Elementary treatise on the function of vision and its anomalies / by Dr. Giraud-Teulon ; translated from the second French edition by Lloyd Owen.

THE FUNCTION OF VISION

Marc Antoine Louis Pélix

THE EYE.

AN ELEMENTARY TREATISE

ON THE

FUNCTION OF VISION

AND ITS ANOMALIES.

BY

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AND OF THE SOCIETY OF SURGERY, ETC., ETC.

TRANSLATED FROM THE SECOND FRENCH EDITION,

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TO

RICHARD MIDDLEMORE,

FELLOW OF THE ROYAL COLLEGE OF SURGEONS,

WHOSE ABLE AND COMPREHENSIVE TREATISE ON THE DISEASES OF

THE EYE

CONTRIBUTED IN NO SLIGHT DEGREE

NOT ONLY TO THE ADVANCEMENT AND PERFECTION OF

OPHTHALMIC MEDICINE AND SURGERY

BUT ALSO TO

THE FOUNDATION OF THE ENGLISH SCHOOL OF OPHTHALMOLOGY,

This little Work is inscribed

AS A SLIGHT ACKNOWLEDGMENT OF MANY FAVOURS

CONFERRED ON HIS OBLIGED FRIEND

THE TRANSLATOR.

PREFACE.

IT has long been the wish of the translator to offer to his medical brethren such a work as this little treatise by his former master, Dr. Giraud-Teulon. He felt that any such production from his hands must draw largely on Dr. Giraud-Teulon's work, both in manner and matter. He therefore sought permission to present it in an English dress.

In this work the author has endeavoured to place the principles of the more abstruse portion of modern scientific ophthalmology within the reach of the general practitioner. This he has done because he knows that to many of his medical brethren in that position both the mathematical knowledge indispensable for dealing with its problems and the time necessary to acquire such knowledge are alike wanting. The rapid development of modern society renders it more than ever essential that the general practitioner should be fairly initiated into such knowledge, since in a large

majority of cases of eye disease his is the opinion first sought, and upon his advice very frequently hangs the welfare of his patient.

The translator believes that this work, by its simplicity of arrangement, unimpeachable accuracy, and marked conciseness, will thus meet a want which books covering the wide range of diseases of the eye fail readily to satisfy.

The division into sections and the careful indexing will, it is hoped, enable the practitioner to obtain at once the information sought.

The author embodies in an appendix some very excellent rules for guidance in examining recruits; but as these apply to the requirements of the French military system only, it has been thought wise to omit them.

51, Newhall Street, Birmingham.

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THE EYE.

Part First.

GENERAL IDEAS UPON THE PHYSIOLOGY OF THE ORGAN.

I.

THE EYE AS AN OPTICAL INSTRUMENT.

§ 1. **The Eye is a Dark Chamber.**—It has been known since the time of Kepler that the eye, considered as an optical instrument, is but the *camera obscura* of the physical laboratory.

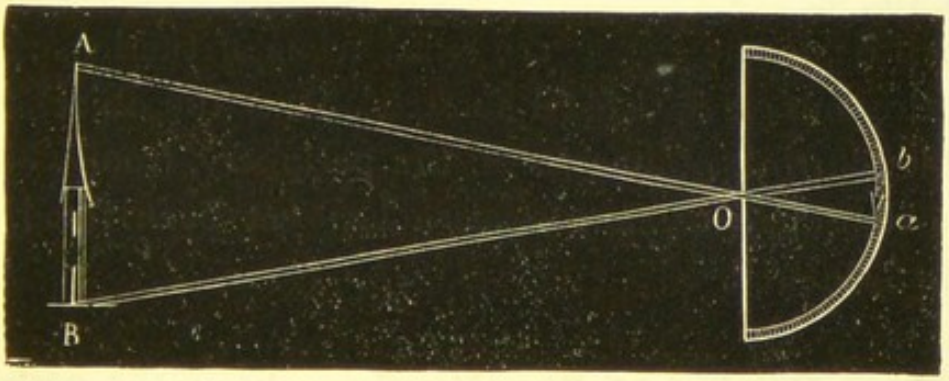


Fig. 1.

The art of photography has in our day so popularized this instrument that it will serve, better than any

explanation, to convey to every one a clear idea of the mechanism of vision.

Imagine, 1st, that in the photographer's camera, placed to receive the image of a landscape, the ground-glass screen upon which the image appears, and which is usually square and plane, is hemispherical in form and endowed with sensibility of a peculiar kind (retina); 2nd, that the object-lens is formed, like that of the microscope, by the association of two lenses juxtaposed (doublets) the cornea associated with the crystalline lens, and you will have an exact representation of the eye in a state of rest, that is to say, of the eye receiving upon its retina a clear image of distant objects.

A representation in other respects entirely to the advantage of the living organ: for the properties of the lens, and the appropriate, hemispherical, form of the screen, insure that all the points of the screen shall be, in the eye, at the exact focus of the lens; its entire surface is a focal surface. Thus the objectionable blurring of images at the periphery, from which no inorganic camera obscura has yet been freed, is not observed.

§ 2. **Centre of Similitude.**—From the perfect similitude of images with the objects which form them, geometricians have concluded that in the eye, as in every camera obscura, and more especially even in

case of the eye, all the straight lines which may be mentally drawn from a certain external point to a corresponding position in the image, should cross each other in one and the same point. This point has received the name of optical centre.*

§ 3. **Lines of Visual Direction; Centre of Sensorial Projection.**—On the other hand, if we regard a collection of objects placed before us and wish to reach any one of them, either by touching or by the aid of a projectile, our geometrical faculty does not hesitate; the end is accurately attained. Now, as between us and these objects, there is no other medium than the reaction of the sensitive screen, or retina, against the local shock caused by the pencil of light, we must conclude that this sensorial reaction creates in us the idea of the externality of the object exciting it, and at the same time gives rise to the notion of the straight line which connects it with the corresponding point of the retina. The screen or retina is, in fact, the first of the organic elements which the light meets, and which is found to be endowed with an organization in keeping with the part performed. This organ offers also to anatomico-physiological observation, a peculiar layer, in the composition of which

* The French and German schools at the present time employ this term in a different sense; to avoid all misunderstandings the term centre of similitude has been substituted.

it is impossible to refrain from localizing the qualities of sensorial direction. It is the layer of rods and cones (Jacob's membrane) which constitutes a bed or mosaic of small, extremely delicate, cylinders implanted perpendicularly upon the sphere and representing *materially* the visual directions, or secondary axes of refraction, corresponding to each diameter of the external sphere. (See fig. 2.) A second conclusion from the same observation is, that all the straight lines of sensorial projection or of visual direction cross equally in the same point, and that this point is none other than the centre of similitude.

§ 4. **Principle of Externality.**—It follows from this that the special sensation attributed to the retina

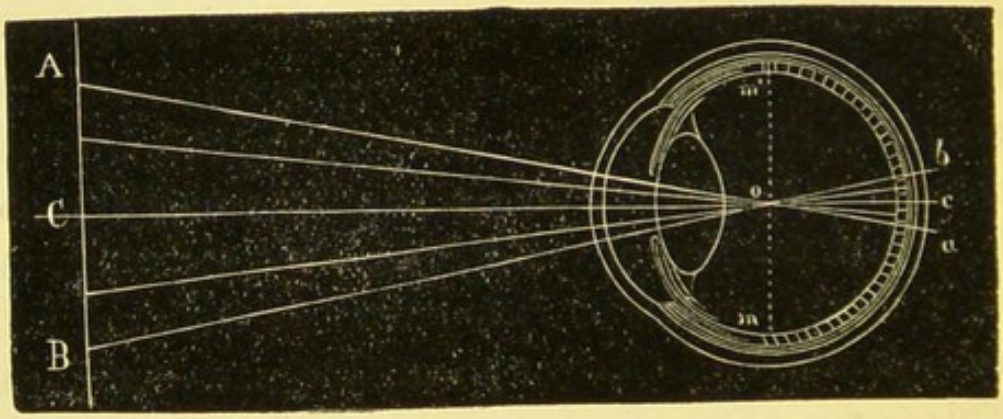


Fig. 2.

The hemispherical surface *m*, *b*, *c*, *a*, *m*, is anatomically constituted by a union of small cylindrical elements of about three millièmes of a millimetre in thickness, formed of nerve-substance, and of which the direction is that of the perpendicular or normal to their common surface.

Such is the most external layer of the retina (Jacob's membrane); this it is which receives the image. When a rod, the point *b*, for example, is influenced in any way (by light or the excitation of phosphenes) it does not perceive in *b*, but in *B*, some point in the direction *o b* prolonged outside the eye, and in this direction exclusively.

o is the centre and also (§§ 1 and 2) the point where all the lines of visual direction intersect. The white external envelope represents the sclerotic in continuation with the transparent cornea. The blackened circle the choroid and iris (uvea). The internal layer, the retina, reduced in the figure, to the layer of rods and cones.

is not a sensation of contact, of touch; it is a peculiar sensation, *sui generis*, which creates and locates in the sensorium the *idea*, the *notion* of the external situation of the object to which it is due (*outness*, Porterfield; *exteriorité*, Serres d'Alais) and the determinate direction of that object in space.

§ 5. **Evidence of the Property of Externality by means of Phosphenes.**—To picture to ourselves this special mode of activity, let us excite, by rubbing gently with the finger a point on the posterior region of the eyeball, the manifestation of the phenomenon which has received the name "*phosphene;*" we shall there recognize two distinct elements: 1st, the general sensation of contact of the finger with the tunics of the eye; 2nd, the *special* sensation experienced by the retina, viz., the appearance of a small luminous ring, *outside* the eye and in the direction prolonged from that of the diameters of the organ which passes through the point excited, the line of visual direction.

§ 6. **Definition of the word to "see."**—To see is therefore nothing else but to *perceive* external objects *exactly where they are.* Sight is a sort of *mediate touching* involving the ideas of externality and of distance.

§ 7. **How objects are seen erect although the retinal images are inverted.**—Since all the visual directions cross at the same point within the eye, and, on the other hand, all these directions correspond to the exact situation of objects or their different points, it is clear that to an exact or erect perception of the situation of these objects must correspond a reversed picture, an inverted retinal image.

It is, therefore, neither custom, nor education, nor the teachings of direct contact, which cause us, as it has been too long termed, *to see erect by means of inverted images.* The faculty of seeing erect is a faculty innate; its seat or its organ exists in the cylindrical retinal element set perpendicularly to the sensitive surface, called the layer of rods *(bacilli)*, and whose mode of perception consists in transporting its sensations outside of ourselves in its diametrical direction. As for the picture which is reversed, it is geometry which reverses it; but it is not this which the sensorium *feels*, this is the object itself; to *see* being nothing but to feel outside of oneself, at a distance.

Observation of the first acts of the life of relation in young animals, observation of the development of the visual sense in those born blind, following the operation which gives them sight, concur equally in establishing in an unimpeachable manner, that the notion of direction in space, the notion of space itself, are retinal products. Failing the help of sight, or its traces in the memory, there is no conception of the relative position of bodies, of their distance; *the retina is the birthplace of geometry.**

§ 8. **Vision of Surfaces.**—Just as the whole of the hemispherical space open before us is depicted upon the retina in a single stroke, and as a complete picture, so the retina perceives or *sees* this picture in a single effort. This picture has received the name of superficial field of vision.

§ 9. **Seat of Visual Attention; the Optic Axis.**

* The properties whose localization we have shown in the retina are, we have said, innate. This word demands explanation and caution; in using it we wish only to enunciate an observed fact and not to decide a question of philosophy.

In using the word *innate*, we wish to say, innate in the *individual*. The fact is indisputable. Do these same faculties exist at present in the species, the race, or the variety? or, on the contrary, have they been gradually acquired, by education, then by hereditary filiation, organic evolution?

We leave to the future the decision of a question which, if it be not yet solved, finds at least in the observation of numerous facts unknown to our forefathers, a justification much more in relation with the scheme of nature than the thoroughly obstructive idea of a creation bit by bit.

Nevertheless one region only in the whole of this extent is seen distinctly ; it is that towards which the attention is directed : and it corresponds exactly with the pole of the eyeball, a point anatomically worthy of notice, known by the name *macula lutea*, or yellow spot, and peculiarly rich in cones and other nervous elements.

Whenever we desire perfect perception of an object we must, therefore, turn our eye towards that object, that is to say, bring it into relation, in its polar direction, with the object. This polar direction is also described under the name of *optic axis* (axis of vision).

The polar centre possesses such a superiority of special activity over all the other retinal elements that an anatomical lesion of the part extinguishes *ipso facto* the faculty of fixing the gaze upon a given point. A patient suffering from central scotoma (see scotoma) can no longer recognize a distant object. We call the attention of the reader to the physiological value of this centre of fixation, the loss of which is one of the first defects of progressive myopia.

§ 10. **The faculty of judging of the Relative Positions of Objects (orientation).**—But in order that this movement may take place without hesitation, without exploration, the sensorium must be able to guide itself, to direct itself in the picture, and to pass from one object to another by the shortest route or in

any definite direction. Now it can only do this by virtue of that faculty which the eye possesses of seeing the entire picture at a single glance, and without which it could not seize the relative situation of objects.

The faculty of orientation (the judgment of the relative position of objects) is, therefore, derived precisely from the property which the retina has of grasping instantaneously the whole extent of the space.*

§ 11. **The Focus of the Eye when that organ is in a state of repose.**—Man and a large number of the superior animals have the faculty of seeing clearly on the horizon. In this condition distinct vision takes place without effort and as the effect of the power of refraction alone, corresponding absolutely with the structure of the transparent media of the organ (static or passive refraction). The rays which strike the cornea are then parallel, and the eye represents exactly the camera obscura at the moment when

* An eye reduced to central vision is in the greatest perplexity in guiding itself; it is in the condition of an astronomer whose telescope is deprived of the additional instrument called the "finder." In order to discover a star in the expanse of the celestial sphere, it must be possible to embrace in a single glance all the region in which it is known to be found, a thing almost impossible with the telescope, in which the superficial field is extremely limited. It is accomplished readily by means of the finder, which possesses a much more extended field of vision, and whose axis is parallel to that of the telescope to which it is attached.

the screen is set precisely at the focal distance of the objective. This is called the *emmetropic* eye.

§ 12. **Necessity for a modification in the Organ for vision of near objects.**—It is known that if an object be presented more or less near to the objective of a camera obscura in which the screen is set at the focus of parallel rays, the image of that object upon the screen is indistinct. In order to restore its distinctness, it is necessary to remove the screen backwards in proportion to the degree of approach of the object, or, if preferred, to replace the first objective by a second stronger lens, leaving the screen in its former position.

§ 13. **Accommodation or the Adaptation of the Eye for Distances.**—When man sees a near object clearly, what occurs? Is the retina removed from the lens, like the screen of the photographer, or does the lens undergo some change which increases its power? Both observation and experiment have learned that the latter expedient is the one adopted by nature. To meet the necessities of near vision, the refractive power of the lens-apparatus of the eye increases proportionately with the approach of the object; the screen (retina) remains in its place.

§ 14. **Seat and Mechanism of the Accommo-**

dation.—This increase of refraction depends solely upon the crystalline lens, of which the curvatures are increased, especially the anterior, at the time of near vision, by the action of a small muscular apparatus situated in the interior of the eye, forming an annular zone surrounding the crystalline lens at some distance from it.

This apparatus bears the name of ciliary muscle, and the amount of refraction which it adds to the static refraction of the organ is called *accommodation* or dynamic refraction. This extent in the physiologically constituted and healthy eye, embraces the whole of the space comprised between the horizon, or infinite distance (parallel rays), and the *punctum proximum*. At twenty years of age this point is found to be at a mean distance of ten centimetres. The sound eye, at that age, possesses the faculty of adding to its static refraction an amount of dynamic refraction equivalent to the power of a lens whose focal length is ten centimetres, or ten metrical dioptrics. This is the sum which expresses the extent of physiological accommodation at twenty years of age.

§ 15. **The near Point (punctum proximum). Range of Accommodation.**—The maximum of the dynamic refraction, or accommodation, corresponds to the nearest point of distinct vision, *punctum proximum*. This point, the inferior limit of clear vision, is nearly

at the same distance, in every regular or emmetropic eye, at the same age. This is expressed by saying that the range of accommodation, or the amount of dynamic refraction available, is nearly the same in all normally constituted subjects of the same age.

§ 16. **Negative Accommodation does not exist.**—Regarded physiologically the accommodation is an *active* or positive force. When it is at rest, static refraction only is concerned, which corresponds to parallelism of the incident rays. This may be demonstrated in a perfectly emmetropic eye. Paralysis of the power of accommodation, either as the result of disease or artificially produced by atropia, destroys clear vision for all objects situated at a *finite* distance; it does not alter vision for objects situated on the horizon; which would be the case if the accommodation could be relaxed beyond that limit.

§ 17. **Acuity of Vision**, *the minimum visibile.* The keenness of perception of the sense of sight considered independently of its range is called the *acuity* of vision; it corresponds to the smallest visual angle which the retina can appreciate. This minute angle is represented by the smallest object which the eye can distinguish from another similar object at a given distance, the two being separated by an interval whose extent equals the size of one of them, the two strokes of an *n* for example.

Two stars separated by an angular interval of less than one minute, produce upon the eye the effect of one star only. This is the limit of the *minimum visibile*. Among less civilised peoples and those devoted to the chase, the keenness of perception certainly reaches a higher degree than this. This angle, the *minimum visibile* of Porterfield, measures one minute and corresponds pretty nearly to the thickness of a hair (one-tenth of a millimetre), seen at a distance of thirty-three centimetres.

§ 18. **The range of Vision.**—The expression "range of vision" has another sense. It designates the state of the organ, its condition as an instrument of refraction, both static and dynamic. It is the faculty of seeing considered in its relations with distance, or the refractive capacity of the apparatus.

A myope and a presbyope may possess the same acuity of vision; they may, for instance, distinguish with clearness a certain *minimum visibile* at eighteen inches from their eyes. But the first shall have no clear perception beyond that distance, and the second none on this side of it. In such case, different ranges of vision correspond to an equal degree of acuity.

§ 19. **Spherical and Chromatic Aberration.** The experiment upon which the proposition of § 1 was founded, the character of the whole focal surface

of the retina, admits of the conclusion that the eye is, practically, free from spherical aberration (see this term in a treatise on optics).*

Other more delicate experiments demonstrate equally that the eye, in the physiological performance of its functions, is also free from refractive or chromatic aberration. When objects appear irisated, the white surfaces from which they stand out in relief being coloured at their borders, it may be concluded that the eye is deformed, asymmetrical, or that the retinal screen is not exactly at the conjugate focus of the object to which the attention is directed. This phenomenon is the symptom of an abnormal state of the refraction of the eye.

* If the eye of an albino rabbit be taken, freshly removed from the orbit, and placed, the cornea in front, in the opening of a window, the *entire* landscape appears, inverted and perfectly clear and distinct on the whole of the posterior surface of the eye.

II.

THE ASSOCIATION OF THE TWO EYES IN THE ACT OF UNAIDED VISION.

§ 20. **Principal Characteristics of Binocular or Associated Vision.**—When the two eyes are directed towards the horizon, and when they are fixed upon a given point in greater or less proximity to them, the image of the point fixed occupies on each side the centre of the yellow spot of the retina. In the first case the optic axes are parallel; in the second, they meet at the point fixed. See § 9.

Now experience teaches us that under these circumstances the two pictures are blended into one in the sensorium, producing a single sensation, at the same time that the optic axes convey to the same sensorium the accurate geometrical notion of the place of their intersection, or, in fact, of the position actually occupied by the object fixed.

§ 21. **Inferiority in this respect of Monocular Vision.**—In vision by means of one eye this is not the case: the retina of one eye gives an exact account only of directions. The experiment of the ring of Malebranche, that of the illusion obtained by means of the hollow mould of a medal, which, looked at with

one eye only, assumes spontaneously the appearance of the medal itself, and stands boldly out; a thousand other illusions demonstrate to us the compounding action exercised by each eye, and the inferiority of the part contributed by each to the resultant or common action.

§ 22. **Doctrine of Identical Points.**—The sensorial fusion of the two pictures into one has been long explained on the hypothesis that each retinal element of one eye had, with the geometrically homologous element of the other, the same isolated conducting nerve filament, divided into two, which bound them to the sensorium. Therefore the same object being depicted upon the two retinæ, at homologous points, must give rise to a single sensation. This it is which has been called the doctrine of *identical points*, upon which doctrine was afterwards established the celebrated theory of the horopter.

§ 23. **The Horopter.**—The first difficulty encountered by the theory of identical or homologous points was presented by geometry. How could two centred spherical systems present images having the same latitude and longitude for external points situated asymmetrically with respect to their axes? In these cases, of course, the correspondence or identity would be at fault, and the points, therefore, would be seen

double. To meet this difficulty it was *imagined* that bodies seen *single* must satisfy certain geometrical conditions, and the harmony, or the situation of the respondent points, was sought in the two retinal hemispheres having equal parallaxes: before, however, having determined the surface curve fulfilling this geodesical condition, it was named *horopter* or *geometrical position of points seen single.*

When the geometrical labour was ended it was discovered that this surface assumed the form of a *torus.*

Whence the conclusion must perforce be drawn that a body having three dimensions, situated in space, should, in order to be seen single, take the shape of a torus.

How strange that although such a conclusion was contradicted every moment by observation, it shocked no one! It was not noticed that a table with four legs, a chair, placed before us were seen single although they certainly had none of the attributes of the *torus;* and the term *horopter* continued to be used even as if it had a real existence. We believe, indeed, that it is used even now, though since the collapse of the doctrine of identical points there can be no valid pretence for the existence of this transcendental fancy.

Let us return to that theory.

§ 24. **The two Retinal Images are not iden-**

tical.—The doctrine of identical points necessarily rested upon the implied supposition that the retinal pictures were identical. But it is not so; the two pictures are not identical.

No object whatever in space is seen by the two eyes in the same manner, nor imprints exactly the same image upon the two retinæ.

Let the position of the object be what it may, the left eye sees a little more of the left aspect, while the right eye takes in more of the right. The images of all the objects forming part of the picture are therefore unequal and asymmetrical in the two eyes: in a word, they are *stereoscopic* images. The doctrine of identical points is incompatible with this indisputable fact.

§ 25. **The Mechanism of Single Binocular Vision.**—Thus strict observation of the phenomena of vision shows us that not only may an object be seen single with the two eyes, without the images falling right and left upon homologous points, but also that the difference of the parallaxes of that object in each eye is intimately connected with the perception of objective relief which it produces, or, more accurately, with the true situation of the object in space. The single vision produced by the two stereoscopic retinal images with the perception of relief, answers, in fact, and independently of all theory, to the following mechanism: just

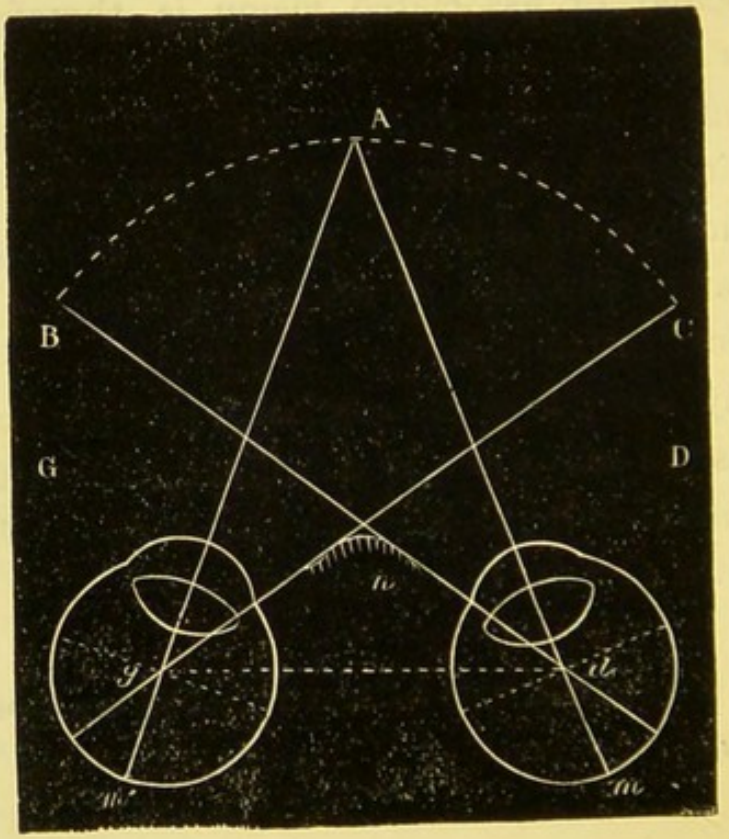
as the two optic or polar axes fix, for the sensorium, by their intersection, the actual position in space of the object regarded, so the axes of secondary visual directions when corresponding to different scattered objects in a vicinity more or less proximate to the point of sight, convey to the sensorium a like idea of the place of their intersection, two by two. In short, by the co-operation of the two eyes, the positions of all the objects in space, within a certain extent around the point of sight or of attention, are brought simultaneously into relation with our own position as a centre, with the same exactitude, the same certainty as they would be on a plane surface, by a system of co-ordinates, or by the intersection of two right lines.

Binocular or associated vision is, therefore, quite another thing than monocular vision *doubled*. It is a resultant producing effects which neither component taken singly can realize. This it is upon which depend exact notions of objective relief, of the distance and the relative situation of an object in space: it is a geodesical instrument.

Briefly, our two eyes associated, perform accurately, so far as the sensorium is concerned, the parts of two intelligent theodolites having a knowledge of the angles of which they take the bearings.

§ 26. **Components of Associated or Complete Vision.**—At the time of associated vision the two

superficial visual fields, right and left, are not superposed in their entire extent, for the excellent reason that they have but one part common to both, and susceptible of fusion. When looking directly forwards the hollowing of the orbital margin in the temporal region and the nasal prominence on the other side cause each eye to receive upon the nasal side of the retina a much more extensive image than is thrown upon the temporal half of the membrane. It follows, therefore, that complete superficial vision is composed of three parts: one central B *n* C the greatest, which is binocular or compound, and two others D and G monocular and in relation with the lateral regions of the space.



The two latter are vestiges of the bilateral vision existing in certain species of animals, and blend into one picture with the central region.

III.

PHYSIOLOGICAL INFLUENCE OF AGE UPON THE PROPERTIES OF THE VISUAL APPARATUS.

§ 27. **Influence of Age upon the Visual Function.**—In the preceding chapter the conditions which the eye fulfils or ought to fulfil in a physiological state are set forth. But in that description, which has an exclusively geometrical character, everything is definite, and we do not meet with the variable elements which age brings in its train.

But the functional perfection of the visual apparatus changes with the progress of age in the same manner as the power of all other organs.

This progressive enfeeblement reveals itself under two different aspects: 1, by gradual diminution of acuity (§ 16); 2, by diminution of accommodative energy. The latter betrays itself by the increasing distance of the near point (*punctum proximum* § 15) from the eye.

§ 28. **Effects of Age upon the degree of Acuity of Vision.**—From the age of twenty to that of eighty years, the acuity of vision descends gradually from $\frac{20}{20}$ or 1 to $\frac{11}{20}$.

§ 29. **Effects of Age upon the near point**

(p. p.).—The near point in the same period is removed in a progressive and very nearly regular manner; it is transferred gradually from ten centimetres distance, to the horizon (infinity) which it attains towards the age of sixty-five. The power of accommodation loses therefore about one metrical dioptric every four years.

§ 30. **Definition of Presbyopia.**—These two variables are essential to the existence of presbyopia: ordinarily, however, this word is understood to mean only the removal of the near point in course of years, the regularly progressive weakening of the power of accommodation.

§ 31. **Causes of Presbyopia.**—This weakening acknowledges as causes, on the one hand the lessening of power in the ciliary muscle, on the other the gradual hardening, or sclerosis, of the chief of the lenticular elements of the organ, the crystalline. The result grows with the united action of these two conditions: diminution of power, and increase of resistance.

For a long time presbyopia was attributed to a flattening of the cornea and a gradual removal backwards of the crystalline lens, which also became flattened. These views are not well founded, the variations of curvature in these organs, due to advance of years, are imperceptible, at least as far as the seventieth year: at this period the surfaces of separa-

tion of the media are somewhat flattened, owing to the senile influence which condenses all the tissues or causes them to decay. The eye then passes into the hypermetropic state, this is the acquired or senile hypermetropia (see Hypermetropia).

§ 32. **Beginning of Presbyopia in its practical bearings.**—Although the gradual removal of the near point begins at a very early period, long before the twentieth year, the effects are not perceived until much later, towards forty or forty-five, a period of life at which the near point, having travelled eight or nine inches (twenty-three to twenty-five centimetres) from the eye, is frequently beyond the distance at which small objects must be held in order to furnish a sufficiently large image. The point at which presbyopia begins is therefore somewhat arbitrary. Bearing in mind the customs and general necessities of civilized life, it is fixed approximatively at about the fortieth year. Nevertheless, there are reasons for taking into account the occupation of the individual. A compositor, a draughtsman, an embroiderer, feel the physiological removal of the near point very much earlier than a countryman, or a man of means living an indolent life.

We shall resume in § 36 and the following sections, the practical study of this condition, in which the functional pathology keeps pace with the physiology properly so called.

Part Second.

FUNCTIONAL PATHOLOGY CONSIDERED IN ITS ABRIDGED SYMPTOMATOLOGY— GENERAL INDICATIONS FOR TREATMENT & HYGIENE RESULTING THEREFROM.

I.

PRELIMINARY CONSIDERATIONS.

§ 33. **Summary of the Elements of Normal Vision.**—The rapid account of the normal conditions of the exercise of vision which the reader has run through leads us to conclude—

That the union of five principal elements is necessary for the regular exercise of the function, namely—

1. Integrity of structure and sensibility of the special membrane, the retina, and of the nerve which is expanded within its substance, the optic nerve.

2. Perfect transparency of the refracting media.

3. An exact relation between the position of the sensitive screen and the refractive power of the organ, or that the eye-ball shall be of normal length.

4. Integrity of the power which presides over the

adjustment of the eye for distances, or the accommodation.

5. Integrity of the powers which govern the movements of the optic axes, and their harmony with that which produces accommodation.

Therefore no disturbance of sight whatever originates within the eye itself, unless it depends upon some change occurring in one of these organic elements. The proved exclusion of each of these five sources puts the cerebral centre itself directly on trial (cerebral amblyopia).

§ 34. **Differential Diagnosis between Amblyopia and Anomalies of Refraction.**—The anatomical soundness of the deep membranes of the eye and of the transparency of the media, cannot be distinguished one from the other, by the mere statements of patients; in order to differentiate an ophthalmoscopic test is necessary.

But there is an extremely simple means of deciding off hand, and with an approximation sufficient for practical purposes, the question at issue between the integrity of the transparency, and of the special sensibility estimated together, on the one part, and the state of the refraction on the other. This means is within the reach of all: it consists in the use of a card pierced with a pin-hole.

A pin-hole in a card (preferably a black card) placed

quite close to the eye, gives passage to minute cylindrical pencils only, which pass either through the very axis of the refractive system, or very near to the axis. These pencils therefore do not deviate sensibly: the apparatus is, so to speak, no longer an instrument of refraction. The images formed are clearly defined for all distances, it is the geometrical camera obscura of fig. 1, § 1.

Therefore an eye whose properties are more or less diminished, and which is not improved by the use of the pin-hole, *does not fail in point of refraction;* there is then reason to suspect the retinal sensibility, or the transparence. It is a case for ophthalmoscopy.*

The symptoms which are present in the cases in which the pin-hole in no respect improves vision, cases of amblyopia and of defects of transparence, will be examined further on (§§ 68 *et seq.*). If on the contrary the pin-hole improves vision, either for near work or for distance, it is manifest that the media are transparent and that the retinal sensibility is intact. We shall therefore find ourselves face to face with an anomaly, either of static or of accommodative refraction.

§ 35. **General aspects of Disturbances merely functional in character.**—The patients

* The fineness of the luminous pencil which penetrates the eye through the pin-hole, necessitates that the test should be applied under favourable conditions of illumination.

in whom the pin-hole improves vision, present themselves to us under the following aspects—

The patient sees well at a distance, but little or not at all near.

Or, indeed, it may be the reverse, he may read, or work at more or less delicate matters, but he sees but little or not at all at a distance.

Finally others, in whom the media are transparent, and the membranes healthy, since they see fairly or very well through the pin-hole, see only confusedly with the naked eye, both near and at a distance.

Again, patients are met with who possess, they say, excellent sight, some for near, others for distant objects, but their sight does not last ; it is disturbed, becomes hazy under certain circumstances ; some images are doubled, others are interrupted in their continuity ; various appearances are observed before the eyes, etc. . . . . , pains are felt in the eyes, around the eyes, in the temples, in the forehead, at the top of the head, etc. . . . . ; and notwithstanding all this the external appearance of the eyes is quite healthy.

What is wrong in all these cases ?

Let us inquire with the reader.

II.

FUNCTIONAL ANOMALIES.

Class First.

DISORDERS OF VISION IN PERSONS SEEING VERY WELL OR SUFFICIENTLY WELL AT A DISTANCE, BUT IMPERFECTLY OR NOT AT ALL NEAR.

§ 36. Patients of this class naturally do not complain of their sight except when they have occasion to direct it to near objects.

These persons present themselves generally in one or other of the following conditions—

Some will complain of the almost entire absence of distinct vision on application to near objects; others will complain of the impossibility of *maintaining* clear vision beyond a certain time, which becomes shorter and shorter.

Thus these two groups have this symptom in common, that they receive clear images of distant objects; but in near vision accommodation is entirely wanting in the former group, whilst it may be obtained for a time in the latter.

Let us direct our attention to the first group.

§ 37. **Near Vision is invariably very confused.** — Accommodation fails absolutely for the distances of ordinary work; this power is therefore lost, either by advance of years, or by disease. In the first case there is simple or premature presbyopia, in the second a paralysis of the accommodation more or less complete.

§ 38. **Presbyopia** (§§ 30—32).—The presbyope presents himself generally under the following aspect: he has always enjoyed excellent distant vision: in this respect his faculties have now suffered but little. But he is drawing near to forty-five or fifty, and begins to experience a certain difficulty in reading small type, in seeing the details of an engraving or of a miniature, especially in the evening. On opening a book printed in rather small type, a first instinctive movement impels him to bring it near to the eyes, but this movement is immediately succeeded by one in the contrary direction; he throws the head back, moves the book farther away, then takes it eagerly to the window or near to the lamp, seeking instinctively a more brilliant light. Sometimes he may be seen to place between his eyes and the book the lamp or candle which he is using. The desired effect is thus obtained; the brilliant light has altered the state of affairs; he recovers the clear perception he was seeking; not, as might readily be thought, by the

action of the increase of an illumination previously insufficient. No. At that age, the acuity of vision is not physiologically sufficiently diminished to need such additional illumination. The benefit experienced is due to the reflex action of the light upon the pupillary opening, whose sudden contraction lessens the circles of diffusion, which previously added to the inaccuracy of the visual focus. This may be readily proved by trial of the pin-hole, the double effect of which is to diminish at the same time the circles of diffusion and the light itself. Soon these symptoms becoming more pronounced lead the patient to seek other aid in the use of spectacles, and he tries those belonging to aged persons of his acquaintance.

The satisfactory effect which he experiences from the aid of weak convex glasses soon reassures him as to the state of his eyes; and the diagnosis is thus most frequently made, either by the patient himself or the first optician at hand.

All the treatment, in simple cases, is comprised in the actual determination of the glass which should make up for the absence of the necessary accommodation. This determination may be rational or empirical, made by the oculist or by the optician, by means of the following scale, *if the case be perfectly normal.*

According to Donders, the following are the numbers of the glasses suitable, generally speaking, for *a perfectly normal eye* (emmetropic), expressed both in

dioptrics (metrical system) and by their focal lengths in inches.

Age.	Metrical Dioptrics.	Focal lengths in inches.	Mean distance of vision with the glass.
48	·50 to ·75	60 to 48	
50	1·	36	
55	1·25	30	35 to 40 centimetres.
58	1·50	24	
60	2·	18	
62	2·50	14	
65	3·	12	33
70	3·50	10	27
75	4·	9	24
78	4·50	8	22
80	5·	7	20

§ 39. **May the convex glasses, adapted to the deficiency in the accommodation, injure the Presbyope?**—The instant that the question of the choice of a glass presents itself, the oculist finds himself face to face with a prejudice as obstinate as it is widely extended. Spectacles, abandoned so far as their choice is concerned to the most deplorable carelessness, are nevertheless the subject of a timid reprobation which is almost universal. It is, they say (and it is not the opinion of the vulgar only), very imprudent to replace a natural power by a foreign element. Exercise is a necessary condition of health and life, for the physiological forces.

Assuredly there is nothing more true than this law, but with this restriction, that there be a force to put in action.

Now, in the terms stated, *no such force remains.* Presbyopia consists, as we have said, in this, that when the patient wishes to read or work at eight inches distance from the eyes, he has, for example, power only sufficient for twenty-four inches. Age has produced this double result; at the very time that his powers have diminished, the effort which nature demands has increased. The hardening of the crystalline lens has kept pace with the decline of the power designed to modify its shape. Would you ask a man of sixty to lift a weight of a hundred kilogrammes, when at thirty he was able to carry fifty only?

You desire, you may say, in order to obey physiological laws, that the presbyope should continue to exercise the power still at his disposal. Then the sole means of keeping in exercise the accommodative power which still remains is precisely by the use of proper spectacles, which are those which *make up for the proved deficiency and which do not exceed this.* The glass indicated is, in fact, that which corrects exactly this deficiency, that which measures precisely the difference of refraction necessary to pass from twenty-four to eight inches. Its adoption takes for granted, therefore, the maintenance in exercise of the power which serves to give clear vision at twenty-four inches.

§ 40. **Cases in which the convex glass may be too strong.**—Still the dominant prejudice must have some grounds for its existence. If the public distrust the use of spectacles, it must be from having observed some mischievous results.

Undoubtedly, in certain cases, the use of convex glasses, even of those best suited to the insufficiency of refraction, has produced evil results. But these cases are very clearly defined, and the mischief has been due, not to the convex glass, but to an unrecognized complication. Let us suppose, for example, the very common case of a presbyopia, complicated by a marked diminution of the acuity of vision, necessitating, as a consequence, a considerable enlargement of the image. The patient is very naturally led to bring the object near to his eyes, and so persuaded to the use of a glass stronger than suffices to correct the simple range of vision. Observers may say with reason, that the glass is *too strong*. But, even here, it is not the glass which is really too strong; the evil arises from the obligation which the patient is under of bringing *binocular vision* to bear upon a near object. The patient is placed in conditions more or less resembling those which we shall study further on, under the title of asthenopia, from insufficiency of the internal recti muscles (§ 61).

The exaggerated effort, rendered necessary in order to bring the optic axes to converge upon a point too

near to the eyes, produces in the eyes an excess of internal tension, which rapidly adds its effects to the other morbid tendencies already existing.

Thus, when he is obliged to remedy a presbyopia complicated with greater or less diminution of the acuity of vision, the oculist has to deal with new indications. Since diminution of the acuity has no other corrective than the enlargement of the image, and since the dimension of this depends upon the distance of the object only, there is necessarily a limit to be fixed. This limit will evidently depend in each case, both on the diminution of vision and on the necessities of the patient. Upon these bases, the oculist will determine the minimum of size of the objects to be used; he will counsel the use of larger type, the adoption of larger handwriting, &c. Whilst, at the same time, by diminishing the mutual distance of the centres of the convex glasses employed, he will give to the spectacles a prismatic effect suited to relieve the action of the internal recti muscles.

But as for the glass itself, whatever it may be, it is not too strong if it is employed for one eye. The use of the magnifying glass, or of the microscope itself, is not dangerous so far as the refraction is concerned: with these instruments, *used for one eye alone*, the organ is placed at the maximum of accommodative relaxation; or rather, the accommodation is reduced to its minimum of activity.

§ 41. **Causes of the prejudices existing respecting the use of Spectacles.**—The case, however, which has just occupied our attention, is relatively exceptional, and the true cause of the discredit of convex glasses is to be found elsewhere. It is due to the confusion, existing up to the present time, between certain diseases of the deep membranes or of the eyeball, and presbyopia properly so called. Human nature has so great a propensity to seek for the cause of diseases outside of itself! Every progressive amblyopia, every cataract of slow development, glaucoma, atrophy of the optic nerve or of the retina, &c., &c., all the forms of chronic disease which make their appearance after the fortieth year, are, according to the popular idea, so many cases of presbyopia aggravated by the careless use of spectacles increased in strength too rapidly. Here again the effect is taken for the cause. When a presbyope, says Donders, desires to change his glasses too frequently, examine the tension of the eyeball, be mindful of glaucoma!*

* The passing question of tension of the eyeball is here of the greatest importance, we are therefore in duty bound to quote some impressive remarks literally from Professor Donders.

"A recognised excess of tension of the eye, a difference between the degree of tension of the two eyes, leads immediately to the suspicion of *glaucoma* simplex. If at the same time commencing excavation of the optic nerve be recognised with the ophthalmoscope, together with arterial pulsation on slight pressure with the finger; and if, with a feeble light, the peripheral field of vision, without being really restricted, be less

§ 42. **Premature Presbyopia.**—In considering the etiology of presbyopia a popular error demands our attention. Many persons believe their eyes, in other respects sound, to have been fatigued by excessive work. Such a thing is by no means impossible. It is however less common than is generally conceived. It rarely happens that work performed under sound hygienic conditions, with the physiological elements intact, impairs the accommodation of the normal eye. The causes of the fatigue experienced by the organ, and the premature diminution of accommodative power, are to be sought rather in general diseases, the exhaustive fevers, premature old age, and the various forms of blood-poisoning which so

sensitive on the inner side, the case demands the utmost care on the part of the practitioner. Although with these symptoms the iris, the size and mobility of the pupil, the depth of the anterior chamber of the eye, and the sensibility of the organ may be still normal, there are no coloured rings about the candles, though the sub-conjunctival vessels are perhaps somewhat dilated. I speak seriously to the patient: 'There is the commencement of a disease of much consequence, which is sometimes rapidly, sometimes slowly developed. Art can, however, prevent it, for this I can answer. I shall expect to see you again in a month. If redness or pain come on, come to me immediately, even if you are indisposed, for by neglect, but by neglect alone, irretrievable blindness might be the result. I shall give you a few lines for your medical attendant. Meanwhile you must spare your eyes. Reading I will not absolutely forbid, but use a large print, stop often, and immediately whenever you have any feeling of uneasiness.' These words are the introduction to the proposal of iridectomy, which at the following visit he has to expect. Humanity urgently requires that prejudice and ignorance should no longer oppose the use of iridectomy in glaucoma."

readily induce muscular pareses and paralyses. There is however another cause, strictly physical in character, of this apparently premature weakness, but its importance necessitates a separate chapter (see §§ 44, &c., *Hypermetropia*).

§ 43. **Paralysis of the Accommodation.**— Failure of the accommodation to satisfy the requirements of vision for near objects acknowledges other causes besides senility; it sometimes has its origin in true paralysis.

If the characteristic common both to presbyopia and to paralysis of the accommodation be found in the ability to see distant objects clearly but the inability to see near objects clearly, and in being in the latter condition equally relieved by a suitable convex glass, the two states nevertheless offer more than one difference as distinctly recognizable.

In paralysis of the accommodation the iris generally follows the fate of the ciliary muscle; there is immobility of the pupil which is dilated to a medium extent (mydriasis); hence a brilliant light does not restore to the patient the power of reading which it momentarily affords the presbyope, by diminishing the extent of the circles of diffusion. Whilst on the other hand, at a similar age, the correcting glass must of necessity be much stronger in the case of the patient suffering from paralysis. Finally, together with the mydriasis

in the latter state, there are micropsy* and multiple uniocular images (see § 87).

Inquiry should also be made if, in the antecedents of the case, there may not exist evident or probable causes of nervous or muscular impairment, such as syphilis, rheumatism, fever, or the various blood-poisonings. The precise difficulties must be tested ultimately by analysis of the refraction by means of correcting glasses.

Class Second.

PERSONS HAVING VISION MORE OR LESS DISTINCT FOR DISTANCE, BUT UNABLE TO MAINTAIN VISION FOR NEAR OBJECTS.

§ 44. **The Patient sees fairly well or very well at a distance, but can only maintain clear vision for near objects for a limited time.**—The simple statement of the question shows at the outset that the patient's eye possesses, under given circumstances, a refractive condition compatible

* Micropsy consists in this; objects appear notably smaller than previously. The eye weakened in its accommodative power is obliged, in order to see with distinctness at a given distance, to make a greater accommodative effect than ordinary. It conveys to the sensorium a false idea of the distance of an object, making it less than the real distance. And as the visual angle remains the same, the final idea resulting is that of a smaller object.

with both distant and near vision ; a property constant in the first case, but temporary only in the second.

What is to be understood by the statement that the power of distinct near vision is only temporary? This evidently signifies that the powers which affect near vision cannot be long kept in action. What then are these powers? The accommodation first of all, the faculty of convergence secondarily ; powers which, being both of them muscular in character, necessarily imply the possibility of fatigue or insufficiency.

The failure indicated will depend therefore either upon each eye considered singly or upon the system which presides over their mutual convergence.

If the case under notice belong to the second category, it is clear that by excluding one of the eyes, by means of a bandage or a suitable shade, the patient will be relieved and rendered fit for near work ; it will indeed happen tolerably often that this fact has not escaped the notice of the patient, and he will tell you unasked that he feels less fatigue and can continue his work for a longer period by closing one eye.

§ 45. **The condition when the difficulty of maintaining near vision depends on each eye considered singly. Symptomatology of Accommodative Asthenopia.** — The functional disturbance, which now occupies our attention, the im-

possibility of continuing near work, generally concerns each eye separately, and shows itself in an almost invariable manner under the following aspects:

"The eye has a perfectly normal appearance, its movements are regular, the convergence of the visual lines presents no difficulty, the power of vision is usually acute—and nevertheless in reading, writing, and other close work, especially by artificial light, or in a gloomy place, the objects, after a short time, become indistinct and confused, and a feeling of fatigue and tension comes on in, and, especially above the eyes, necessitating a suspension of work. The person so affected now often involuntarily closes his eyes, and rubs his hand over the forehead and eyelids. After some moments' rest, he once more sees distinctly, but the same phenomena are again developed more rapidly than before. The longer the rest has lasted, the longer can he now continue his work. Thus, after the rest of Sunday, he begins the new week with fresh ardour and fresh power, followed, however, by new disappointment. If he is not occupied with looking at near objects, the power of vision appears to be normal, and every unpleasant feeling is entirely absent. If, on the contrary, he endeavours, notwithstanding the inconvenience which arises, by powerful exertion to continue close work, the symptoms progressively increase; the tension above the eyes gives place to actual pain, sometimes even slight redness and a flow

of tears ensue, everything is diffused before the eyes, and the patient now no longer sees at first well, even at a distance. After too long-continued tension he is obliged to refrain for a long time from any close work. It is remarkable that pain in the eyes themselves, even after continued exertion, is of rare occurrence" *(Donders).*

§ 46. **The signification of these symptoms.** Such a condition, the aggregate of symptoms and all the secondary consequences which supervene after a certain period which will be noticed hereafter, daily experience teaches us disappear as if by enchantment before the use of a suitable convex glass for near work.

On the other hand if, by means of a drop of solution of atropia, the accommodation be paralysed in the subject of these symptoms, it is found that he no longer possesses clear vision for *distance*, and that, in order to restore it to him, it is necessary to place before his eyes a convex glass of greater or lesser power. This condition, formerly unrecognized or vaguely designated under the name *hyper presbyopia*, is termed by modern science *hyperopia* or *hypermetropia*.*

* The typical (emmetropic) eye (fig. 4) is, as we have said (§ 11), that which, without any action of the accommodation, has its retina at the exact focus for parallel rays. But although the majority of eyes answers to this condition, we constantly meet with a large number in which the

If the hypermetropic eye, having its accommodation paralysed, can see at a distance by the aid of a convex glass only, we must conclude, that in its usual state it employs part or the whole of its accommodation in order to secure clear vision for distance. On this account whilst the patient is young, and has accommodation at his disposal, his infirmity does not betray its presence in vision for distance.

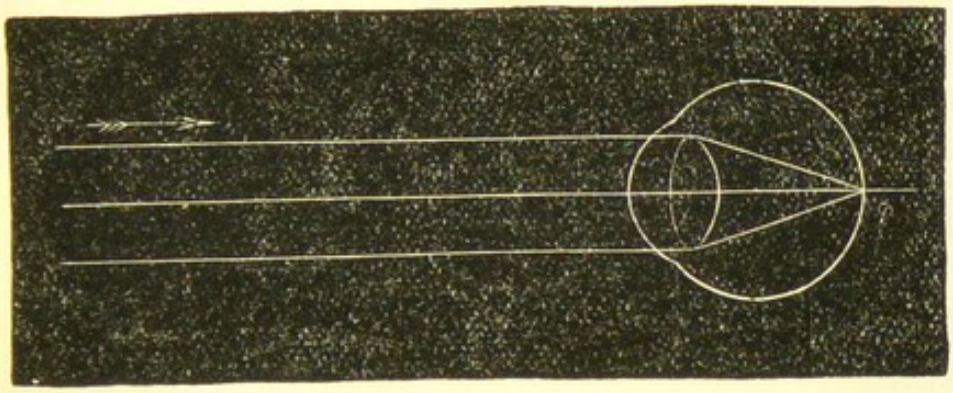


Fig. 4.

retina is found, by the very structure of the organ, placed either *in front* of the focal distance (hypermetropes, fig. 5), or, on the contrary, *behind*

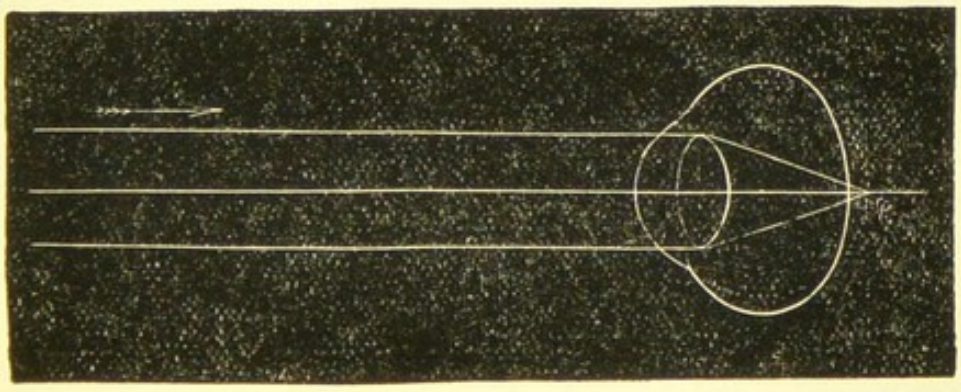


Fig. 5.

But if the degree be ever so slight, or if the patient be confined to a laborious occupation in which the sight is directed to near objects, the fault shows itself sooner or later. The extent of the power of accommodation is manifestly the same in all subjects of the same age and state of health; if, therefore, the hypermetrope is compelled to borrow for distant vision a certain part of this power, the quantity borrowed will be wanting for near vision. And at the end of a fluctuating period, gradually becoming reduced in length, the power capable of being used for near work being

the focal distance (myopes, fig. 6); and this is always the case, be it understood, whilst the accommodation is at rest. The first are *too short* for the focal length of the refractive media; the second *too long*. It may be said also that those in which the retina is in front of the focus have too little refractive power for their length, and that the others have too much.

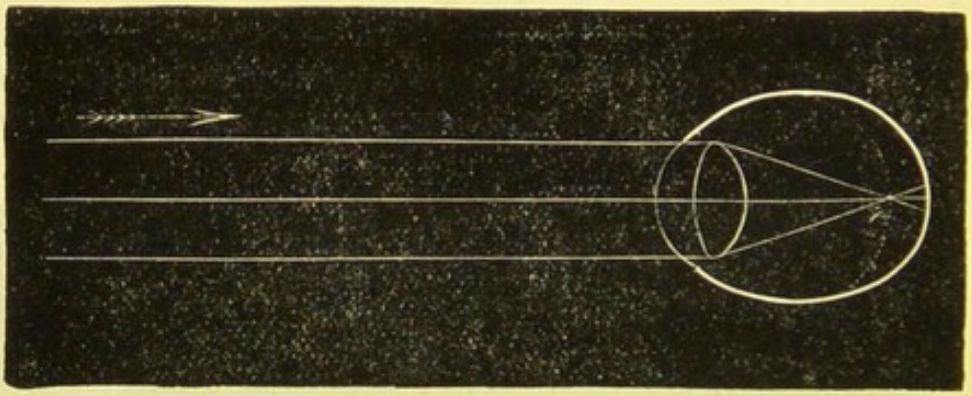


Fig. 6.

It has been shown, anatomically, that in hypermetropes the eye is actually too short, the refractive media (cornea and crystalline lens) being normal. And inversely, in myopes, the eye is too long, the refractive power being in these cases normal also.

continuously employed at its maximum of tension, is overstrained, and the relief afforded by the convex glass is as immediate as it is surprising. By contributing the amount of refractive power needed, it relieves instantaneously the fatigued accommodation.

§ 47. **Frequency of Hypermetropia.**—All practitioners of medicine should pay attention to its symptomatology.

The characteristic symptoms of accommodative asthenopia should be present in the mind of every general practitioner; this affection is one of the most frequent which presents itself in the study of diseases of the eye; in the statistics of special cliniques it occupies the fifth or sixth place in point of frequency. The practitioner should, however, be on his guard with respect to a deceptive appearance; it sometimes happens, either from the effect of spasm of the overstrained accommodation, or from a true consecutive amblyopia, that the hypermetrope presents, with the semblance of the opposite condition, myopia, phenomena due to two varieties of causes.

In a high degree of hypermetropia, the long accommodative efforts, by congesting the deep membranes, frequently induce a certain degree of amblyopia. And the amblyope no longer seeks clearly defined images; what he desires are large images, and these are not obtained but by increased approximation of objects,

by which means the retinal pictures enlarge much more rapidly than the circles of diffusion.

On the other hand, a forced convergence of the optic axes which is more easily attained in hypermetropia than in any other refractive condition, comes to the aid of the accommodation, and tends, in addition, to contract the pupil. It is not, therefore, very uncommon to see hypermetropes bring small objects near to their eyes after the manner of myopes. And when it is remembered that in case of the latter, the amblyopia of which they are the subject affects also distant vision, it will be easily understood how, for so long a time, hypermetropia was confounded with the opposite condition.

Apparent myopia is nevertheless exceptional, and hypermetropia of medium or advanced degree generally presents itself under the form of accommodative asthenopia. This is almost an invariable rule in young persons following delicate employments, as is seen in schools and many of the industrial callings in towns; and among compositors, draughtsmen, engravers, tailors, seamstresses, etc.

§ 48. **In persons advancing in years, Hypermetropia shows itself in premature Presbyopia.**—At a more advanced age, towards thirty or thirty-five, and where there has been no excess of work, the manifestation of the hypermetropia takes

another form; this form is that of *premature presbyopia* (§ 42). The patient suffers, at from thirty to forty years of age, the visual disturbances, which the normal eye only experiences physiologically between forty and fifty.

§ 49. **Physiognomy of the Hypermetrope.** The hypermetropic eye may be recognized at a glance by the characteristic shortness of the globe. The cornea projects above the sclerotic, whose widened equator is separated from it by a sort of groove; it may be said of a markedly hypermetropic eye as it is of the terrestrial globe, that it is flattened towards the poles and swollen at the equator (see fig. 5).

Hypermetropia is, to a notable extent, a hereditary condition, although it may, as is well known, be entirely individual.

This form of eye is very frequently complicated with convergent strabismus, confirmed or intermittent; in any given family rich in hypermetropes, convergent strabismus is found more frequently than in any other.

§ 50. **Complications of Hypermetropia.**— Accommodative asthenopia, if it be not opportunely relieved by appropriate glasses, is soon complicated by a number of secondary disturbances. The first in point of date is generally a habitual congestion of the deep membranes, which is followed sooner or later

by an alteration in the nutrition of the transparent media. Of these membranes it is the retina which appears the most affected, and its sensibility often suffers, presenting either hyperæsthesia or a feebleness in its reactions. A certain diminution of acuity is the ordinary consequence of a prolongation of this abnormal condition.

Let us add to this description the habitual congestion of the ocular appendices, bringing in its train blepharitis, frequent conjunctivitis, lachrymation, sometimes engorgement of the lachrymal sac, and we shall have an idea of the inevitable consequences of an asthenopia depending upon refractive fault. As a symptom frequently complained of, let us note also a great feeling of weight in the eyelids, with difficulty in opening them on awaking in the morning.*

§ 51. **Treatment and Hygiene of Hypermetropia.**—With an origin so entirely physical is it possible to apply a remedy other than that which neutralizes its cause, that is to say, the optical compensation of the refractive deficiency! Here the convex lens proves a real boon to humanity.

Face to face with this simple means should be placed the picture of the vague methods, wanting in precision and proof, endless in application, useless and moreover

* The results of recent statistics (Badal) show that hypermetropia is by far the most frequent cause of engorgement of the lachrymal passages.

cruel, with which ancient surgery ignorantly combated asthenopia. The period is indeed not far removed from us, when against the symptoms which have just been described there were no other forms of treatment than leeches, repeated purgatives, cuppings dry and moist, blisters, moxas, and finally that last resource, the seton to the nucha. This thorny path trodden, the patient was definitively classed among those suffering from an incurable amblyopia.

But enough; proof is no longer needed, and the thousands of asthenopes relieved, *cured* each year by the simple indication of the glass correcting their hypermetropia, leave henceforth no ground for the smallest objection. Let any one try to prevail upon those unfortunate patients whom the use of glasses has snatched from despair and restored to usefulness, to give up their precious succour!

The prejudice existing with regard to glasses is met with sometimes under a curious shape. "But in using, from the present time, a glass of so high power (referring for example to No. 12 (3 D.) for a man aged fifty), have I not to fear, doctor, getting into such a condition, as age advances, that I shall not be able to find any glass sufficiently strong?" The reply to this anticipation is easy. A total hypermetropia of 10 dioptrics is that which at twenty years of age, needs, after paralysis of the ciliary muscle by atropine, a glass of 10 cm. focus for distant vision.

At sixty years of age the patient will be in the same condition, *without the use of atropine;* he will have lost the ten dioptrics which indicate at the age of twenty the range of his accommodation. And he will therefore be compelled for reading at 25 cm. to add to the 10 dioptrics necessary for distant vision, a lens of 25 cm. focus, or 4 dioptrics. He will need, therefore, for very near work, 14 dioptrics or a glass of 7 cm. focus. Now the boxes of ordinary test glasses extend to 20 dioptrics, and ordinary commercial limits would thus not be exceeded by a hypermetropia of 16 dioptrics. Let us add that an emmetropic eye, after the operation for cataract, does not need a glass stronger than 10 dioptrics for distance and 13 for reading, and it will be seen that the margin is sufficiently ample.

§ 52. **The condition in which the vision for near objects is maintained without difficulty by excluding one eye.**—This state, fully established, shows that the difficulty of which the patient complains, that of being unable to continue near work for any length of time, depends upon the resistance which attends the maintenance of convergence of the optic axes for a near point. This resistance originates in the preponderating action of the abductor muscles over the adductors, and has received the name of *insufficiency of the internal recti.* This want

of harmony may be met with in the emmetrope, and even, although more rarely, in the hypermetrope. But as it is a very frequent concomitant of myopia, we shall study it among the consequences or complications of this malady.

Second Division.

Persons who see clearly at a short distance only.

§ 53. **Myopia. What constitutes Myopia.** We have seen (§ 46, note) what is to be understood by the myopic eye: an eye too long for its refractive system, an eye in which the principal focus falls in the vitreous chamber anterior to the retina.

This condition of eye, which corresponds to an excess of refraction in the dioptric apparatus compared with the distance which separates it from the retina, is not, as was long believed, the consequence of an absolute excess of refractive power. Contrary to ancient opinion, the cornea and the crystalline lens have actually the same curvature as in the normal eye, and the media the same index of refraction.

It is the eyeball itself which is too long for the refracting media (it has been known to measure almost one-third more than the measurement of the normal eye. See fig. 6). This lengthening of the eyeball, the immediate cause of the myopia, derives its origin from an

anatomical change characterized by an outward protrusion of the deep membranes, the result of their atrophy or progressive absorption (posterior staphyloma).

§ 54. **Diagnosis of Myopia.**—Myopia is easily diagnosed: vision for distance is either absent or, if present, confused, and is immediately and extremely improved by the use of a suitable concave glass.

§ 55. **Peculiarities of near vision in the myopic eye.**—If the myopic eye has but indifferent vision for distance it enjoys excellent near vision; better, apparently, but apparently only, than any other eye. Its near point is actually brought nearer with its far point. And since it possesses the same extent of accommodation as other eyes at the same age, and like other eyes possesses a ciliary muscle, it is able to permit considerably greater approximation of small and delicate objects, and so procures much larger images of these small objects than the emmetropic eye. Thus with an actually reduced acuity of vision, it appears to enjoy a superior degree of visual power. Let us add that, considering the habitual state of the pupil, which is naturally more dilated than in the emmetropic eye, it needs a lesser degree of illumination in near vision. These are all circumstances which have contributed to the deplorable prejudice that "the myopic eye is a good eye."

The gradual elongation of the eyeball in progressive myopia depends upon the distension and softening of the tunics which follow serous choroiditis, which is itself an almost inevitable companion of myopia even of slight degree. There is nothing, therefore, within the range of ocular hygiene, more deserving the attention of the practitioner than the surveillance of myopia. Left to itself, resigned to the continuous action of the causes which have determined its form, the elongated eyeball is threatened in the future either with progressive myopia or muscular asthenopia. The myopic eye approaches normal conditions only when the atrophy and distension of the deep membranes become stationary; and this happens only as the result of special hygienic treatment, or on the cessation of near work. The sole attention of the practitioner ought therefore to be devoted to the means best calculated to arrest this progressive tendency.

Let us consider a little more fully a subject of so great interest to all whose employment needs accurate vision.

The diminution, often extreme, of visual acuity in myopia, is exhibited with startling veracity, in a table presented by me to the Academy of Medicine, on the 15th of June, 1875, in a study of myopia in its relations to military service. This table presented five curves, reproducing in graphic form the abstract of the visual acuity of 900 cases of myopia, divided into five classes,

differing from each other by one-twelfth of excess of refraction (3 dioptrics).

In the first class, myopiæ ranging between 0 and $\frac{1}{12}$, in one hundred cases, one-third or 28·44 per cent. showed normal acuity or = 1 ; about four-fifths or 79·10 per cent., an acuity equalling at least $\frac{1}{2}$; the remainder or 21 per cent., a reduced acuity, of which 1·25 were lost eyes. In the second class, myopiæ ranging between $\frac{1}{12}$ and $\frac{1}{6}$, normal acuity is met with only about ten times in the 100. An acuity of $\frac{1}{2}$ is seen in about $\frac{2}{3}$; but below $\frac{1}{2}$ is found in 34·25 per cent., among which are 1·85 of lost eyes.

Between $\frac{1}{4}$ and $\frac{1}{6}$, myopes fall off greatly with respect to acuity of vision. In 100 of these, not more than 3·62 possess complete visual acuity. An acuity of $\frac{1}{2}$ measures the extent of $\frac{2}{5}$, or about 43·44 per cent.; and if the examination be carried on, the numbers corresponding to lesser degrees of acuity increase sensibly and reach 56·56 per cent., of which there are eleven below $\frac{1}{10}$ and 4·34 lost eyes.

Between $\frac{1}{4}$ and $\frac{1}{3}$ the disproportion is marked. There is no longer a single case of normal acuity, or equalling unity; an acuity of $\frac{1}{2}$ is represented by only 22 per cent., or less than one-fourth of the total; with an acuity of less than $\frac{1}{2}$ there is the threatening proportion of 77·20 per cent., of which 28·80 are below $\frac{1}{10}$ and 11·40 of eyes lost, or more than one-tenth.

But the picture is more gloomy still when we ap-

proach the last division, myopiæ of higher degree than $\frac{1}{3}$. Here the number of cases in which the acuity does not reach $\frac{1}{2}$ rises to 45·55 per cent., of which 31·15 are below $\frac{1}{10}$ and 28·48 lost. In short, 60·63 per cent. without any industrial value whatever!

And it should be remarked that under the denomination "*lost eyes*" allusion is intended to the following occurrences: central scotomata from choroidal hemorrhages, or invasion of the polar region by posterior staphyloma, detachment of the retina, synchysis or opaque softening of the vitreous body, secondary cataracts, &c.

Such are the statistics of myopia with respect to visual acuity.

§ 56. **Actual value of the myopic eye unprovided with spectacles, in its relations with distant objects.**—The question of myopia in its relation to military service, and the use of spectacles in the army, has given rise to the necessity for knowing: "to what degree of diminution of the visual acuity, the perception of the myopic eye without glasses, corresponds, in vision for distant objects."

Experiment upon emmetropic eyes rendered myopic by the apposition of convex glasses, has led me to the conclusion, that, a physiologically acute eye has its vision reduced by one-half for the first dioptric of excess of refraction ($\frac{1}{36}$); the acuity falling to $\frac{1}{10}$ for an excess of two dioptrics ($\frac{1}{18}$).

Direct trials of myopic eyes endowed with physiological acuity, have led Professor Noël, of Louvain, to the following results, which are nearest the truth: acuity useful for distant objects varies between $\frac{2}{3}$ and $\frac{2}{5}$ for myopia inferior to $\frac{1}{42}$; it is below $\frac{1}{4}$ from $\frac{1}{30}$ to $\frac{1}{20}$; descends to $\frac{1}{7}$ between $\frac{1}{18}$ and $\frac{1}{15}$; to $\frac{1}{12}$ between $\frac{1}{13}$ and $\frac{1}{10}$; then falls suddenly to $\frac{1}{30}$ in myopiæ included between $\frac{1}{6}$ and $\frac{1}{5}$.

§ 57.—**Appearance of the Myopic Eye.**—The eye of the myope most frequently carries with it the apparent signs by which it may be distinguished; it is relatively large, and hard under pressure; the cornea, without being on that account more curved than in the normal eye, is continued, without any sudden projection, in the same curvature as the sclerotic; the globe is therefore pointed in front; it forms the anterior extremity of an ovoid with its greater axis antero-posteriorly.

The myope himself has a manner peculiarly characteristic, having very confused distant vision, he does not give himself the useless trouble of trying to distinguish the features or aspect of persons forming part of the same assembly. Indeed, when he wishes to see a little more clearly, he instinctively brings his eyelids together, whence his name of myope: *μύειν, to close the eye.* This characteristic habit requires notice.

§ 58. **The habit of screwing the eyelids together.**—The narrowing of the palpebral opening, thus reduced to a horizontal slit, has for its immediate effect a remarkable amelioration of vision. This effect is commonly attributed to the correction of astigmatism or that asymmetry of refraction which often accompanies high degrees of anomaly of that function. The real optical mechanism of this habit is more complex in its causes; it was discovered in the seventeenth century by Dechâles, a learned jesuit. It is due, not to the reduction in all directions but one, of the circles of diffusion in the images produced by an inaccurately adapted refractive apparatus, as would have been the case in a homogeneous lenticular system. The retinal circle of diffusion is not, properly speaking, a circle, nor an ellipse, nor any other simple figure. It is composed of a circular group of many images, arranged side by side, and produced individually by one of the well-defined sectors of which the crystalline lens consists. All these images are accurately superimposed, when the refractive apparatus *is exactly accommodated for the distance of the object.* Under all other circumstances they encroach more or less upon one another, and may even be entirely separated; such are the physiological circles of diffusion. It is by this mechanism that the phenomenon of uniocular polyopia is produced, complained of in certain affections of dynamical refraction, as, for example, in paralyses of the accommodation,

and also in anomalies of static refraction. We have a common example in the statement of myopes who see the lunar crescent terminated by several horns.

Now the lessening of the palpebral opening reduces these images to two, situated in the same, horizontal, meridian, overlapping each other, therefore, much less than those furnished by two contiguous sectors.

Besides, one of these is always better illuminated and more central than the other, and therefore attracts the attention specially. In a word, the two most prominent images belonging to each eye are fused in the act of binocular vision, to the exclusion of the weaker, and an improvement of vision results, the value of which can only be appreciated by experience.

It is only necessary to render oneself myopic by placing before the eyes convex glasses of six or eight inches focus, and everything becomes indistinct immediately. Let the palpebral fissure be then reduced to a mere horizontal slit, and the great importance of this instinctive little act, in the vision of myopes, becomes apparent.

§ 59. **Progressive Myopia. Symptomatology.** Let us now notice the symptomatology of progressive myopia.

A patient suffering from progressive myopia is known by the appearance of congestive irritation of the eyes, varying in severity and frequency. When the retina

and the choroid become the seats of changes, which the ophthalmoscope alone reveals incontestibly, the ocular appendices and the subjective sensations of the patient indicate to him and to the practitioner the existence of internal changes. The patient feels a sense of heat in the part, the eyes are often red; the eyelids glued together in the morning; there is a sense of weight, of fulness, about the orbits; the eye feels too large for its socket. But the most striking and the most troublesome symptom is the constant presence of muscæ volitantes (§ 85).

These entoptic appearances are of all shapes and all sizes; and, whilst the small *pearly spectres*, phenomena almost physiological, need give no cause for anxiety, it is of the utmost importance that the number and the dull tint of floating bodies in the vitreous chamber should be taken into consideration.

When these bodies become considerable in size, when, with each movement of the eye, they change position in a marked degree, the integrity of the vitreous body is necessarily compromised.

If too, patients see from time to time flashes of light, or stars; if from day to day external light fatigues them more and more, we may know that these are the signs of atrophy which is consuming the choroid and laying bare the pearly substance of the sclerotic. Soon images are interrupted in their extent or in their contour (scotomata); the peripheral acuity of vision diminishes

more and more rapidly, the patient begins to be no longer able to fix objects with one eye, and this difficulty extends sooner or later to both eyes. Having reached this stage, the affection is extremely serious, effusions of blood, serous infiltrations, opacities of the vitreous body, detachments of the retina, and cataract, threaten the well-being of the patient.

§ 60. **Mechanism of progressive Myopia.** Without, however, reaching this almost final stage, there is another complication of myopia more particularly interesting, in that its study leads us directly to the establishment of hygienic rules adapted to counteract the disease itself.

The analysis of the mechanism of binocular vision teaches us that if all the symptomatic manifestations previously noticed depend upon lengthening of the eyeball, this in turn owes its origin to the excess of pressure exercised upon the eyeball, during the act of convergence, by the muscles which embrace it and govern its movements. In the state of equilibrium of the normal eye, the simple movement of mutual convergence of the optic axes irresistibly involves an increase in the intra-ocular pressure. But this tension, which is far from being imperceptible in a spherical globe under normal conditions when an object is brought within 25 cm. distance, must be considerably exaggerated under the action of tense muscles applied

to an eyeball which has become ovoid in form, and is imbedded in a conical infundibulum, the orbital cavity.

In proportion as the myope is obliged to bring objects nearer to his eyes, and thus to compel his optic axes to a more marked degree of mutual convergence, so the forces necessary to produce that effect must be increased. But at the same time, and in the same proportions, the internal tension, which also increases, augments the lengthening of the eyeball, or, in other words, the progress of posterior staphyloma. An unavoidable dilemma! The tendency of the disease to a more rapid advance increases with each stage of its development.

§ 61. **Muscular Asthenopia.** — The consequences of the struggle established between the motor forces applied to the eyeball and the reacting tension of its contents have at times quite another aspect, and present totally different characters.

In the mechanism which we have just analysed, the reaction of the ocular envelope, supported by its contents, against the excess of pressure developed by the muscles in the act of mutual convergence, instead of giving way gradually before that pressure, may struggle with it with advantage, and so hold the muscles in check. In fact, in this struggle, the over-strained muscles may and often do become unequal to the duty imposed

upon them. Their power becomes more or less quickly insufficient for the calls upon them. What is this insufficiency, if not a condition approaching closely that of fatigue or exhaustion? Then the impossibility of fixing binocular vision for any length of time upon near objects is noticed, and at the end of a variable, and relatively short period, patients complain of an aggregate of symptoms offering a certain analogy to those of accommodative asthenopia.

For example: "Vision, which is distinct at the commencement of the task, soon becomes more and more painful, and at length impossible. The eyes become clouded, fill with tears, patients have a sense of uneasiness, of pain in the orbit, particularly towards the inner angle of the eye (sometimes over the temples): the letters become mixed, or have a dazzling appearance, or appear double and quickly run together. The patient feels the need of putting his work farther from him, and experiences great relief from closing one eye and covering it with his hand" (see 50).

In these cases we often see chronic inflammations of the tassal margins, repeated styes, epiphora, migraine, as in accommodative asthenopia. And it is useless to say that these discomforts are ever completely removed without previously remedying the anomaly of refraction.

Among the manifestations of muscular asthenopia, there is one which we have never seen mentioned in any book, but which we have frequently noticed,

sufficiently often indeed to attach to it great importance as a diagnostic sign. It is a certain redness, an active rosy injection of the face, almost erysipelatous (less the tumefaction), an exaggeration of the English "floridness."

We mention it for the observation of our specialist confreres.

§ 62. **Mechanism of Divergent Strabismus, symptomatic of Myopia.**—The exclusion of one eye, of which mention was made in the preceding section, is often brought about spontaneously. Myopia in advanced life, and high degrees of myopia in youth, frequently exhibit this symptom, *divergent strabismus.* This is in reality only a spontaneous action, instinctive on the part of the individual, who thus avoids the consequences of insufficiency of the muscles of convergence, and the muscular asthenopia which is its result, by an outward deviation of the eye.

§ 63. **Hygiene of Myopia.**—These considerations suffice to indicate the general principles which should guide the conduct of the surgeon. The eye of the myope is threatened in two directions, by intra-ocular tension and by muscular insufficiency. But these two dangers have only one and the same starting point: binocular convergence, especially if this be exaggerated. The accommodation has no share in it. The myope

has always at his service a greater amount of accommodation than circumstances demand. The source of danger lies in forcibly directing binocular vision to a point too near to the eyes. All the advice of the practitioner should have this object, viz., to procure for the myope distinct vision at the greatest possible distance, speaking generally from eight to twelve inches.

Another consideration, secondary, it is true, when considered in relation to the first, that of holding objects at a certain distance, is the danger the myope incurs when bending over his work, and leaning his head forwards, of compressing the blood vessels which convey the blood from the head; in this impediment to the circulation congestion of the choroid finds an evident auxiliary.

The means of preventing the too great approximation of objects consists exclusively in the employment of spectacles adapted to give the insufficiently divergent rays (or those proceeding from points too far distant in respect to the refractive power of the eye) the degree of divergence required by the state of the refraction. The glasses needed are well known to be concaves. Their exact determination necessitates calculations which would be out of place here. From the preceding analysis, the following conclusion, contrary to received custom and opinion, is derived; viz., that the myope is more bound to use concave glasses for near than for distant vision.

Unless he should be placed on the look-out, or as sentry, the myope may, strictly speaking, content himself with imperfect definition for distance. According to his choice, he may or may not use glasses adapted to neutralize his myopia. But in near work, where accurate images are absolutely necessary, distinct vision can be obtained only by a dangerous approximation of the object, and he can escape this necessity solely by the employment of glasses suited to the degree of his myopia and the distance at which it is necessary to keep the object from the eyes. In short, in the case of the myope concave glasses have a double object, for distance they serve him to see accurately; near at hand, they serve him to see, not more distinctly, but at a greater distance.

§ 64. **Does the Myope require two kinds of glasses?**—It now becomes a question if the myope should use different glasses for near and for distant vision.

In accustoming himself to the constant use of neutralizing glasses, the myope places himself, so far as artificial means allow, in the condition of an emmetrope; and thus what theory teaches experience confirms. Donders has observed that those persons who have been provided, from their youth, with neutralizing glasses, have not had to deplore, later on, the consequences of myopia. Their myopia has remained stationary.

But to this general rule there are two exceptions. First, where the patient is the subject of a high degree of myopia complicated by amblyopia. The greatly reduced acuity of vision necessitates great approximation of objects, if images of a sufficient size are to be obtained. The use of a concave glass may therefore be contra-indicated, for the intervention of a strong concave glass diminishes notably the size of the image.

And if, as is often the case, there exist at the same time a certain degree of insufficiency in the power of convergence, the case becomes one of extreme delicacy, because it is necessary to choose between the exclusion of one eye for near vision, and tenotomy of one or both of the external recti muscles. The preservation of sight, in one eye at least, is only insured at this cost.

Secondly, where the myope is no longer young and his myopia is of tolerably high degree (between $\frac{1}{5}$ and $\frac{1}{8}$ for example), unavoidable discord is established between the accommodation of each eye and the mutual convergence of the two eyes, and the habits so acquired have become a second nature. Here the glass proper to neutralize the myopia, excellent though it be for distant vision, if applied, without gradual change, to near objects, reveals the want of harmony existing between the two synergical forces which co-operate in near vision. The patient then says that his glasses

for distance give him pain when used for near objects; they *draw* his eyes. This may be explained perfectly.

The myope, as we have seen, has always more accommodation available than is needed for a given degree of convergence. Working ordinarily without glasses, he accustoms himself to relax that power; and when this has been done for a long period, the regular relation, physiologically established between the two muscular powers, accommodation and convergence, is found to be gradually sundered. All at once, a relatively strong concave glass is interposed, and to a given relation of the optic axes corresponds suddenly an unaccustomed divergence of rays and as a consequence the necessity for adequate accommodation. These new relations, accurate if the eye were normal, become for the myope modified by habit, abnormal relations, and the organ is unable to accept them readily. It becomes necessary therefore to prepare it gradually for such functional regeneration. This is attained only by correcting a part of the difference at a time. The patient is therefore fitted, for near work and reading, with the weakest concave glass which gives him clear vision at about fourteen inches (40 centimetres); then every six or twelve months the power of the glass is increased, so as to reach in three or four years a glass of full neutralizing power. Then the same glass, constantly worn, will serve equally for near and for distant vision, and the patient will be

restored as nearly as possible to physiological conditions.

But in all these circumstances neither the patient nor his advisers should lose sight of the main points just demonstrated; viz., that glasses, in near vision, are not given to *improve vision*, but to *increase the distance* at which objects may be seen. If the patient should make use of these glasses to bring objects still nearer to his eyes, far from being useful to him, they would infallibly aggravate his condition. However, such is not generally the case; the patient, for the reasons above given, has no longer, when aided by the glasses, the same tendency to approximate objects. In short, the end to be aimed at is to lead the myope gradually to the condition of normal refraction by means of the use of a glass exactly neutralizing the defect for all distances and all occasions. Success may be obtained rapidly if the patient be young, but the more he is advanced in years the more important it becomes to use circumspection.

§ 65. **Myopia as time advances.**—If presbyopia is nothing more than senile insufficiency of the accommodation, myopia may and must be complicated by presbyopia, as is the case in other states of defective vision. Only the patient may not suffer from it, or at least not be conscious of it. That will depend upon the degree of his defect.

High degree of myopia.—Thus the starting-point of presbyopia being fixed at eight inches, a myope whose far point is eight inches, after the total loss of his accommodation, will still see distinctly at eight inches, but he will not see clearly either beyond or within that distance. If the necessities of his calling do not impose upon him very delicate work, he may therefore practically ignore the existence of his presbyopia: he is presbyopic without knowing it.

Slight degree of myopia.—In myopia of a low degree this is not so. Starting from $\frac{1}{15}$ the myope, like the emmetrope, should, although very slowly, feel the effects of the loss of his accommodative power. Then he will need a concave glass for distant vision and a (weak) convex glass for reading. But this will scarcely ever be necessary before sixty years of age, and only then in slight cases of myopia.

The preceding explanations anticipate the answer to the question so often asked: does not the sight of a short-sighted person improve with advancing years? In reply, it is only necessary to consider, first, that as years pass on the acuity of vision diminishes with every one; and secondly, that the myope threatened, or attacked by a progressive change in the deep membranes of the eye, has this as a second cause to add to the physiological diminution of visual acuity; and thirdly, that if the disease of the deep membranes progress, the myopia itself increases in proportionate degree.

Two causes ought however to be mentioned, which, without altering really the optical condition of the myope, may render his sight better as time advances, and have certainly given rise to the general prejudice that the sight of a myope improves with time. Presbyopia, in the preceding pages, has been regarded only in its fundamental condition: the receding of the near point. We have supposed that during this recession of the near point, the far point remains perfectly unchanged. Accurately speaking this proposition is an error; the far point is not actually involved until late, after sixty-five, and is then only slightly removed ($\frac{1}{30}$ at most). Now this amount, which converts the normal into a hypermetropic eye (the acquired hypermetropia of Donders), evidently diminishes the degree of excess of refraction in the myope.

Thus a myopic eye of $\frac{1}{30}$ becomes at the age of sixty-five an emmetropic eye; a myopia of $\frac{1}{10}$, or of ten inches, is reduced to $\frac{1}{18}$; a myopia of sixteen inches descends to $\frac{1}{36}$, and so on. At the same time, the near point has approached the far point and the patient has become really presbyopic.

To this must be added the secondary action of the pupil which contracts with advancing years. The magnitude of the circles of diffusion thus decreases simultaneously with the degree of the myopia or the primary excess of refraction.

In all these relations it is undeniable that the myopic

eye may, with the progress of time, experience actual advantages, and so far the popular prejudice has certainly ground for its existence. It remains however only a prejudice. The improvements, whose mechanism has just been explained, apply only to slight degrees of myopia, or rather to myopia when the termination of diseased action has been reached. The myopic eye, which remains the subject of the too common causes of progressive myopia, is very far from being benefited by these consequences of age. The atrophy of the deep membranes, which is constantly gaining ground, unhappily more than compensates for the slight effects of lapse of time upon the position of the limits of the range of vision.

§ 66. **Myopia is a product of civilization.** All cases of myopia are certainly not progressive; if the myope place himself early under favourable conditions, if he carefully ward off all influences likely to increase intraocular pressure, that is to say to necessitate a more or less marked degree of convergence of the optic axes, he may entertain a well-founded hope of preventing the progress of the myopia.

Put a young myope to follow the plough, or place him on board ship, so that he may not have to weary his eyes by attention to books or the use of delicate instruments, and the myopia, in all probability, will not progress, and if of slight or of moderate degree, will improve.

But should the young myope after leaving school continue, without knowing or without following the hygienic rules to which he ought to submit, occupations which necessitate the close approximation of objects to his eyes, then it may be said without fear of contradiction, that his myopia is doomed to progress, and he is threatened with all the consequences of incessant protrusion of the ocular membranes. And this result especially to be feared if the young patient belongs to a family in which myopia is hereditary, becomes inevitable if symptoms of insufficiency of the internal recti present themselves; the irregularity which constitutes the true starting-point of protrusion of the globe.*

Myopia depends therefore upon an hereditary or congenital predisposition; but the circumstances which develop it are entirely the products of civilization.

The rural populations, those engaged in pastoral pursuits, and soldiers brought up in the country, embrace only a small proportion of myopes. This proportion, on the other hand, increases in such a way as to leave no doubt as to its cause, among those engaged in the various employments which are the outcome of civilization.

The myopic eye is not especially distinguishable at birth. An experienced observer may recognize a predisposition to softening of the ocular tunics in a young subject of seven or eight for example; but it is

* Vide *Annales d'oculistique*, Dec., 1866.

very rare to find a myopia higher than $\frac{1}{36}$ and more than the very commencement of a posterior staphyloma at that age.

The comparison of statistics, however, shows us the proportion of myopia among the population, and the degree of the myopia advancing with the closeness of application of sight.

Facts observed during recent years in numerous schools throw a brilliant light upon the previous sketch. Dr. Hermann Cohn, of Breslau, imposed upon himself the task of examining a large number of scholars (10,060) and students of all classes, and measuring the degree of their refraction.

Among these 10,060 he found 1,834 cases of functional anomaly; and among them 1,004 cases of myopia, of which 10 were hereditary and 58 the results of other ocular affections.

From which it appears at once that in schools myopia is alone five times more frequent than all the other visual anomalies put together.

The statistical tables arranged by this patient observer show us in addition:

1. That myopes are found in all schools;

2. That whilst relatively few in the village schools (1·4 per cent.), they become eight times more numerous in the town schools (11·4 per cent.);

3. That in the town schools the proportion of myopes increases with the standard of the schools;

primary schools 6·7 per cent., medium schools 10·3 per cent., normal schools 19·7 per cent., high schools *(gymnases)* 26·2 per cent.

4. In the high schools more than one half of the pupils of the first class (highest) are myopic; and in all schools of whatever kind the upper classes contain more myopes than the lower.

5. In short, the degree of the myopia increases in a tolerably regular manner with the standard of the schools and about 1·5 D with each two years of the age of the pupils. On the other hand myopes are not found among those who have not completed their first half year.

Application of sight to near objects is therefore the determining factor in the production of myopia, as insufficiency of the abductor forces in the motor mechanism of the eyes is the predisposing factor. And these results will be so much the more marked and rapid according as the patient finds himself in peculiar circumstances obliging him to bring the object of his attention nearer to his eyes.

Among the secondary causes should be cited:

Insufficient illumination;

Bad print, pale ink and very small type;

Corneal opacities;

Antecedent amblyopia;

In a word, all the conditions which impel the patient to seek a larger retinal image by the approximation of the object.

These considerations, it will be seen, are of the highest importance for the future of the young, and call for the greatest solicitude, not only on the part of their families and medical practitioners, but also of departments of public health.

§ 67. **The influences which these considerations ought to have upon the education of youth.**—Before consigning a youth, whose vision is impaired, to the rigorous discipline of college life, it is imperatively necessary that his eyes should be subjected to a careful ophthalmoscopic examination.*

If the choroid be thinned and eroded in certain spots, if the optic disc exhibit a small crescent, if also there be any sign of insufficiency of the internal recti muscles, the future of the eyes is seriously compromised. Six or eight years of university life severely threaten the ultimate integrity of the organs.

This warning, directed to families and their advisers, may not unjustifiably reach the shepherds of these young flocks. If alimentary hygiene have become at the present time, so far as our youth is concerned, the subject of anxieties, such as our own generation never profited by, there can be no doubt that, in its turn, the

* In such children ophthalmoscopic examination shows a rosy white fundus, a choroid sparsely pigmented, through which the sclerotic may be seen; the source and origin of atrophic choroiditis. And in these cases there is frequently the indication of insufficiency of the internal recti muscles.

hygiene of vision will be equally considered. We shall then see the heads of educational establishments consulting in this respect the prescriptions of science, and shall no longer have before us the spectacle of unfortunate children stooping, in badly lighted classes, over badly printed books, looking at type of a greyish or indistinct character, or microscopically small, for many hours successively. The periods of work alternating with frequent periods of rest will no longer be followed by the harsh necessity for change, which the lung evidences by the cries proceeding from the crowd of scholars suddenly leaving the school-room for the playground, a necessity which the ocular tension would as often manifest if, like the lung, the choroid had the larynx at its disposition.

§ 68. **The influence of heredity and of certain other non-mechanical causes.**—Heredity has been cited among the most ordinary causes of myopia. The fact is incontestible, and may be observed over a large area. But in this observation should be recognized the hereditary transmission of conditions, which contain in themselves the mechanical elements, the future factors of myopia, rather than established myopia. As has been said again and again, these factors consist in a congenital difficulty in bringing the optic axes into convergence, and secondarily, in the application of the individual himself to prolonged

work of a delicate character. The latent predisposition to divergent strabismus is in fact not less frequent than the inverse condition of convergent strabismus, so often met with in connection with hypermetropia. This view does not, moreover, set aside the idea of a similarly hereditary transmission, clearly proved on many occasions, of morbid predisposition to organic and congestive affections of the choroid. These affections of the choroid, together with posterior staphyloma more or less marked in degree, but generally slight, are met with in patients who have only moderately applied their sight to continued work, and who are free from all symptoms of muscular insufficiency.

The cause of these disorders, with which a certain degree of myopia is ordinarily allied, depends then upon some disturbance of the general cardiac circulation or of the portal system. The author has observed this especially in gouty subjects and in those suffering from hæmorrhoids. This must be stated in order to complete the outline of myopia, but must be stated also with the reserve which should always be accorded to exceptional facts, when considering the relatively enormous number of myopias having an exclusively mechanical origin.

§ 69. **Secondary complications of Myopia.** We have seen that myopia, at least in its progressive form, presents complications of a congestive and in-

flammatory nature affecting the deep membranes, and lesions of nutrition or of transparence of the ocular media, and hence all the secondary disturbances of vision which these disorders necessarily entail.

These complications call imperatively for special treatment; the sole observance of hygienic rules is not sufficient to remove them.

The frequent congestions occurring in the deep membranes must be met by small local abstractions of blood, from the temporal or mastoid regions, by derivative action upon the intestinal canal, by frequent bathings of the eyes with cold water; here the use of the eye douche is most beneficial.

Lastly, the dazzling effect due to the denudation of the sclerotic must be relieved by the use of blue-tinted glasses, which, without interfering with the clearness of vision, intercept the central rays of the spectrum, which are the most irritating to the retina.

§ 70. **Apparent Myopia due to spasm of the Accommodation.**—The foregoing definition of the ocular condition described under the name myopia, will not allow us to confound with elongation of the globe that faulty state of the refraction in which the screen is not too far removed from the lens, but where the lens itself develops an excessive degree of refractive power.

Such a case is met with where the accommodation

is put into play spasmodically; frequent examples are seen in accommodative asthenopia, in a condition of eye which has received the title "*myopia in distans*," a condition where the ciliary muscle is contracted or obeys ill the commands of the will or the synergical instinct. The differential diagnosis of these states is reached by means of the instillation of atropia, and depends on an analysis which demands a certain degree of precision.

Latterly, the observation of the beginning of myopia in schools has led certain distinguished ophthalmologists to admit that myopia, before presenting evidence of anatomical change, passes through a stage characterized by simple accommodative spasm. This remark is well founded, we have had many opportunities of proving its correctness. In such cases, myopia, which has only a subjective existence, disappears under ophthalmoscopic examination, or by the instillation of atropia, and no trace of posterior staphyloma is found.

But sooner or later the characteristic symptoms show themselves, the apparent myopia becomes real and *rooted*, as one may say. And not only does the emmetropic eye become so transformed; the cases are not rare in which a slight congenital hypermetropia itself gives place to an ultimate, progressive myopia.

Class Third.

Astigmatism or Asymmetry of Refraction.

§ 71. **Patients who do not see clearly either near or at a distance, but whose sight is greatly improved by looking through a small aperture.**—This condition, distinctly proved to exist in the eye—seeing clearly neither near nor at a distance—was formerly accepted as one of the definitions of amblyopia. Modern science has done justice to this unconditional formula. For without entering into the details of ophthalmoscopy, it is easy to give the practitioner a means of determining whether an impairment of vision depends upon the retina or optic nerve, or upon loss of transparency in the media, or upon certain faults of refraction answering to the description given above. This means consists in the use of a card pierced by a pin-hole.

Imagine, for example, a patient unable to read any type distinctly, whom neither convex nor concave glass relieves, either for near work or distance, but who by the use of a card, having in it a small pin-hole, reads or makes out distant objects with a clearness to which he has hitherto been a stranger. This patient is thus shown not to be amblyopic; and he is not myopic, for no concave glass improves his distant vision; nor is he hypermetropic, since a convex glass gives him no

relief; what then is the matter with him? By closely questioning we shall find:

1. That the absence of clear vision dates back longer than he can remember; it is therefore not an acquired fault; it dates from birth, and is necessarily allied to the form of the eye. This characteristic is of the greatest value.

2. Large objects of regular shape, of which he recognizes the general contour, large capital letters for example, appear to him not merely confused but actually deformed, surrounded with greyish or coloured halos; circles appear to him oval, &c., &c.

3. He sees at the same distance vertical and horizontal lines with different degrees of distinctness; thus in a grating he sees the bars in one direction and not the others; and on a distant clock face he sees the fingers only when pointing to certain hours; by inclining the head to one side or the other the lines first seen lose their distinctness, whilst the lines perpendicular to them grow clear.

These indications suffice: the state of the refraction is different in opposite meridians. The patient is astigmatic. Still the symptoms which enable us to establish the malady are not those which lead the patient to seek advice. Independently of his sensations he has all the symptoms of asthenopia. We shall not be surprised at this if we picture to ourselves the continued efforts which the patient is compelled to make in vainly trying

to obtain images approximating to the actual shapes of objects.

The trial of sight by the comparative test of horizontal and vertical lines shows that there are very few eyes entirely free from astigmatism. But so long as the asymmetry does not reach a degree which induces the troubles above described, and more particularly a marked diminution of visual acuity, it does not demand attention ; the condition is not pathological.

§ 72. **Treatment and Hygiene.** — From a curative point of view the indications are most conclusive in favour of artificial optical aid. If optical industry affords a means of compensating for the difference in refraction proved to exist between the two principal meridians, its adaptation becomes an absolute boon, since it remedies the very cause of the malady. The possession of spectacles, which, whilst correcting the faulty refraction in one meridian, do not affect that of the meridian perpendicular to it (cylindrical glasses), is therefore a genuine benefaction to humanity.

When, after a delicate and painstaking analysis, the ophthalmologist has been able to determine exactly the difference in the refraction of the two principal meridians; when, by the precise combination, calculated beforehand, of two cylindrical glasses, he has restored to life, or rather created anew, an eye up to that time

all but useless, the satisfaction which he feels finds no equivalent save in the honour which science thereby receives.

Class Fourth.

Functional anomalies not remedied by a small aperture — amblyopia.

§ 73. **Amblyopia.** — After having reviewed the principal forms of visual disturbance, the results of faults, or anomalies of refraction, or of the consensual movements of the two organs, we meet in our course the troubles which originate in changes in the deeper tissues, and test the transparence of the media or even the sensitiveness of the eye.

These disturbances consist in a more or less marked diminution of visual acuity, both central and peripheral, and are accompanied in addition by a number of secondary symptoms, which may place the practitioner upon the track of the deeper alterations.

The latter points only will now occupy our attention; the exact determination of these changes being within the more immediate province of the ophthalmoscope.

§ 74. **Interruptions in the peripheral visual field, and in the continuity of images. Hemiopia.** — Neither circumscribed nor uncircumscribed

interruptions of the superficial field of vision are unimportant circumstances in the symptomatology of affections of the eyes. Their importance extends often so far as to indicate serious changes, not only in the retina and optic nerve, but also in the brain itself.

One of the earliest inquiries to be instituted in every case of amblyopia consists in determining if it be general, that is if it embraces the entire sensitive surface, or only partial. In the second place it is important to decide whether the partial suppression has its seat in the centre or the periphery.

In this respect careful attention devoted to the patient's description of his case, a direct examination, and a precise measurement of the superficial field of vision by means of the perimeter, become for the practitioner an important source of diagnostic information. And this applies not only to the specialist but also to the general practitioner.

In numberless cases this functional examination, which by no means demands a previous acquaintance with the use of the ophthalmoscope, by pointing out *certain lacunæ or interruptions in external vision*, ought at once to direct the practitioner's mind towards the suspicion of corresponding definite morbid conditions, and towards their localization.

Let us take hemiopia for example. Generally speaking we may admit :

1. That binocular hemiopia is symptomatic of a

lesion affecting the two tracts which constitute each of the optic nerves.

2. That this hemiopia presents two varieties: in the one (*a*) the hemiopia is *homonymous*, that is to say, involving at the same time the two right halves or the two left halves of the retinæ; the halves of same name. On account of the semi-decussation at the chiasma, we may conclude in such a case that the morbid change has occurred above the chiasma, in the nerve of the same name as the halves rendered insensible.

In a second variety (*b*) it is the symmetrical halves of the two retinæ (left in the right eye and right in the left eye) which have become atonic. The lesion, in this case, is necessarily situated in the chiasma itself; and here we must suspect the existence of some extremely grave cause of compression or alteration. Lastly, as in cases of alternate hemiopia, that is of vision of the right half-field when the right eye is closed and of the left half-field when the left eye is closed, the opposite halves of the retinæ remain intact, there is reason to suspect that the seat of the malady lies in the median and anterior region of the optic thalami.

Every form of *apparent* hemiopia, however, does not acknowledge this central origin.

Certain abolitions of the sensibility of half the retinal area may spring from other sources. The surface of the visual field is, for example, often seen to be divided more or less exactly in half by a separation of the

retina. The mischief is then limited to one eye. In this case the separation of the two parts of the visual field ultimately assumes the horizontal position, the effused fluid having occupied the inferior or dependent portion.

A division by halves again, but in this case oblique, and generally the insensible half on the inner side, is not rarely seen in glaucoma.

All these circumstances must be borne in mind in diagnosis, and the general practitioner may here anticipate the ophthalmologist.

A large semi-central scotoma, resulting from the absorption of a choroidal extravasation, will produce the same sensations and presents on superficial examination the same appearances.

It will be easily understood that the prognosis depends essentially upon the nature of the cause, and that an ophthalmoscopic examination is absolutely necessary.

§ 75. **Eccentric limitation of the field of vision.**—Abolition of the field of vision in the peripheral regions is a relatively novel pathological fact. Not many years have passed since physiologists have grasped the idea that we see normally by means of the whole retinal surface. And the attentive study of pathology, in rendering our knowledge of this point exact, has taught us in addition that one of the gravest signs of various amblyopiæ is actually the loss of peripheral sensibility, the progressive loss by which the

visual field becomes contracted, and ends by being reduced to vision only in the direct axis of the organ. It is thus that the singular visual anomaly manifests itself, in the cases of certain patients who are able to read, to distinguish large objects at a distance, and small ones near, but who are, on the other hand, quite unable to guide themselves in the streets or in any other place, having lost the faculty of *orientation* (vide § 10).

In order to realize the condition of these patients we have only to close one eye and to look at objects with the other through a long narrow tube. The tube will allow of a perfectly distinct view of every object situated in its axis, but will render it almost impossible to find an object whose situation is not known with the eyes closed.

The eccentric limitation of the field of vision does not occur only in a zonular form, but presents itself also in the shape of obliterations of geometrical sectors of the visual field. These forms often have a definite origin, and are peculiar to certain morbid changes.

Thus limitations taking the form of sectors, would make us suspect embolism of some branch of the central artery of the retina, or fatty degeneration of the posterior tracts of the spinal cord (progressive atrophy of the optic nerves, accompanying locomotor ataxy), or pigmentary retinitis; the same form, is also often met with, in cases of glaucoma.

§ 76. **Central interruptions of vision (Scotomata).**—The lacunæ observed in the central region are met with also in some of the affections enumerated above, but they are related most frequently to material, alterations localized in the retina and choroid. Special attention has already been directed to those which habitually accompany staphyloma posticum, or choroiditis from ectasis in its higher degrees. The interruptions thus caused have a notable importance, as much from the existing effects as from the unfavourable prognosis which they disclose, that of progressive myopia.

Among the central abolitions of the visual field certain forms are encountered, which are, so to speak, subjective and wanting in objective or ophthalmoscopic signs. In these forms of amaurosis, having a central seat, and being localized there, and which do not affect the rest of the retina, the prognosis is less unfavourable than in limitations advancing towards the centre, and too often progressive.

§ 77. **Photopsy, Chromatopsy, Ocular Spectra.**—Subjective visual sensations, such as photopsy, or the appearance of rings or flashes of light, chromatopsy, or coloured vision, and certain spectra, have no longer, so far as amblyopia is concerned, the very serious signification which they had formerly. They are connected rather, as has been previously said, with congestive states of the ocular membranes,

and particularly with those which accompany a certain degree of tension of the globe, they are also noticed in retinal hyperæsthesia. It is, however, very necessary to give serious attention to the appearance of rapid flashes of light, of luminous rings and showers of stars, which so often accompany glaucoma. Here the matter at stake is most grave, and the practitioner should not be wanting in vigilance; a clear diagnosis is necessary, and demands the aid of an experienced ophthalmoscopist, who at once removes the doubt which may exist between a simple hyperæmia of the deep membranes and the imminence of glaucoma.

§ 78. **Hazy vision.**—Hazy vision, the sensation of looking through a smoky atmosphere, with its amelioration at twilight, are, as is well known, presumptive evidence of commencing cataract; the following symptoms corroborate this presumption: multiple and confused images of brilliant objects, such as gaslights, candles, &c., the exaggeration of the starlike spectrum of the crystalline, which changes the flame of a candle into manifold stars, or surrounds it with numerous branching rays of light. The sight becoming obscured more or less suddenly with a cloud or veil, which persists, should direct the attention towards a retinitis. In short, all sensations of this kind will indicate to the practitioner the development of an obscurity in some part of the transparent media. And it will

be for the ophthalmoscope alone to determine the diagnosis.

§ 79. **Hemeralopia.**—This form of modification of special sensibility is ordinarily accompanied by a set of symptoms, which have, in all ages, forcibly claimed the attention of observers, and have been considered as constituting of themselves a clearly defined disease; we refer to hemeralopia, or nocturnal, or rather *twilight* blindness. Without going so far as to assume that hemeralopia may not be an especial morbid entity, it is certainly permissible to affirm that in the generality of carefully observed cases this disturbance of vision is nothing other than the evidence of a more or less marked diminution of the retinal sensibility; it shows the beginning of amblyopia. If we observe the patients carefully, we notice that the commencing amblyopia, whatever its origin, shows itself first in the evening, or in circumstances where the light is deficient, but not entirely wanting. Hemeralopia is only an early symptom of a diminution in the general acuteness of vision. Thus considered, this symptom ought to attract the most earnest attention of the practitioner, and should cause him to think of retinitis, pigmentosa, glaucoma, and atrophy of the optic nerve.

Hemeralopia is, however, not always of so grave a character; it is met with in transient forms not in-

frequently where it assumes, for example, an epidemic character, as in warm countries, and in marshy regions, as a result of prolonged debility. One of the most conclusive instances as to the value of that cause, *adynamia* and *anæmia*, is the frequency of endemic, or rather epidemic hemeralopia, in the countries in which ascetism is rigidly practised, where it occurs as a result of the prolonged fastings of a strict Lent, as for example in Russia. In these cases even, there is evidently amblyopia in addition; but the retinal impairment is not organic, and disappears with the cause which produced it.

§ 80. **Nyctalopia.**—It is the custom to place nyctalopia or day blindness in contrast with hemeralopia.

In the rare cases where one is enabled to observe it, this symptom must be referred either to an alteration of nerve function or to some mechanical cause. Under the first order of facts we should range periodical amblyopiæ, such as those produced by miasmic poisonings, and also retinal hyperæsthesia. The nyctalopia of prisoners suddenly brought into full light is assuredly of this kind.

The malady admits also of a mechanical explanation. The improvement of sight at sunset is often the indication of the formation of central cataract. Myosis is sometimes accompanied by this same symptom;

yielding before the diminution of the brilliancy of a bright day, the dilating iris allows the passage of larger but less irritating pencils of light.

§ 81. **Nystagmus.**—By this term is designated a constant mobility of the eyeballs, over which the will has no longer any control.

These movements are of two kinds; in some cases they are purely choreic, and to be placed under the head of a disturbance of innervation. In these the patient, in spite of the rapidity of the movements of the eyes, is able to fix, or at least sees clearly, and is capable of defining the relative position of objects with exactitude.

In the greater number of instances this is not the case, and the nystagmus consists in the perpetual oscillation of eyes, which, while having perception of light, search in vain for a point or a direction more distinct than the rest, in order to fix upon it. This variety of nystagmus is the result of a defined central amblyopia and of a relative peripheral amblyopia dating generally from early infancy. It is most frequently the symptom of a congenital amblyopia.

§ 82. **Phosphenes.**—In all the above mentioned conditions, the search for phosphenes may find a place as a supplementary aid in diagnosis. This procedure is indeed especially indicated in cases of cataract;

there it gives indications as to the special sensitiveness of the various regions of the retina of equal value with the sensorial projections of Von Graefe. So far as other applications of this procedure are concerned, there can be no better guide in this delicate study than the excellent treatise of our learned and lamented friend, *Serres d'Uzès.*

§ 83. **Differences between the two eyes.**— The daily observation of affections of vision, whilst establishing in a general fashion that the original construction of the two eyes is approximately the same, and that congenital anomalies of static refraction manifest themselves ordinarily under the same aspect, teaches us nevertheless that acquired maladies, when they run through the same courses on the two sides, do not invariably show themselves equal in degree.

It is by no means rare to find a serious impairment of function in one eye without the other participating in the slightest degree, and every day one meets with patients with whom only one organ is active and who have not been in the least aware of it.

It is, however, of the highest importance to be apprised as soon as possible of the existence of an amblyopia; first, because every disease is more easily controlled in its early than in its later stages, and secondly, because, though it may be even trifling at the beginning, advancing time impresses upon it almost

ineffaceable characteristics. Notice, for example, what has become of a strabismic eye, excluded from vision for twenty years, the want of exercise, if it have not destroyed it, has marvellously impaired its function.

If we consider, in addition, the immense importance attaching to sure knowledge in good time of a glaucomatous tendency, or of a disposition to progressive atrophy, &c., it will be seen why we insist upon the following counsel:

In every family having hereditary tendencies to affections of vision, the medical attendant ought carefully to watch the action of each eye, and to assure himself, by examining them alternately, of their actual condition.

§ 84. **Excess of sensibility or Retinal Hyperæsthesia.**—Patients are often met with who present, taking them superficially, the symptoms of asthenopia, both accommodative and muscular, and in whom the optical and the mechanical causes are wanting. A general character observed in them is aversion to light in the more advanced stages of the malady: and the photophobia, for it deserves that term, is accompanied by violent orbital or ocular pain (fifth pair of nerves); there is also sometimes photopsy and chrupsy, &c.

In the lesser degrees, the aversion to light is marked by a certain dread of clear images. In these circum-

stances, if there be any anomaly of refraction, the correcting glass and the one which gives an accurate image cannot be borne.

This condition is as yet imperfectly known, and awaits more complete observation.

It is wise, however, to arrange in this class certain asthenopic conditions described under the term painful accommodation, in which light, or rather the act of fixation, following the efforts of abnormal accommodation, has become intolerable to the retina.

III.

VARIOUS SYMPTOMS OF FREQUENT OCCURRENCE IN AFFECTIONS OF THE EYE.

The absence of definition in visual images, and the functional disturbances which we have now passed in review, are not the only subjects of complaint, of a similar kind, which the surgeon receives from his patients. Connected with some of the preceding forms, or presenting themselves singly, there are others which do not fail to absorb the attention of patients, and of which it is in all respects well, that the practitioner should recognize and appreciate the indications. Among these must be placed, muscæ volitantes, fixed muscæ, multiple images, coloured images, mydriasis, myosis, micropsy, macropsy, daltonism or colour-blindness. We will now proceed to examine these various conditions, with which it is desirable that every practitioner should be familiar.

§ 85. **Muscæ Volitantes.**—We are very frequently asked what signification is to be attached to the entoptic phenomena of vision, known by the name *muscæ volitantes.*

This question has recently been actively discussed, and the conclusions reached in various quarters do not

appear to be entirely exempt from a certain exaggeration, some in one way, others in the opposite. Muscæ volitantes consist of small bodies, more or less pale, or on the contrary more or less deep coloured, moving before the eyes under conditions which are ordinarily similar. When the individual who is troubled by them looks towards large and equally lighted surfaces, each movement of the eye is accompanied by the sudden appearance in the field of vision of small strings of beads in the shape of grey or whitish pearls, which follow the movements of the organ; and when these movements have ceased, these little corpuscles are seen to glide backwards, descend and return to the position they occupied at first. Very slightly marked, indeed scarcely perceptible, they have received the name of *pearly spectra*, which describes them exactly.

In this stage they are only the first degree of extension of physiological conditions. They may in fact be made to appear in the healthy eye by placing before it a card perforated by a small pin-hole, and held about half an inch from it, directing the vision at the same time towards a uniformly illuminated surface.

Reduced to the proportions of a slight exaggeration of physiological phenomena, these entoptic images are by no means disquieting; they scarcely indicate more than a little fulness of the choroid, a slight congestion of the eye.

But when they become persistent, and darker in

colour, so that the patient sees them constantly, and in variable conditions of illumination, when the strings or ribands increase in length and their grey colour becomes more pronounced, they are no longer purely physiological phenomena: we see in them the symptoms of an actual choroidal congestion, and consequently, of a slight softening of the posterior layers of the vitreous humour. It is certain that this symptom is almost constantly met with in chronic hyperæmia of the choroid; it prevails in those anomalies of refraction which induce turgescence of the organ, in progressive myopia for example, as also in the asthenopia consequent upon hypermetropia or astigmatism.

This symptom should therefore be considered as the index of a morbid condition, but certainly not as an alarming one; in this respect patients exaggerate its importance, and the interpretation attached to it by Maitre-Jan was unwarranted (hallucination of vision). It is simply necessary that the practitioner should bear it in mind in his directions respecting ocular hygiene.

There exists, however, a third state, in which we no longer find only fine slender strings of pearls passing over the visual field, but also bodies of larger size, subject to much more marked displacement with the ocular movements. These bodies represent portions of membranes, spider-webs, actual opaque bodies, traversing the field with greater or less regularity.

Here, there is no time for delay; these phenomena correspond to the presence of actual bodies floating in the vitreous humour. They are either an exaggeration of the conditions just described, or a manifestation of the passage into the hyaloid of the detritus which follows an extravasation of blood in the retina or choroid. The surgeon here sees the sign of the beginning of softening of the vitreous body, a most serious condition, and one which ought to engage his earnest attention.

§ 86. **Fixed Muscæ (Scotomata).**—The fixed musca or scotoma has already been the object of our attention, under the title "interruption of the visual field" (§ 76), but the scotoma properly so called is an interruption of small extent.

Its causes are found among extravasations of blood, choroidal or retinal exudations, lacunæ existing in the retinal sensibility, as the result of atrophy of its own elements or of the elements of the underlying choroid. After this general statement of its etiology, there is no need to insist upon the importance of the symptom in prognosis.

§ 87. **Multiple Images, Uniocular Polyopia.** Diplopia, strictly speaking, may be the act of one eye alone, or may result from the dissociation of the two eyes. The signification of the symptom is very different

in the two conditions, and needs precise definition. By shutting one eye the nature of the diplopia is promptly ascertained; if it persists after the closure of one eye, it is undoubtedly uniocular. In this case, it points out in a conclusive manner the variance between the distance of the object and the state of the refraction in the patient. If the latter be known to the practitioner to be myopic or hypermetropic, the state of refraction may suffice to explain the unexpected anomaly; but if he have never observed any abnormality of refraction in the patient, it is the accommodation which is the source of the trouble; there is paralysis of the ciliary muscle (§ 43).

We shall see further on (§ 116) the signification which ought to be attached to binocular diplopia, or that form which exists only when both eyes are open.

We leave on one side the uniocular diplopia due to facettes of the cornea and to luxations of the crystalline lens, the mechanism of which has been long understood.

Nor shall we mention either another cause of uniocular polyopia recently described, which the author attributes to an actual hallucination of the retina or of the nerve-centres. Cerebral hallucination may be readily allowed, its modes of action are too little known for us to contest it, equally so for us to affirm anything concerning it. But as for the seat of the diplopia being in retina, the idea of a double sensation in the

same element (rod) seems rather a hallucination of the author than of the membrane; it is absolutely incompatible with the fundamental property of the rod—the idea of direction and externality (§§ 3 and 4).

§ 88. **Mydriasis.**—By this term is meant excessive dilatation of the pupil, with persistence of immobility of the iris.

From a symptomatic point of view, mydriasis presents two classes of results, offering many points of distinction. Those involving at the same time the iris and the ciliary muscle, and those limited to the former of these organs.

When limited to the iris, mydriasis manifests itself only by indifference on the part of the iris to its natural stimuli, light, convergence of the optic axes, and accommodation for near objects.

When united to paralysis of the ciliary muscle there is added to the former conditions the recession of the near point or premature presbyopia, uniocular polyopia, micropsy, colouration of images (§ 43).

Such symptoms are therefore not to be treated lightly; they assert the existence of paresis or paralysis of the accommodative system; and these nervous changes are but too often the precursors of more serious paralyses of the motor muscles of the eyeball.

Mydriasis has two sources of origin; one spasmodic or by contraction (see myosis); the other paralytic.

The latter in its turn acknowledges two starting points: 1st, the suspension or diminution of action of the third pair of nerves (oculo-motor); 2nd, anæsthesia of the centre of reflex or sympathetic movements which the iris possesses in the retina, that is to say the loss of sensibility of the retina to light (amaurosis). In this latter case the pupil, which is immobile when the light strikes the affected eye, re-acts at the same time as its fellow when the light is directed to the sound eye. This characteristic of amaurosis is of great value in daily practice.

§ 89. **Myosis (excessive contraction of the pupil).**—This symptom, the opposite of the preceding, is produced by excess of action of the sphincter over the radial fibres of the iris. It most frequently follows spasm of the muscle of accommodation, thus affording a sign analogous in value but opposite in conditions, to that furnished by mydriasis.

It is then, by a mechanism equally easy to understand, accompanied by macropsy (§ 43).

The alliances which bind the muscular system of the iris and of accommodation to the ganglionic nervous system and to the spinal system, must not be lost sight of, in connection with these two symptoms, mydriasis and myosis.

The practitioner will easily understand the presence of mydriasis in all conditions of evident depression of

the cerebro-spinal system, and of myosis in a similar condition of the great sympathetic system.

The irritative conditions of these two systems are, however, less known in their symptomatology, and it may readily be suspected that irritation of the spinal system brings on myosis, as irritation of the ganglionic system produces mydriasis. But in this respect, formal propositions, true as they may be in experimental physiology, would be as yet doubtful in a pathological point of view.

§ 90. **Coloured Images (Chrupsy).**—The method of production of coloured images has been described in § 19. Whenever we meet with it we must consider that there is a want of harmony between the accommodation of the eye and the distance of the object regarded, or that the eye is asymmetrical.

The first case refers more especially to high degrees of anomaly of refraction, or to paralysis of accommodation. The second has been described under the head *astigmatism*.

§ 91. **Daltonism or Dyschromatopsy (Blindness for certain colours).**—Under these names is described a total or partial inability to receive the impression of colours, and consequently to distinguish them one from another. It is divided into two classes:

The first, anerythropsia, consists in insensibility to

red; the only clear sensations being those of yellow and blue.

These patients see red only when it is very intense, and place the limit of spectrum at that point: they confound brown and green with it. The most brilliant colour in the spectrum, is, for these patients, not the pure yellow, as is the case ordinarily, but the blue-green.

The second class embraces those who make mistakes in trying to distinguish *green*, and its various shades. Exact observations respecting this class are almost entirely wanting.

Lastly, and exceptionally, yellow may be perceived alone; and here, strictly speaking, we have to do with complete *achromatopsy*. The notion of colour is absolutely wanting.

This anomaly is generally congenital. It has, however, been noticed in many diseases, and in certain forms of amblyopia, particularly in those resulting from tobacco and alcohol. Our knowledge is in reality very incomplete on this point.

But if it be as yet only a feeble aid in diagnosis, dyschromatopsy possesses in itself great importance as a functional malady. The possession of exact ideas in regard to colours is of great value in a vast number of callings. Painters, dyers, managers of weaving manufactories, have the greatest interest in possessing sound physiological qualities in this respect, that is to

say in conformity with the perceptions of mankind in general. But the situation in which this anomaly may be the source of the greatest perils is in the case of those charged with the interpretation of coloured signals, such as the watch at sea, and engine drivers upon railways. There can be no need to insist upon the importance of this matter.

The physiological explanation of this imperfection has given rise to some hypotheses and to numerous controversies. I have always abstained from entering into the question, not having been convinced of the value of the physical and physiological theories relating thereto. This reserve is well founded, if we regard the recent discoveries of Professor Boll, of Rome, of which the following is a summary:

1st. The retina is not transparent and colourless throughout its whole thickness, as was believed. Examined in a dull light, or in a yellow light, the external surface of Jacob's membrane is of a beautiful red colour. This colour is secreted by the choroidal epithelium (Kühne).

2nd. During life the red colour of the retina decreases and wastes away under the action of light, whilst it grows again and becomes stronger in the dark.

3rd. The said red layer or purpurine receives the differential impressions of light and darkness after the manner of a sensitive photographic plate. So

that the formation of retinal images should be a photo-chemical phenomenon.

No more need be said, save to urge upon the attention the results which investigations now being carried out, founded upon these new facts, must have upon a complete theory of vision.

IV.

ANOMALIES OF BINOCULAR OR ASSOCIATED VISION.

§ 92. **Anomalies of Binocular or Associated Vision.**—The want of harmony between the motor forces of the eyeballs generally manifests itself by two kinds of symptoms: the one objective, *strabismus;* the other subjective, *diplopia.*

We will first speak of strabismus.

§ 93. **Strabismus.**— Simple binocular vision depends upon an exact relation of the principal optic axes with the points to which vision is directed, and strabismus is said to exist whenever the image of the object regarded, which is depicted on the pole of one eye, is found to occupy in the other eye an eccentric position with regard to its pole.

In such circumstances the strabismus is called *internal* or *convergent* if the false or eccentric image be formed upon the inner half of the retina.

If the relation be the reverse of this, the strabismus is *divergent* or *external.*

In the first case, the cornea of the eye looks inwards, in the second, outwards.

§ 94. **Simple and Double Strabismus.**—Strabismus is simple or double: this means that in certain cases, the discordance of the optic axes is not limited to a want of harmony between themselves, but that the optic axes are *individually* in faulty relation with the limits of the orbital, or palpebral opening, this being otherwise normal.

This being admitted, it may be said that a strabismus of long standing is almost always double.

§ 95. **Apparent Strabismus.**—The strabismus may be apparent only; this is owing to the fact that, in its normal position, the cornea presents an axis relatively slightly divergent from the exact axis of vision; in such a way that the eyes may be said to present ordinarily a slight apparent divergence.

This appearance of divergence is most marked in hypermetropes; least so, and even wanting, in myopes: so long, in each case, as the real strabismus, which commonly exists in connection with each form of optical defect, and which is opposite in character, has not made its appearance.

§ 96. **Strabismus is permanent or variable.** The strabismus may be fixed, constant in its degree, and constant in its manifestation: it may be, on the other hand, variable in its degree and in the times

of its manifestation. In the latter case it has received the name intermittent or periodic.

§ 97. **Permanent or Concomitant Strabismus.** Permanent strabismus is characterized by the fact that the deviating eye maintains unaltered its relative position to the other, in all directions of vision. In this case, when the eye which fixes is covered, the other alters its position in order to fix in its turn. Whilst the former, behind the hand that covers it, takes upon itself the deviation which first of all affected the squinting eye.

§ 98. **Strabismus at a variable angle.**—In strabismus at a variable angle the deviation is not the same in all directions of vision ; being absent in certain positions of the object fixed, the deviation appears when the object is carried in a certain direction and increases with the distance the object is made to traverse in that direction.

§ 99. **Explanation of these differences.**—This behaviour of the eyes, different in the two conditions above described, indicates that in the first case (fixed or concomitant strabismus) the muscular innervation is the same on the two sides; the deviation therefore depends solely upon a disproportion between the muscular lengths. In the second case (strabismus

at a variable angle), on the contrary, there is unequal distribution of the nerve supply to the right and left at the time of the associated movements; the affection depends then upon a nervous change of the class of active contractions or of paralyses, generally the latter.

§ 100. **Strabismus, with Diplopia.** — The second of the forms of deviation above mentioned is accompanied by the presence of double images. Thence originates such confusion of vision, that the patient often of his own free will excludes one eye from vision, or assumes the most eccentric attitudes in order to get rid of the diplopia which besets him. These attitudes are very evidently connected with the species of movement paralysed, and generally afford sufficient evidence on which to found a diagnosis.

§ 101. **The Psychical Abstraction of Images.** Permanent (or concomitant) strabismus is generally exempt from the complication of double images. For as in health the optic axes of the two eyes form with each other constantly the same angle, so in this form of strabismus the secondary deviating axis is in constant and definite relation with the axis of the sound eye, and all the region common to the two fields of vision, that is the territory of binocular vision, and the necessary situation of double images, is neutralized

in the deviating eye. The image thereon depicted is not perceived; the sensorium accustoms itself not to see it. This is what is called *psychical abstraction*. But the image appears the moment that the sound eye is covered, and this is the reason that the eye rights itself in order to fix in its turn.

§ 102.—**Its effects upon the deviating Eye.** The habitual and chronic neutralization of the central part of the retina and of an eccentric region more or less extensive, almost invariably brings in its train the gradual weakening of special sensibility, or in other words amblyopia of the organ. After twenty years of this neutralization, the squinting eye is too often almost absolutely amaurotic.

It is therefore a matter of the greatest importance, when a squint is only intermittent or periodic, not to allow it to become permanent. If we do not decide to operate, it is expedient to transform the squint, by alternate exclusion of the eyes, into the alternating form, until the time for operation has arrived. By this means the ill effects of a too prolonged neutralization are avoided.

§ 103. **General Etiology of Strabismus.**—The etiology of permanent or concomitant strabismus rests upon the following foundations:

	Proportions in 100.
Congenital preponderance of the group of adductive muscles over those of abduction, very frequently allied with hypermetropia, or the reverse state allied with myopia . .	60
Spasmodic and paralytic affections of the muscles of the eye giving rise first to a variable strabismus	15
Ophthalmiæ — opacities of the cornea, results of wounds	15
Marked amblyopia of one eye followed often by divergent strabismus of that eye . . .	5
Unknown causes	5
	100

§ 104. **The most usual deviations are allied with Anomalies of Refraction.** — These numerical results should invite our consideration, they testify to the important fact that in the immense majority of cases, strabismus is connected with some anomaly of static refraction of the eye. This relation, closely examined, may be thus formulated :

In eyes the subjects of an insufficiency of refraction (hypermetropes), there exists very frequently a congenital preponderance of the muscles of convergence over those of abduction.

In those, on the contrary, the subjects of an excess of refraction (myopes), we not less frequently meet with the opposite condition.

In other terms, convergent strabismus (by far the most frequent) is, in two-thirds of the cases, associated with hypermetropia.

And, inversely, divergent strabismus is for the most part noticed in association with myopia.

§ 105. **Before becoming permanent these forms of Strabismus are intermittent.** — In both cases, it is noticed that before the deviation has become confirmed and permanent, the want of harmony passes through a period of intermittence. The patient, whose axes are parallel, when his vision is not directed to any particular object, squints directly his attention is engaged.

As time advances this condition of deviation becomes permanent.

§ 106. **Mode of Production of Strabismus in nervous diseases.**—In the table above given, it is seen how comparatively small a place is held in the general etiology of strabismus by the class of affections to which, twenty-five years ago, almost all the cases were attributed; nervous affections, paralyses, and contractions. They reach only the sum of about 15 per 100. In these cases the final strabismus is the result of the long duration of the paralytic strabismus: the muscles long nourished in a condition of dynamical shortening, end by becoming actually shortened. Thus the devi-

ation is seen to persist, when the primary cause, the nervous paralysis, has disappeared.

We shall not speak here of deviations upwards or downwards, because, in the first place, they are much less common than those inwards or outwards, and in the second, because they have as yet no physiological history.

§ 107. **Therapeutics and Hygiene.**—The question of strabismus is practically abandoned at present—in France, be it understood. The notoriety of innumerable unsuccessful operations which formed the reckoning at the noisy period of the inauguration of ocular myotomy (1841—1842) cast such universal discredit upon the method, that even at the present day the most strikingly favourable results are received by us with the reserve which attaches to some exceptional manifestation. The progress accomplished in this direction is too generally ignored here, since tenotomy assigned to its true place is only performed in cases exactly suitable for it.

The brilliant discovery of myotomy was in certain respects before its time: surgery had stolen a march on special physiology, and, knife in hand, divided and shortened the motor organs of the eyeball, before having learned to know the laws of their function.

The various propositions which precede this, and in which are summarized very briefly the relations which

connect strabismus with ocular dioptrics, suffice to give an idea of the progress realized by science in this matter; and the new aspect under which it presents itself to us cannot henceforward but strike the mind forcibly.

Every examination of strabismus ought to be based primarily upon a functional analysis of the vision of the patient. By the light thrown upon the case by this analysis will the question of treatment be decided, just as by the same light, derived from the facts and principles involved, the value of the different methods employed up to the present time in treatment of strabismus are discussed, and also the choice to be made between them in each form of deviation.

The different methods which have been designed to remedy strabismus, are: the use of louchettes (goggles), the adaptation of deviating prisms, spectacles, exclusion of the sound eye in order to compel use of the squinting eye, lastly myotomy.

Let us examine these various methods.

§ 108. **The use of Louchettes.**—By this name are designated shells or ovoid hemispheres embracing by their rims the whole of the anterior region of the orbit, and having at their centre a small orifice equal to an average-sized pupil. The object of them is to force the deviated eye to place itself in relation with the artificial pupil thus obtained, and consequently to regain a position in harmony with the sound eye.

The effect produced is the alternate use of each eye in vision, with persistence of the deviation underneath the screen which covered one of them. Bearing in mind the psychical abstraction, or neutralization of the binocular region of vision, acquired by the deviated eye, the perforated screens have really no other effect than to exclude each eye alternately from the exercise of vision.

§ 109. **Exclusion of One Eye.**—Nothing more can reasonably be expected from the use of louchettes than from the exclusion of the sound eye by means of a bandage; a method which fulfils no other indication than that of preserving the acuity of the deviated eye by means of compulsory exercise, but which has no influence whatever upon the deviation, except perhaps if the strabismus is of variable degree, in which case the exclusion of the sound eye can only increase the relative deviation.

§ 110. **Use of Prisms.**—If we pass from the last question to the use of prisms and to all other methods whose object is to change the direction of the incident rays, in order to present them to the deviated eye at an inclination in harmony with its own, we shall be led to a conclusion equally unfavourable. Prisms and other similar means often produce marvellous effects in the earlier stages of their use. They recall deviations, often exaggerated, to the

same degree of muscular disproportion which originated them. Success appears to be then on point of attainment; but having reached the limits just described, one of the following obstacles is encountered: either the last degrees of the deviation are invincible, or, having been overcome, they give place to asthenopia from muscular insufficiency.

Now muscular asthenopia is a very dangerous affection, and one of which strabismus often causes a sort of spontaneous cure. The employment of prisms has therefore done nothing but restore the earlier malady, the real treatment for which is that very operation of strabotomy, from which it is the object of all these palliative measures to save the patient.

§ III. **Spectacles in connection with Strabismus.**—The frequent relation which is observed between strabismic deviations and anomalies of refraction, and the physiological synergy which maintains, under harmonized laws, the accommodation and the mutual convergence of the optic axes, has led to the employment of convex glasses with the object of correcting convergent strabismus. This method has sometimes succeeded, in the period of intermittence, and is often imperatively necessary after tenotomy when there remains a slight degree of preponderance of the adductor muscle.

That is to say, it is permissible to try it in the

before-mentioned period of intermittence, when there is reason to believe that the preponderance of the internal muscles is only slight in degree. But in the confirmed stage it is absolutely without effect. The trial of convex spectacles in intermittent convergent strabismus should only be continued so long as its efficacy is evident upon simple associated vision; if, however, the strabismus persists, it will be necessary to have recourse without delay to the following procedure—tenotomy.

§ 112. **Tenotomy.**—At the present time thousands of examples suffice to establish the fact that the only remedy for concomitant or permanent strabismus lies in tenotomy. The operation, as it is now practised, consists in the simple separation of the attachment of the tendon to the sclerotic, without loss of muscular length. Repair takes place by the grafting of the freed tendon some *millimetres* farther back than its former insertion. The success of this operation, which is, so to speak, uniform at present, is entirely on account of the maintenance of the integrity of Tenon's capsule. The free anterior extremity of the muscle, contained within, and attached in its passage through it, to the capsule of Tenon, is kept in relation with the eyeball, in actual contact with the sclerotic, at some *millimetres* (from 1—1½ lines) from its primary insertion. It can only afterwards attach itself at that exact distance

from its original insertion. In the old method, the muscle, divided in its continuity, behind the capsule, and floating thereafter freely in the orbital fat, attached itself where it could. Hence the secret of those frequent transformations of an internal into an external strabismus, or *vice versâ*.

The retraction of the free tendinous extremity is now limited to 1½ to 2 lines from its primary position. This is the exact measurement of the rectification which may be calculated upon from a single tenotomy. Observed facts permit us actually to conclude that, almost without exception, an angular deviation of from 13 to 26 degrees or from 1 to 2 lines may be corrected by *one* tenotomy; and that two will be needed to overcome three lines of deviation (or rather a tenotomy for each eye); and finally that a third or fourth operation will be required for deviations of 4 to 5 lines or 45 to 60 degrees.

§ 113. **Results of Tenotomy.**—By this means, in one half of the cases, simple binocular vision is obtained, that is to say, the restoration of physiological vision; in reality, an eye which the patient may consider to be not only useless but *lost*, is restored to him. In the remainder of the cases a beautifying effect, that is one of external harmony, is acquired, and often there is obtained, in addition to this, the cessation of abnormal ocular pressure, which is the source

of numerous secondary casualties belonging to the class asthenopia.

§ 114. **Apparent Strabismus.**—If true strabismus, that is that which is defined by the impossibility of common and simultaneous fixation of the two poles of the eyes upon the same point, calls manifestly for the intervention of art, it is by no means the same with apparent strabismus.

The latter is differentiated from the former, in that when the sound eye is covered, the deviated eye does not right itself, although in all the directions of vision it faithfully accompanies its fellow. The sensibility of the organ, though more or less diminished, is not extinct; and when the sound eye is covered, the deviated eye, without any rectification of position, gives perfectly trustworthy indications of the relative situation of objects. Under these circumstances the ophthalmoscope reveals some lesion of the yellow spot, which renders that part of the retina inferior in sensibility to the point which is spontaneously presented as the supplementary pole. The discord between the two eyes is, therefore, in these rare cases, in appearance only; and one would not lightly propose to rectify that appearance at the expense of binocular vision, and, as a consequence, with injury to the deviated eye itself. An earnest desire to please one of the softer sex would alone justify such a sacrifice.

§ 115. **Tenotomy in Muscular Asthenopia.** Tenotomy is, on the contrary, decidedly indicated in the opposite condition; in strabismus, not apparent, but dynamic; previously defined under the term muscular insufficiency (§ 61).

Insufficiency, combined with asthenopia, is really nothing other than a potential strabismus overcome momentarily by the imperious need for simple vision with both eyes. The double or false image of this virtual strabismus, not being neutralized by psychical abstraction, the sensorium finds in the muscular system forces which cause it to be fused into one with the real image, but these forces are excessive; they overstrain the organ, and soon compromise its integrity. Under such conditions, when the insufficiency is too great to allow of the use of prisms or of concave glasses, there is no other resource but the exclusion of one eye, or tenotomy. The results of the latter procedure are moreover very remarkable. In this measure is to be found the true treatment of progressive myopia.*

§ 116. **Strabismus with variable deviation from Muscular Paralysis.**—Concomitant or per-

* I have shown (*Ann. d'oculistique*, Dec., 1866) that posterior staphyloma is purely the mechanical effect of excess of pressure developed in the interior of the eye by excess of tension of muscles appointed for the convergence of the optic axes, developed in insufficiency of these muscles, or preponderance of their antagonists.

manent strabismus must not be confounded with the obliquity of one eye in which the angle of deviation varies with the position of the object towards which the attention is directed. In the former there is simple disproportion in muscular length, but the nervous influx sent to the two organs for their associated acts is the same in quantity to the right and to the left. In strabismus with a variable angle, the variation of the angle shows by itself that the nervous influx is different for the associated muscles of the two sides. The latter is therefore the result of a lesion of innervation: it belongs to the class paralyses.

As long as strabismus with a variable angle has not passed into a state of permanence, and whilst its primary cause, the nervous disease, is actually present, this affection is distinguished by a character more striking than the manifest want of harmony: we allude to *binocular diplopia* or the presence of double images.

§ 117. **Binocular Diplopia.**—This symptom, if the distance of the double images increase with the movements of associated vision in a definite manner, may, in the generality of cases, be considered as a sign of muscular paralysis. It precedes apparent strabismus often by many days, and from the first moment of its existence denotes simple *paresis* of the muscles. The relative position of the double images is of itself

sufficient to lead to a differential diagnosis of all the paralyses of these muscles.

If the images are crossed the strabismus is divergent, and homonymous images correspond to absolute or relative convergent strabismus. In associated vision upwards, if the double images are of unequal height, the higher belongs to the eye whose movement upwards is in abeyance; whilst in associated vision downwards, the lower of the double images belongs to the eye whose movement downwards is insufficient.

Paralysis of the third pair of nerves is ordinarily accompanied by that of accommodation, and gives rise to all the symptoms described under the latter head (§ 43). In the case where uniocular polyopia intervenes, the images are sometimes multiple, the two kinds of diplopia being associated.

From this it is seen that the practitioner ought to pay the greatest attention to double images, when they appear in a patient; he may almost to a certainty recognize thereby either the beginning or the sudden accomplishment of a muscular paralysis.

§ 118. **Treatment of Binocular Diplopia.** It would be out of place to speak *in extenso* of the various therapeutic means which may be directed against muscular paralysis, and its most striking symptom, diplopia. We shall only say that surgery has made a veritable conquest for that class of affec-

tions, in the art of displacing the insertions of the ocular muscles, in advance of the point of their primary implantation, by means of simple modifications of tenotomy. It may be added, lastly, that as a palliative, prismatic glasses are often a most precious aid against the disturbances and the extreme discomfort which attend the presence of double images.

V.

SPECTACLES — INSTRUMENTS WHICH MODIFY REFRACTION AND THE QUANTITY AND QUALITY OF THE LIGHT — THE NATURE AND USE OF SPECTACLES.

§ 119. **Spectacles.** — We shall not offend our readers by defining, or rather describing, these instruments. But we may be allowed to mention that they have, according to their form or their properties, one of the three following aims to fulfil. To modify the inclination of the luminous rays at their incidence upon the cornea: to modify the quantity of light: or to modify its colour.

§ 120. **The action of Spectacles in modifying the quantity of refraction; collective or positive glasses; dispersive or negative glasses.**—The modification caused in the mutual inclination of rays of light about to fall upon the cornea by the interposition of a lens, produces, in the mechanism of the formation of the retinal image, exactly the same effect as a plus or minus alteration in the refractive power of the dioptric apparatus of the eye. Thus, the glasses which diminish the divergence or mutual inclination of the incident rays *add* to the refraction

of the dioptric system; they are called *collective* or *positive*. Whilst, on the other hand, the glasses which increase that divergence, diminish the quantity of the refraction of the dioptric system: on account of this property they are termed *dispersive* or *negative*.

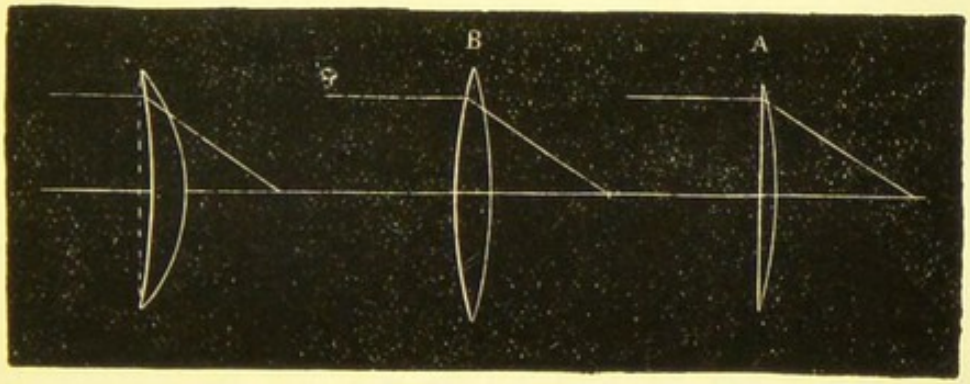
§ 121. **Their action upon the quantity of light.**—At the same time that they have the effect of increasing or decreasing the quantity of the refraction of the apparatus, positive and negative glasses exercise also a definite action upon the quantity of light or of rays which, other things being equal, should enter the eye. The reason will be easily understood: the more the cone of the penetrating rays is converged, the more it will contain of rays in proportion to an equal degree of aperture of the pupil. It follows from this that positive glasses, whilst adding to the refraction of the eye, add equally to the quantity of light which enters it; and, inversely, that negative glasses, whilst diminishing the refraction, lessen at the same time the aggregate of the rays destined to depict by their union the image of each visible point.

§ 122. **Their action upon the size of the image.**—At the same time that they produce these two effects, positive glasses bring the centre of refraction of the system slightly forwards; whilst, on the contrary, negative glasses carry it backwards. This

movement of the optical centre increases the image in the first case, and reduces it in the second.

§ 123. **Spectacles according to the geometrical form of their surface.**—Every one knows that ordinary spectacle glasses have a spherical or plano-spherical form.

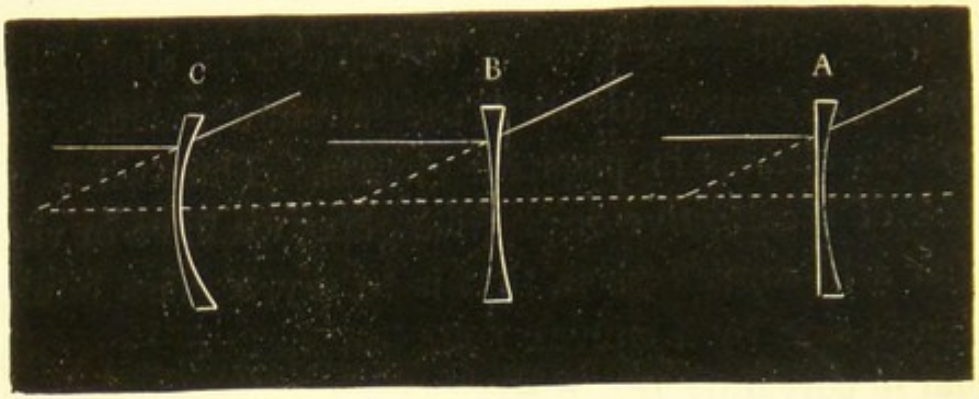
In the collective glasses the thickness diminishes from the centre towards the circumference. The opposite obtains in negative glasses. Thus when we speak of a collective or positive glass, we have in view either a bi-convex glass, that is to say, a glass bound on each side by a convex spherical surface, generally equal in curvature (fig. 7 B) ;



A plano-convex in which one of the sides is plane (fig. 7 A) ; or,

A convexo-concave in which the surface of emergence is concave, but less curved than the surface of incidence (fig. 7 C).

In like manner the negative glasses may be bi-concave (fig. 8), plano-concave, or concavo-convex: in the latter the side which corresponds to the emergent rays has a surface more curved than that which corresponds to the incident rays, so that the glass is always thicker at its circumference than at its centre.



§ 124. **Relation of focal length to the radius of curvature.**—In the plano-convex or plano-concave glass (*crown-glass*), the focal length is manifestly equal to *double* the radius of the spherical surface in which the lens is cut. (See *works on Optics*.)

If two plano-convex lenses of equal radius, or of the same focal length, be joined together by their plane surfaces, the refracting power of the first is evidently doubled. A bi-convex lens is thus obtained, whose focal length is, consequently, equal to that of the *exact radius* of curvature of the spherical surface.

On the other hand, if two lenses of equal curvature, one plano-convex and the other plano-concave, be joined together, all refracting effect is cancelled, no

more effect is produced than by means of a sheet of glass with parallel surfaces. From this it may be seen that bi-convex and bi-concave lenses have the same numbers, when they have the same radius of curvature, since they then mutually cancel each other; and also that they are distinguished by a simple change of sign borrowed from geometry: the convex having the sign +, and the concave the sign −.

The numbers under which they are arranged represent their focal lengths. The oculist's trial-boxes are composed of a double series of positive and negative glasses, extending from 1 to 96 or 100; that is, including glasses from *one inch* of focal length to 96 or 100 inches.

§ 125. **The Metrical System of Numeration.** The plan above described has been altered; for a long time the necessity had been felt for reforming a scale with irregular intervals, requiring the use of fractional terms and variable with each nationality. The object contemplated was the substitution of a regular series, increasing by equidistant terms and based upon the quantities of refraction, for measurements founded upon the decrease of focal lengths.

The practical elements of this substitution having been agreed upon in France in 1875, the change of system was carried out the same year by the International Medical Congress of Brussels, in conformity

with the decisions prepared by the Ophthalmological Congress of London in 1872, and the Ophthalmological Society of Heidelberg. The metrical system was with one accord substituted for the duodecimal method of division. The unity of the series is the quantity of refraction (or the power) developed by a lens of *one metre* (39·37 inches) focal length; the series itself is composed of equidistant terms, regularly increasing by the natural succession of whole numbers, with licence granted, for the necessities of practice, to insert the decimal fractions 0·25, 0·50, 0·75, when required.

The numbers 1 to 20 therefore indicate at present the uniformly increasing power of the glasses; the first being a lens of one metre, the last (20) of five centimetres focus. This reform brings this branch of science into harmony with the great universal metrical system.

§ 126. **Periscopic Glasses.**—Positive or negative glasses having the two faces of a similar direction of curvature, the convexo-concaves and the concavo-convexes, have been called periscopic (*περί σκοπεῖν*), since the time of Wollaston their inventor.

This authority found them advantageous, bearing in mind the curvature of the surface next to the eye, in permitting the vision to be directed more easily on all sides. This is true of the negative glass in which the optical centre is by this means brought near to the

eye; but as to the positive glass the contrary holds, and the advantage, if it really exist, becomes changed into an inconvenience. It should however be said that the negative glass being more frequently employed for vision generally than the positive glass, there would be, so far as the lateral spherical aberration is concerned, a balance in its favour. But is not this advantage more than compensated by the inconveniences proceeding from the double reflection, by the concave surfaces of the glass, of the luminous images reflected by the cornea itself? I shall avoid any definite expression upon this point, and say only that I have never been struck by a perceptible difference in action between these glasses and bi-concaves or bi-convexes.

Be it as it may, the effect sought from these glasses is in fact only the addition or the subtraction of a certain quantity of refraction from that of the visual apparatus, and it suffices to be able to measure rapidly the refractive effects produced by a given glass. Now in their construction the periscopic glasses obey an empirical, ill-defined law of manufacture. They present besides the enormous inconvenience, that their optical centre being external to them, the focal length is not the same, if one or the other surface be opposed to the incident rays. It may be added that for equal focal lengths these glasses are and must be heavier, which is sufficient to exclude the use of glasses of high numbers. But it is precisely for the higher

refractions that the advantages attributed to the periscopic glasses would be more particularly valuable, if they were as certain as they are doubtful.

Finally, it may be said that on acccount, no doubt, of the obscurity which hovers over the rules of their manufacture, periscopic glasses are dearer than others.

§ 127. **The modification caused by Positive Lenses in the position in the antero-posterior field of objects seen distinctly.** — Collective, or positive, or convergent glasses have, as has been already said, the property of increasing, more or less, the images depicted upon the retina, by causing the advance of the optical centre of the dioptric system. With this advantageous property they couple, unfortunately, an effect which reduces its value, that of approximating in the gross the whole field of the accommodation, which is henceforth comprised between the new near point and the anterior focus of the lens. Now, if it be always advantageous to procure larger images, it is not equally beneficial to be obliged to bring objects unreasonably near to the eyes.

This approximation of objects in presbyopia is certainly the effect sought; but only to a limited extent. Within the distance of eight to ten inches, the binocular function being supposed normal, approximation becomes dangerous; it leads to excess of intra-ocular pressure. It is with these facts before him that the

practitioner ought to search for the limit below which glasses, although called for by insufficiency in the size of images or in the refraction, should be judged as *too strong*. They cannot be considered too strong, however, except binocularly.

§ 128. **A Convex Glass cannot be too strong for vision with one eye alone.**—In monocular vision this is by no means the case; the approximation of objects has here no directly injurious effect, as has been shewn by experience in the callings in which one eye is habitually used, and applied either to a lens or to the microscope. In these instances the eye places itself in the condition of the greatest relaxation of the accommodation possible.

§ 129. **Modifications of an opposite character but similar in degree caused by Negative Lenses.**—It is entirely different with concave glasses. By displacing posteriorly the optical centre of the system, they diminish the image: this effect is unfortunate, but absolutely unavoidable. As a consequence of the same fact, they displace wholly the field of visible objects on the side towards the horizon, restricting it also on the side towards the observer. The latter effect is assuredly not to be regretted, so far as binocular convergence is concerned, which is by its means relieved from strain, and herein is con-

tained the principle which has guided us (§ 64) in prescribing the use of concave glasses for work in the case of myopes. But the notable diminution of images in the case of strong glasses existing in extreme degrees, gives rise to serious disadvantages. It becomes a hindrance, and an impediment professionally, similar to the diminution of acuity in high degrees of presbyopia.

§ 130. **Cylindrical Glasses.**—Among the number of the glasses designed to modify the amount of refraction, must be mentioned the plano-cylindrical form, which are used either alone, or in combination with themselves, or with spherical glasses, with the object of modifying, by addition or subtraction (convexes or concaves), the refraction of one meridian, without affecting that of the meridian perpendicular to it. All that has been said, in a general way, of positive or negative glasses, applies to cylindrical glasses, whilst limiting their application to the meridian only for which they are designed. The treatment of astigmatism (§ 71) depends upon their special construction.

§ 131. **Prismatic Glasses.**—We must now give an account of prismatic glasses, the use of which is of such great value in diplopia and muscular asthenopia.

These glasses, which are single prisms, in no respect modify refraction; they have no other effect than that

of changing the direction of the rays which pass through them, by making them, at their emergence, to incline towards the base of the prism. By this means the retinal or sensorial projection is thrown on the side

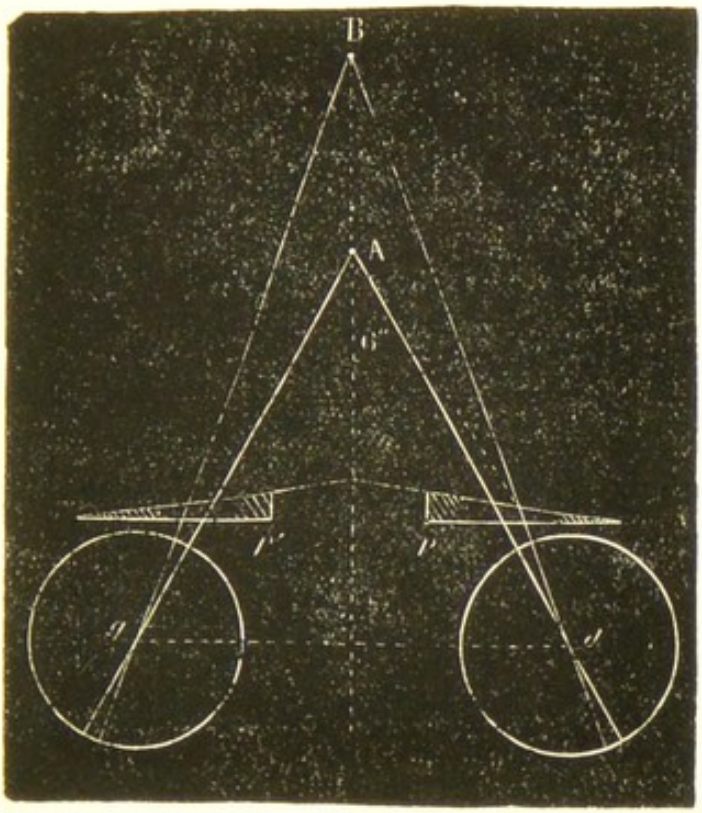


Fig. 9.

of the *refracting angle* of the glass, in such a manner, that for a given position (A) of an object, there follows, according to the kind of prism, either a convergence of the optic axes to a more distant point (B) (see fig. 9); or, on the other hand, if the position of the refracting angle of the prism be reversed, a convergence to a point nearer than that at which the object actually

stands. Prisms are therefore a means of causing an object to be seen, either nearer or farther off from the observer than it is actually. This property, like that of causing double images to coincide, is often most useful in its application.

§ 132. **Of the materials of which Spectacles may be made.**—The substance of which the glasses are made is by no means unimportant. Flint-glass and rock-crystal are harder than crown-glass, and for that reason their surface does not become scratched so readily. This property is by no means to be despised, especially in convex glasses, which, by their shape, are rendered so liable to deterioration from this cause. But in regard to the advantage offered by flint-glass or rock-crystal, it is expedient to take into account the greater dispersive power of the two substances. In this respect it appears that the preference should be given to crown-glass, when strong convex or concave glasses are in question; and it may be added that the price of crown-glass is so low that they may be readily replaced when their surfaces are scratched.

Achromatic glasses should not be employed in the form of spectacles. In glasses of short focus the attainment of achromatism necessitates thickness, and consequently too great weight; and in weak glasses the result does not justify the outlay.

§ 133. **The manner in which Spectacles should be set in their frames.**—In the setting of the spectacles there are certain conditions which should be fulfilled, which are, however, very generally neglected. Thus the plane of the glasses, which should be parallel to the plane of the face in glasses set for distant vision, should be inclined and remain perpendicular to the optic axes, when these are lowered for application to near objects. Spectacles for near work should, therefore, present a plane directed from above downwards, and from before backwards.

Under certain circumstances the artist or other worker may find it necessary to change his point of sight frequently. The painter, for example, after having directed his vision to his model, or to the landscape, may bring it rapidly back to his work. In order to realize this double object in the same instrument, spectacles composed of two half-glasses for each eye, brought into relation by their horizontal diameters, have been often employed and called *verres à double foyer*, or Franklin's spectacles, after their inventor.

The upper half-glass is intended for the parallel rays, or for distant objects, the lower meets the necessities of near vision.

§ 134. **The distance between the Glasses of Spectacles in its relation to the distance apart of the eyes.**—It is advisable, generally speaking, that

the centres of the glasses should be brought into relation with the pupils of the eyes, when these are in their most usual position of convergence. This precaution is very generally neglected, opticians not generally having frames suitable to all variations of distance between the eyes; an unpardonable piece of negligence, shewing how great a degree of imperfection is still to be observed in their art.

The necessity for this exact relation between the distance of the glasses and that of the pupils is, however, to be here considered as the starting-point only, for this relation may have to be modified according to circumstances.

In a number of cases it is, in fact, necessary to set this rule aside, and to decentre the glasses, following certain indications within the exclusive cognizance of the ophthalmologist. According as the patient has greater facility in accommodating than in converging, as in the case of the myope, or the reverse, as in the case of the hypermetrope, it will be necessary to give the glasses the action of prisms, in one way or the other, by a separation of the glasses, greater or less in extent than that of the pupils.

Let us add that sometimes, as in real muscular insufficiency, this decentration is not sufficient, and the use of prisms must be therewith associated.

§ 135. **Instruments which modify the quan-**

tity of Light (Stenopaic Glasses).—These instruments are small opaque screens, pierced either with holes or with vertical or horizontal slits, having a width of from one to two *milimetres*. The effect of these spectacles is to allow only a very small quantity of light to enter the eye (as in the card pierced with a pin-hole), or to limit the luminous pencils to one only of the meridians of the eye.

Their object is to preserve the sensitive membrane from the dazzling effect produced by the diffusion of the light at its passage into the eye, through the margin or substance of corneal opacities, a form of diffusion the action of which is one of the most unfavourable as regards the formation of retinal images. They are also useful after iridectomy, after the making of an artificial pupil, in mydriasis, or when many pupils (polycoria) or synechiæ exist.

They are also employed with advantage when one eye is excluded, and in a general way in monocular vision, by permitting a very great approximation of small objects, so as to procure enlarged images.

For distant vision, the pin-hole should be replaced by the horizontal slit, which allows of movement of the eyes and is very advantageously substituted for the action of screwing the eyelids together.

§ 136. **Preservers.**—By this name are designated spectacles which exercise little or no effect upon refrac-

tion. They are either very weak convex glasses (96 to 72 inches focus ; 0·25 to 0·50 metrical dioptrics), which are even in the case of the emmetrope pleasant to use in the evening, or when the light is insufficient, or they are neutral glasses, of a tint designed to modify the quality and the quantity of light penetrating them.

These glasses are of various shades of green or blue, and sometimes a dark portion is added with the purpose of lessening still more the quantity of light ; they then bear the name of smoke-tinted glasses.

Green glasses have been for a long time in favour ; why is not easily explained. The green colour belongs to the middle portion of the spectrum ; it is therefore rich in yellow rays, the most irritating for the sensitive membrane and so the least beneficial. These are the rays which abound in artificial light, and it is well known how irritating this is.

Blue is at the present time considered greatly preferable. This shade excludes orange rays; besides from its rank in the series it is rich in chemical or photogenic rays, and eliminates the calorific rays. Taking into consideration its refractive power, it acts in some degree as a collective glass.

The grey smoke-tint acts upon the quantity not the quality of the light, which it extinguishes in bulk, without preference for one or other of the divisions of the spectrum. It is very useful when it is proposed to employ the coloured preserver simply as a shade and

to produce a sort of obscurity. But when the aim is to relieve the retina directly, or the choroid through a reflex path, without injuring the clearness of vision, the blue, which is richer in photogenic elements, should be preferred.

§ 137. **Are Preservers or Coloured Glasses beneficial to the healthy Eye?**—We are often asked if blue or green preservers are means of protection applicable to the healthy eye. The answer is by no means doubtful. A healthy eye should continue to be in well-regulated relation with its natural stimulant, light, the element which is most necessary to its preservation. There is, therefore, no necessity to make use of tinted preservers, save in exceptional circumstances where one may be subjected for a long time to an excessively brilliant light, such as may exist in a journey to the Desert, or to the snowy steppes of the North (both amblyopia, and irritations of the retina have been observed under these circumstances). Outside these rare cases, the coloured glass is to be considered a remedy, and reserved for eyes in which the membranes are affected. The practitioner alone should prescribe them.

§ 138. **The use of the Opera Glass.**—There is an instrument widely known, and the daily use of which, considering the carelessness exhibited in its

construction, is a frequent source of injury to sight. I speak of the opera glass. In the opera glass, two similar images are presented in parallelism before each eye, upon the axes of the instrument. At the time of parallelism of the optic axes, that is to say, when the natural vision is fixed upon a distant object, simple binocular vision takes place without effort, the accommodation of each eye being at the maximum of relaxation. If the tubes of the opera glass be situated exactly as far apart as the pupils of the eyes, when these are regarding distant objects, the conditions of natural vision are realized, the glass being properly adjusted. But if the distance apart of the tubes of the opera glass and of the eyes be different, double images are produced; homonymous, if the distance between the tubes be greater than that between the eyes, crossed in the reversed condition. To begin then with the parallelism of the optic axes, the eyes have generally much greater difficulty in fusing homonymous images slightly apart, than crossed images separated by the same interval. It is therefore extremely important to use those opera glasses only in which the distance apart shall be at the utmost equal to that of the pupils, and still better to have the tubes a little nearer together than the pupils. Opera glasses having the centres of the tubes more widely apart than the pupils should be absolutely forbidden. Under these circumstances I would suggest the use of opera glasses

having their tubes movable upon a transverse axis, so that they might be brought nearer to each other, in proportion to the degree of separation of the eyes. The emmetrope would then have no other rule to follow, the glasses being properly arranged for parallelism, than to cause the two luminous circles, which are the images of the objectives, to coincide, by giving them as a common centre the point to which vision is directed. And as generally the instrument is frequently passed from one to another, this arrangement ought to be specially recommended. All opera glasses in which the tubes are wider apart than the pupils of the eyes to which they are applied are dangerous instruments.

Thus far for the emmetrope; but the conditions are not the same in those suffering from anomalies of refraction. In the myope, the optic axes have a natural tendency to diverge; distant objects therefore give rise to images slightly crossed. It would be well, therefore, in order to do away with all fatigue, that the opera glass should be able to present images formed in a position slightly less separated than that of the two axes of the instrument, or of the objectives. In order to accomplish this, it should be possible to place the eye-pieces slightly farther apart than the objectives, that is, they should be more or less movable from within outwards.

In the hypermetrope, the contrary tendency is ob-

served; it should therefore be possible to move the eye-pieces from without inwards, upon the line which joins their centres.

For a long period (since 1860) I have sought to induce manufacturers to adopt this modification in the construction of double instruments; the power, that is, of graduating at will the extent of separation of the centres of the eye-pieces. I have no doubt that the gain would be great in diminishing fatigue; a large number of people not being able to use opera glasses on account of anomalies of relation between their convergence and their accommodation.

§ 139. **The Use of Lenses in Amblyopia.**— We have seen that when the acuity of vision was so reduced as to reach the level of amblyopia, either a momentary or a permanent exclusion of one eye from vision often occurred, the binocular convergence becoming incompatible with the distance at which an object ought to be placed in order to furnish an image of sufficient magnitude. In this condition the amblyope is advised to use a magnifying glass, with the view of procuring the desired increase in the size of the image. One of the best combinations to employ for this purpose, as in all cases where it is advantageous to excite to action a sluggish retina by exercise, is the lens of Fraünhofer, introduced latterly by von Graefe. This instrument is constructed with two convex lenses,

one of six inches and the other of four inches focal length, separated by an interval of an inch, thus forming the equivalent of a lens of two inches. This combination offers less spherical aberration than a single lens of equal focus, and has the advantage of being held at a greater distance both from the object and the eye. Bi-cylindrical lenses, as recommended by Chamblant, are very useful in reading, because, on account of their lessened spherical aberration, they allow the reader to include, at the same time, several lines of moderate-sized print.

VI.

CONCLUSION—HYGIENE OF NORMAL VISION IN ITS APPLICATIONS TO NEAR OBJECTS.

§ 140. **Hygiene of the Normal Eye when employed in near vision.**—Three principal active elements come into play in the performance of the visual function:

1. Dynamic refraction or accommodation;
2. Synergy of the two eyes in the act of mutual convergence;
3. Light, as regards its quantity and quality.

It will be understood that it is thought unnecessary to represent here the static refraction, which we may suppose to be normal, inasmuch as separate chapters have been devoted to its anomalies. We therefore occupy ourselves with the dynamic elements, which it is the object of hygiene to keep in harmonious action.

One of the primary laws which governs muscular organisms is the following: In order to be kept in a state of power and efficiency, a muscle should be made to undergo regular exercise, too prolonged strain should nevertheless be carefully avoided; it is necessary to ensure frequent alternations of activity and repose.

In animal mechanics locomotion generally has for its organs solid osseous levers, to which the power and the resistance are applied. The simple toughness of these levers suffices to support the strain, and their integrity is usually not endangered by the exercise of the natural forces. The levers in action in the ocular apparatus are of quite another kind; they are membranous pouches filled with fluid, and in which the contents re-act upon the envelopes; these envelopes, themselves, being vascular or sensitive tissues of extreme delicacy. The necessity therefore exists, under these conditions, of treating the levers themselves with as much, if not more, caution than the powers which are applied to them. This affords a second reason for formulating this absolute precept in hygiene. No prolonged occupation should be followed which is not interrupted by frequent intervals of repose, such as the suspension of work for some minutes every half-hour.

§ 141. **The consequences of bringing objects too near to the eyes.** — Binocular vision directed to objects brought too near to the eyes is a more marked source of mischief even than too prolonged application of the eyes. We have already seen (§§ 60 and 61) the effects of the mutual convergence of the optic axes in the case of insufficiency of the internal recti muscles. So also purely physiological convergence

cannot, in some cases, be held to be free from risks of a similar kind. Each act of convergence causes more or less notable increase of compression of the globe, and this excess is the more perceptible according to the degree of deviation of the plane of the optic axes from the plane of the horizon. Whence may be deduced two important principles: 1, to hold the object as far from the eyes as is compatible with distinct vision, say from 30 to 45 centimetres (11 to 17 inches); 2, to place it as far as possible in the neighbourhood of the horizontal plane of the eyes.

Reading whilst lying on the back is particularly dangerous in this respect, and not less so in relation to the conditions of passive congestion of the upper parts of the body which this position induces.

Now, no organ is more apt than the sponge-like choroid to feel the effects of this position. It is therefore advisable in all occupations to maintain an upright and unembarrassed attitude. Which does not mean that the eyes should be kept elevated above the horizontal plane for a long period, for persistent direction of the vision upwards is by no means less unfavourable in relation to ocular pressure. Standing for a long time looking at objects in a museum will suffice to establish the truth of this proposition.

§ 142. **The influence of Light in various degrees of illumination.**—How shall we deter-

mine the question of quantity between the eye and the light? The proportion is really a question of race and of acclimatisation. When an eye accustomed to London finds itself at Nice or Naples it is protected by green veils, or parasols lined with the same colour; in walking, cover is sought and the sight directed to the shade thrown by its own proper body or "umbrella," which does not permit it to wander to the brilliant sunshine that surrounds it. But the guide, who walks side by side with the traveller, without any other protection than a large straw-hat, casts his eyes indiscriminately on all surrounding objects. The normal quantity of light is therefore not the same for those habituated to different latitudes; and it is advisable to bear these differences in mind in connection with travel and emigration. Under these circumstances, it will be wise therefore to prepare the organ gradually for any change by means of protective veils or tinted preservers. But with these exceptions, and where the eye and its supply of light are in harmonious relation, the one is the natural stimulant of the other, and they need no reconciliatory medium.

The quantity of light, instead of being in excess, may however be deficient; this condition is one greatly to be dreaded so far as the soundness of the organ is concerned, particularly in the case of persons forced to work at fine and delicate work. Insufficiency of illumination can only be compensated for by a cor-

responding increase in the size of the image, and this can be gained only by bringing the object unduly near to the eye. This is one of the most active elements in the production of myopia (see §§ 60 and 61). Older authorities thoroughly recognised this, for they acknowledged a form of myopia the result of insufficient illumination.

Among the working classes it is not always possible to procure sufficient illumination, and therefore, in this, as in many other instances, we see the sad consequences of poverty. But in the higher classes, in the secondary schools, for example, it would be inexcusable to keep children closely at their work in badly-lighted class-rooms, such as were usual half a century ago.

§ 143. **The quality of the Light.**—The same principles must be followed in daily work; but here the quality of the light is a matter of not less importance than its quantity. As it is by no means natural to read in the full sunlight, we shall only here occupy ourselves in the consideration of the degree of artificial light to be employed.

The artificial light most habitually in use (gas—lamps—candles) is generally rich in yellow rays. Now, we have already noticed (§ 135) the particularly irritating quality of the yellow rays. Thus it is in the evening work that fatigue of the eye is most frequently manifested. It is, therefore, a useful hygienic measure

to abstain from close work in the evening, or at least to be moderate in amount. A second time therefore, and with renewed emphasis, we would say, on no account read in bed.

There is a second kind of artificial light which has been brought into use to a limited extent; we allude to the electric light. According to the experiments of M. M. Foucault and Regnauld, the electric light, which is almost exclusively composed of violet rays, exercises an unfavourable action upon the media of the eye.*

The light produced by the combustion of magnesium, appears to approach very closely to white or solar light.

* We owe to the courtesy of M. Leon Foucault some valuable information concerning the influence exercised upon the eye (and not as we have mentioned above upon the *media*, as stated by many authors) by the electric light. As the result of numerous observations, and also of experiments repeated expressly with this intent, M. Foucault has obtained proof of the evil effects produced upon the organ of vision, and more especially upon its external epithelium. The symptoms observed after prolonged exposure to the electric light are not those of retinitis, choroiditis, or hyperæsthesia of the sensitive membrane. There is a mucous conjunctivitis, as painful as ordinary conjunctivitis, and complicated by a corneal affection, in which the cornea loses its polish as in cases of superficial keratitis. This condition is accompanied by an erysipelatous redness of the skin of the face, especially of the eyelids and forehead, having a variable duration, extending over some hours only when the exposure to the electric light has not been too prolonged. Here the effect of the electric light may be fairly compared with insolation and with the visual trouble (snow-blindness) following long exposure to the brilliancy of snow. A glass tinted with oxide of uranium has a marvellous effect in protecting the eye from these disagreeable consequences.

These two varieties of illumination are besides so limited in the extent of their use that accurate pathological observations respecting their effects are wanting.

§ 144. **Recapitulation of some former remarks.** — The vision of numbers of persons is not normal, although believed by them to be so; many eyes are ametropic, whose possessors far from thinking their sight beneath the average, even believe themselves to be peculiarly favoured in that respect and boast of it.

It is, therefore, especially necessary that the practitioner should not be misled, and that he should judge of the facts for himself.

When a person upwards of fifty years of age glories in the fact of never having perceived the need for glasses when reading in the evening: when children say to us :—My father or my mother were able to read without glasses at seventy, we must conclude that these excellent eyes were myopic to a certain degree.

When a man of fifty requires glasses for reading of a power relatively too great for his age (above + 20), when he removes the book or paper he is reading to a distance from his eyes greater in inches than the focal length of his glasses, we may affirm without fear of error that he is hypermetropic.

Be suspicious also of floating muscæ in all these cases of pretended normal vision, of chronic blepharites

which are not otherwise accounted for by the existence of a very lymphatic constitution in the patient, of the repeated styes on the eyelids, the redness of the palpebral margin, the watering of the eyes after slightly prolonged application of the eyes to books or to close work, &c., &c. These symptoms are so many signs of congestion of the internal membranes, consecutive to either muscular or accommodative asthenopia.

As for the remaining points, they have been treated with sufficient detail in the special articles devoted to them, and to avoid repetitions we refer our readers to them.

THE END.

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