Reads.....

No relaxation of the standard of vision will ever be allowed.

Recruits for all Arms of the Military Service.—In examining a recruit's vision he will be placed with his back to the light, and his visual acuteness will be tested by means of test types placed, in ordinary daylight, at a distance of six metres (20 English feet) from the recruit.

Each eye will be tested separately:—

(*a*) If a recruit can read D = 24 at 20 feet, or better, with each eye without glasses, he will be considered "**FIT.**"

(*b*) If he can read D = 6 at the same distance with one eye, without glasses, and not less than D = 36 with the other eye, without glasses, he will be considered "**FIT.**"

The foregoing is the standard test of vision for all arms of the service, with the exception of the Corps of Army Schoolmasters, for which a candidate will be accepted if the examining medical officer is satisfied that his vision, with or without glasses, is good.

The visual acuity of each eye in the case of approved recruits will be entered on the medical history sheet.

The Royal Navy.—Candidates for Naval Cadetships must possess full normal vision (Emmetropia, and V = 6/6) as determined by Snellen's tests, each eye being separately examined.

For candidates for other branches of the Royal Navy, full normal vision is not required, but any defect of vision must be due to errors of refraction which can be corrected to normal by glasses, and vision without glasses must in any case be not less than 6/60 with each eye, and the candidate must also be able to read D = 0, 6 of Snellen's test types. A candidate is disqualified by any imperfection of his colour sense.

Strabismus, any defective action of the orbital muscles, any derangement of the lacrimal apparatus, or any chronic disease of the eyes or eyelids disqualifies.

For candidates for the seaman class (including boys and youths), marines (excluding marine bandsmen), armourer ratings, engine-room artificers, electricians and boy artificers, full normal vision is required.

For candidates for other artisan ratings and for stokers, the vision must be 6/8.

For all other ratings, including writers, ship's stewards' assistants, ship's cooks, sick berth staff, boy writers, ship's stewards' boys, and officers' stewards and cooks, the vision must not be less than 6/12.

For all ratings except writers, ship's cook ratings, and officers' servants, the colour sense must be normal.

Defects of vision must only be due to errors of refraction, and must be capable of correction to 6/5 Snellen by means of glasses, and the candidate must be able to read D = 0, 6 without the aid of glasses.

Marine bandsmen, sick berth staff, writers, ship's steward ratings, ship's cook ratings, and officers' servants are allowed to wear glasses.

Home Civil Service.—Any serious defect of vision disqualifies. A moderate degree of ordinary short sight corrected by glasses would not as a rule be regarded as a disqualification; but candidates for the Customs Outdoor Service are liable to disqualification for any defect of vision. Candidates for some other appointments of a special character would be rejected for colour-blindness, but for ordinary home appointments it is not by itself a disqualification.

No precise standard of eyesight is at present laid down for candidates for appointment as assistants of Customs and Excise. Under the existing rules, it is probable that a moderate degree of short sight, properly corrected by glasses, would not of itself be held to disqualify, but any

serious defect of vision would be a disqualification. The Regulations, however, are liable to alteration, and the Civil Service Commissioners cannot say what rule in regard to eyesight may be in force for subsequent competitions.

The Commissioners cannot undertake to give prospective decisions in the case of intending candidates, or to define more closely the requisite standard.

For the situations of Customs Preventive Man and Parkkeeper in the Royal Parks, candidates must have vision acute enough to perform their duties without the use of glasses; a practical test is made, if necessary, by officers of the departments concerned.

The Indian Civil Service.—1. A candidate may be admitted into the Civil Services of the Government of India if ametropic in one or both eyes, provided that, with correcting lenses, the acuteness of vision be not less than 6/9 in one eye and 6/6 in the other; there being no morbid changes in the fundus of either eye.

2. Cases of myopia, however, with a posterior staphyloma, may be admitted into the service, provided the ametropia in either eye does not exceed 2·5 D, and no active morbid changes of chorioid or retina be present.

3. A candidate who has a defect of vision arising from nebula of the cornea is disqualified if the sight of either eye be less than 6/12; and in such a case the acuteness of vision in the better eye must equal 6/6, with or without glasses.

4. Squint or any morbid condition, subject to the risk of aggravation or recurrence, in either eye, may cause the rejection of a candidate. The existence of imperfection of colour sense will be noted on the candidate's papers.

India. The Departments of Forest, Survey, Telegraph, Factories, and for various Artificers.[1]—1. If myopia in one or both eyes exists, a candidate may be passed, provided the ametropia does not exceed 2·5 D, and if with correcting glasses, not exceeding 2·5 D, the acuteness of vision in one eye equals 6/9 and in the other 6/6, there being normal range of accommodation with the glasses.

2. Myopic astigmatism does not disqualify a candidate for service; provided the lens or the combined spherical and cylindrical lenses required to correct the error of refraction do not exceed 2·5 D; the acuteness of vision in one eye, when corrected, being equal to 6/6, and in the other eye 6/9, together with the normal range of accommodation with the correcting glasses, there being no evidence of progressive disease in the chorioid or retina.

3. A candidate having total hypermetropia not exceeding 4 D is not

[1] Artificers engaged in map and plan drawing may be considered separately, and this standard relaxed if it appears to be desirable.

disqualified, provided the sight in one eye (when under the influence of atropine) equals 6/9, and in the other eye equals 6/6, with + 4 D or any lower power.

4. Hypermetropic astigmatism does not disqualify a candidate for the service, provided the lens or combined lenses required to correct the error of refraction do not exceed 4 D, and that the sight of one eye equals 6/9 and of the other 6/6, with or without such lens or lenses.

5. A candidate having a defect of vision arising from nebula of the cornea is disqualified if the sight of one eye be less than 6/12. In such a case the better eye must be emmetropic. Defects of vision arising from pathological or other changes in the deeper structures of either eye, which are not referred to in the above rules, may exclude a candidate for admission into the service.

6. Squint or any morbid condition, subject to the risk of aggravation or recurrence, in either eye, may cause the rejection of a candidate. The existence of imperfection of colour sense will be noted on the candidate's papers.

India. Public Works Department and Superior Establishments, Railway Department.—1. If myopia in one or both eyes exists, a candidate may be passed, provided the ametropia does not exceed 3·5 D, and if, with correcting glasses not exceeding 3·5 D, the acuteness of vision in one eye equals 6/9 and in the other 6/6, there being normal range of accommodation with the glasses.

2. Myopic astigmatism does not disqualify a candidate, provided the lens or the combined spherical and cylindrical lenses required to correct the error of refraction do not exceed 3·5 D ; the acuteness of vision in one eye, when corrected, being equal to 6/9, and in the other 6/6, together with normal range of accommodation with the correcting glasses, there being no evidence of progressive disease in the chorioid or retina.

3. A candidate having total hypermetropia not exceeding 4 D is not disqualified, provided the sight in one eye (when under the influence of atropine) equals 6/9, and in the other eye equals 6/6, with + 4 D glasses, or any lower power.

4. Hypermetropic astigmatism does not disqualify, provided the lens or combined lenses required to cover the error of refraction do not exceed 4 D, and that the sight of one eye equals 6/9, and the other 6/6, with or without such lens or lenses.

5. A candidate having a defect of vision arising from nebula of the cornea is disqualified if the sight of that eye be less than 6/12. In such a case the better eye must be emmetropic. Defects of vision arising from pathological or other changes in the deeper structure of either eye, which are not referred to in these rules, may exclude a candidate.

6. Squint or any morbid condition, subject to the risk of aggravation or recurrence, in either eye, may cause the rejection of a candidate. Any

imperfection of the colour sense is a disqualification for appointment to the Engineering Branch of the Railway Department, or as Assistant Superintendent in the Traffic Department. In all other cases a note as to any imperfection of colour sense will be made on the candidate's papers.

The Indian Medical Service, and the Indian Police Department.—1. Squint or any morbid condition of the eyes or of the lids of either eye, liable to the risk of aggravation or recurrence, will cause the rejection of the candidate.

2. The examination for determining the acuteness of vision includes two tests ; one for distant, the other for near vision. The Army test types will be used for the test for distant vision, without glasses, except where otherwise stated below, at a distance of 20 feet; and Snellen's Optotypi for the test for near vision, without glasses, at any distance selected by the candidate. Each eye will be examined separately and the lids must be kept wide open during the test. The candidate must be able to read the tests without hesitation in ordinary daylight.

3. A candidate possessing acuteness of vision, according to one of the standards herein laid down, will not be rejected on account of an error of refraction, provided that the error of refraction, in the following cases, does not exceed the limits mentioned, viz. :—(*a*) in the case of *myopia*, that the error of refraction does not exceed 2·5 D ; (*b*) that any correction for *astigmatism* does not exceed 2·5 D ; and, in the case of myopic astigmatism, that the total error of refraction does not exceed 2·5 D.

4. Subject to the foregoing conditions, the standards of the minimum acuteness of vision with which a candidate will be accepted are as follows :—

STANDARD I.

Right eye.	*Left eye.*
Distant vision.—V = 6/6.	V = 6/6.
Near vision.—Reads 0, 6.	Reads 0, 6.

STANDARD II.

Better eye.	*Worse eye.*
Distant vision.—V = 6/6.	V, without glasses, = not below 6/60 ; and after correction with glasses, = not below 6/24.
Near vision.—Reads 0, 6.	Reads 1.

STANDARD III.

Better eye.	*Worse eye.*
Distant vision.—V, without glasses = not below 6/24 ; and after corrcteion with glasses, = not below 6/6.	V, without glasses, = not below 6/24 ; and, after correction with glasses, = not below 6/12.
Near vision.—Reads 0, 8.	Reads 1.

The Indian Pilot Service, and Candidates for Appointments as Guards, Engine-drivers, Signalmen and Pointsmen on Indian Railways.—1. A candidate is disqualified unless both eyes are emmetropic, his acuteness of vision and range of accommodation being perfect.

2. A candidate is disqualified by any imperfection of his colour sense.

3. Strabismus, or any defective action of the exterior muscles of the eyeball, disqualifies a candidate for these branches of service.

The Indian Marine Service, including Engineers and Firemen.—1. A candidate is disqualified if he have an error of refraction in one or both eyes which is not neutralised by a concave or by a convex 1 D lens, or some lower power.

2. A candidate is disqualified by any imperfection of his colour sense.

3. Strabismus, or any defective action of the exterior muscles of the eyeball, disqualifies a candidate for this branch of service.

Royal Irish Constabulary.—A candidate for Cadetship in the Royal Irish Constabulary must be able to read with each eye separately, and without glasses, Snellen's Metrical Test Types (Edition 1898) numbered D = 10, at 20 English feet, and those numbered D = 0, 8 at any distance selected by the candidate himself. Squint, inability to distinguish the principal colours, or any morbid condition liable to the risk of aggravation or recurrence in either eye, will involve the rejection of the candidate.

The British Mercantile Marine. *Form Vision Test.*—The test is the letter test on Snellen's principle, for all candidates, and they are not allowed to wear spectacles or glasses of any kind. If the candidate can read correctly five of the eight letters in the fifth line from the top of the sheet of letters he may be considered to have passed the test. If he cannot do so, his case should be submitted to the Principal Examiner of Masters and Mates.

Candidates may use both eyes or either eye when being tested for this standard.

On and after January 1, 1914, a higher standard of Form Vision will be required of candidates, but the colour vision and colour ignorance tests will be unaltered. The new Form Vision Test will be as follows:—

If a candidate can read correctly at a distance of 16 feet nine of the twelve letters in the sixth line from the top and eight of the fifteen letters in the seventh line with one eye, and the whole of the eight letters in the fifth line with the other eye, he may be considered to have passed the test. If he cannot do so, his case is submitted to the Principal Examiner of Masters and Mates.

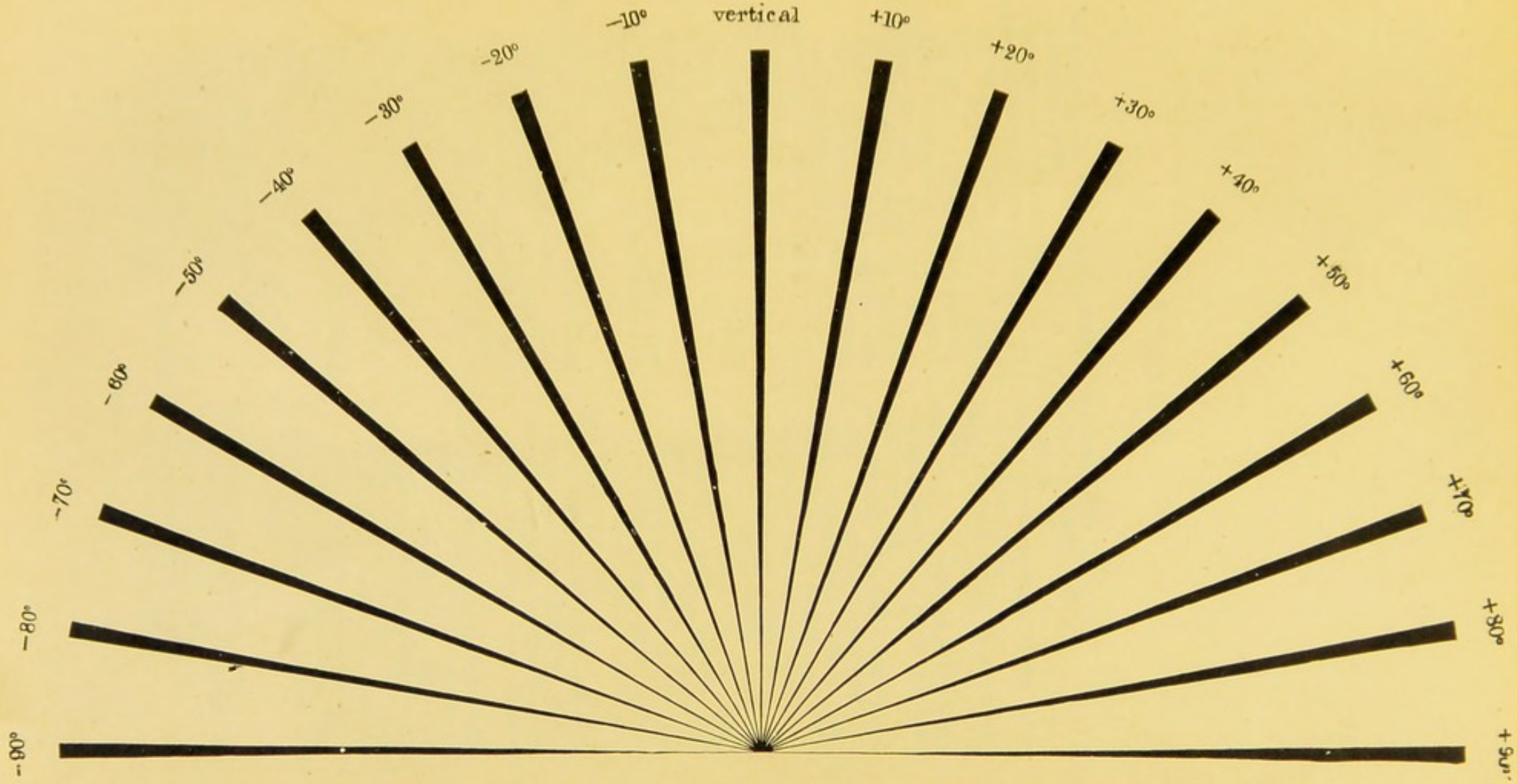
Candidates who before January 1, 1914, shall have obtained any certificate of competency as Master or Mate (foreign-going or home trade), shall have the option of undergoing the present tests, and shall not, in order to obtain certificates of higher grades, be required to pass the more severe test.

From November 1, 1909, it will be possible for any person serving or intending to serve in the Mercantile Marine to be examined with reference to the higher standard, and if he passes he may receive a certificate to that effect, or, if he holds a certificate of competency, the fact of his having passed the higher standard will be endorsed upon it.

Colour Vision Test.—The colour vision of candidates is tested by Holmgren's Method.

Colour Ignorance Test.—The object of this test is to ascertain whether the candidate knows the names of the three colours—red, green, and white—and the test is confined to naming those colours.

The Board of Trade examinations for Form Vision, Colour Vision and Colour Ignorance are open to all persons intending to serve in the Mercantile Marine, and all such persons are recommended to ascertain, by means of these examinations, whether their vision is such as to qualify them for service in that profession before entering upon it.



SNELLEN'S SUNRISE FIGURE FOR TESTING FOR ASTIGMATISM. (*See p.* 437.)

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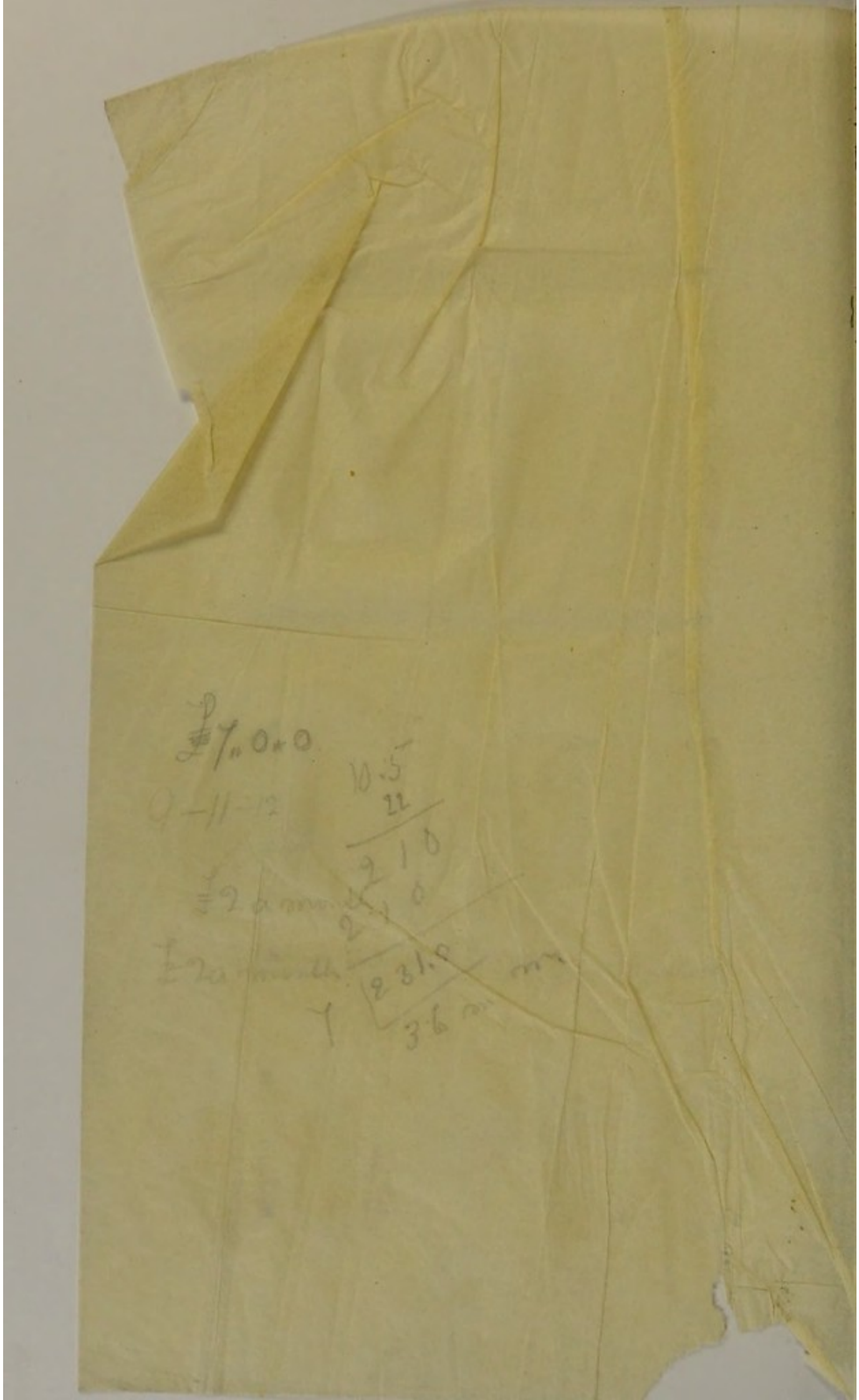
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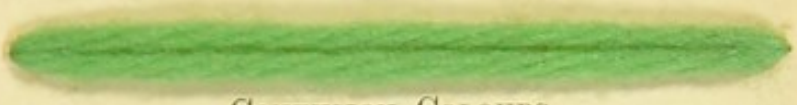






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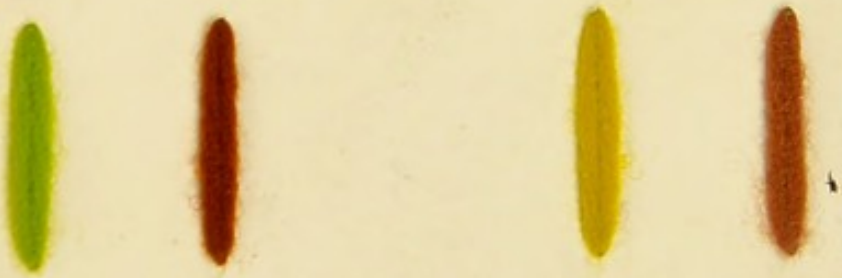


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