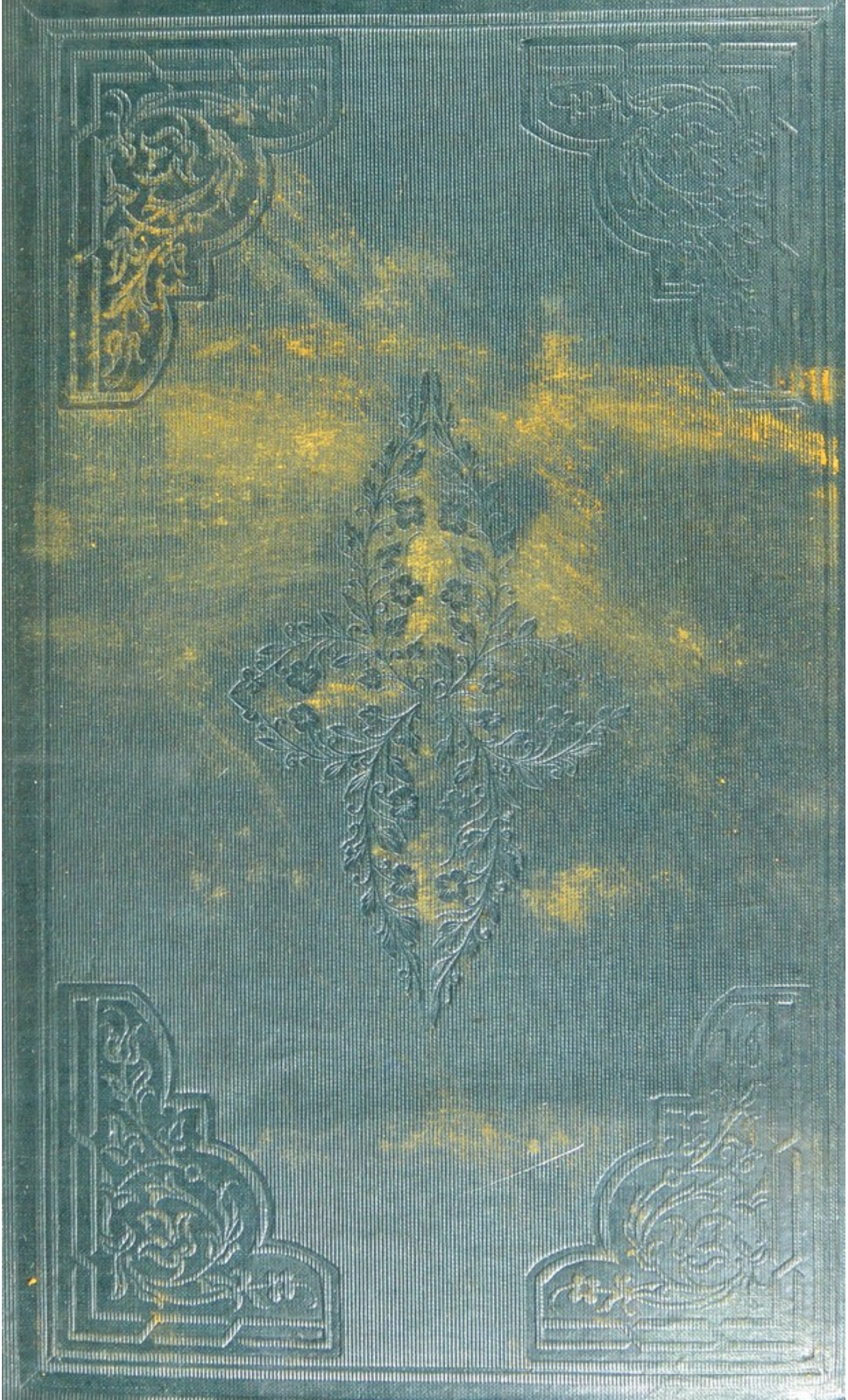
Lectures on the parts concerned in the operations on the eye, and on the structure of the retina ... To which are added, a paper on the vitreous humor; and also a few cases of ophthalmic disease / by William Bowman.



LECTURES,

&c. &c.

WILSON AND OGILVY, 57, SKINNER STREET, LONDON.

LECTURES

ON THE PARTS CONCERNED IN THE

OPERATIONS ON THE EYE,

AND ON THE

STRUCTURE OF THE RETINA,

DELIVERED AT THE

ROYAL LONDON OPHTHALMIC HOSPITAL, MOORFIELDS, JUNE 1847.

TO WHICH ARE ADDED,

A PAPER ON THE VITREOUS HUMOR;

AND ALSO

A FEW CASES OF OPHTHALMIC DISEASE.

BY WILLIAM BOWMAN, F.R.S.

FELLOW OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND;
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ROYAL LONDON OPHTHALMIC HOSPITAL, MOORFIELDS.

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1849.

TO

JOSEPH HODGSON, ESQ. F.R.S.

LATE SURGEON TO THE GENERAL HOSPITAL AT BIRMINGHAM,

IN GRATEFUL RECOLLECTION OF EARLY KINDNESS AND ENCOURAGEMENT,
DURING FIVE YEARS SPENT WITHIN THE WALLS OF
THAT NOBLE INSTITUTION:

AND TO

JOHN RICHARD FARRE, M.D.
FREDERICK J. FARRE, M.D.
GILBERT MACKMURDO, ESQ. F.R.S.
JOHN DALRYMPLE, ESQ.
JAMES DIXON, ESQ.
GEORGE CRITCHETT, ESQ.
ALFRED POLAND, ESQ.

MY COLLEAGUES AT THE OPHTHALMIC HOSPITAL,

IN TOKEN OF SINCERE RESPECT AND ESTEEM:

THIS SMALL WORK IS

Dedicated.

PREFACE.

The following Lectures were hastily put together, and were delivered nearly in their present shape, in the summer of 1847, with the simple object of exciting in the minds of the pupils some interest in the study and treatment of Eye Diseases. They are quite elementary, and touch very briefly, or not at all, on many points, which could not have been suitably passed over in a treatise of more pretensions or of wider scope. It is matter of regret to the Author, that want of leisure has rendered it impossible for him, in this reprint of them from the "London Medical Gazette," to hazard any attempt at making them less imperfect than they are.

A paper on the Vitreous Humor has been added, which was published last year in the "Dublin Quarterly Journal of Medical Science;" together with a few cases of Ophthalmic disease, selected chiefly on account of their having some reference to the subjects of the Lectures.

A Tabular Statement has also been appended of the Cases treated, and the principal Operations performed, at the Ophthalmic Hospital during the last ten years. This has been compiled by Mr. Ledger, the intelligent house-surgeon to the Hospital, from the Annual Reports, drawn up by the Medical Officers, and regularly published by the authorities of the institution.

14, Golden Square,
March 1849.

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Gentlemen,—The benevolent founders and supporters of this hospital have ever been desirous that it should not merely minister (as it does so largely) to the relief of the poor of the metropolis and surrounding counties, but that its ample resources should be employed as means of instructing the rising generation of medical men in the very important class of diseases which are daily treated within its walls. I need not inform you particularly of the share it has had in enlarging and diffusing the knowledge of ophthalmic diseases. It will be enough that I refer, as evidence on that point, to the names of Saunders, Farre, Travers, Lawrence, and Tyrrell,—the distinguished men who, for more or less of the first forty years of its existence, were the instruments of its usefulness, and the main source of that amount of celebrity which it has acquired. Of these we can still number but one amongst our present colleagues: and I cannot mention the name of Dr. Farre, without a passing acknowledgment

of what this institution owes to him, and of the honour I feel it to be associated with one so venerable and respected.*

It is our wish, according to our ability, to continue to make the Ophthalmic Hospital subservient to the same ends as heretofore. The number of patients considerably exceeds that at any former period, being now upwards of 7000 annually, and these afford the means of studying on a great scale the several forms of disease which attack the complex and important organ of sight.†

The lectures which we offer are not intended to supersede the necessity of your observing, each one for himself, with minute and accurate attention, the realities of disease and the effects of remedies, but rather, by opening the subject, and acquainting you with the general outlines, to remove the first difficulties from your path, and to stimulate your minds with a fore-taste of the pleasure which all will certainly experience, who devote themselves to the earnest pursuit of knowledge in the field before us.

In the arrangements for the present season the task has devolved upon myself of giving you some account of certain structures of the eye-ball, which are of primary consequence to the practitioner, as being those involved in the operations he will be called on to perform, and also as being the seat of several of the more common, as well as severe, morbid actions which affect the organ. That you may form some estimate of the importance of that class especially which belongs to the *cornea,* I may mention a circumstance which I remarked with concern during a visit to that noble institution the School for the Indigent Blind, in St. George's Fields. It was this—that a very large number of all the cases of total and irremediable blindness which those walls receive are the result of inflammations of the front of the eye, its transparent inlet having been darkened or destroyed by the ravages of disease, which we are *quite sure* might, in a great majority of instances, have been controlled by skilful and timely

* To these distinguished names must be added that of Mr. Dalrymple, who is now retiring from the Institution after a service of nearly twenty years, during which he has contributed to raise its character by his excellent work on the Anatomy of the Eye, published in 1836, and who is about still further to extend its reputation by an admirable series of coloured illustrations of the diseases of the eye.

† In 1848, upwards of 8000.

treatment. These cases occur amongst the poor—a class to whom the eye is, if possible, even more valuable than to the rich, because without it they can hardly obtain their daily bread, or enjoy the common comforts of existence,—a class, too, among whom it is probable that most of you will be called on to minister during the early years of your professional life. More than this, I think, need not be said to impress you with the importance of the subject which is about to engage our attention.

It would be easy to expatiate on the utility of an exact knowledge of the structure of the body to one who desires to study that body in its morbid states; but I am willing to hope that such an argument would be almost superfluous; and at any rate, (that I may not detain you any longer on introductory topics) I shall content myself with observing, that, though a man of genius has now and then become a great physician, like Hippocrates or Sydenham, by an acute and persevering observation of disease, and of the effects of remedies, and without much acquaintance with anatomy, yet that the common voice of mankind proclaims that he who best knows the *mechanism* of the body will, with a like study of the other departments of medicine, be the best able to comprehend the *actions* of that body, both in health and disease.

General view of the eyeball.—The eyeball, gentlemen, as you know, consists primarily and essentially of a *sheet of nervous matter visually endowed,*—that is, capable of being so affected by light, that, when duly connected with the sensorium, what we call *sight,* or *perception of light,* is the result. This sheet, which we term the *retina,* is brought towards the surface of the body to meet its appropriate stimulus; and the commissure of nervous substance which connects it to the brain and to the opposite retina is called the *optic nerve.* In front of the retina are placed *transparent media,* which, as a whole, refract the light so as to bring it to a focus on the nervous layer, which is spread out in a concave form to receive the more perfect image. The retina is supported behind by a firm resisting tunic, the *sclerotica,* which is prolonged in front of the transparent media, as a transparent, partly integumental membrane, the *cornea.* Between the retina and the sclerotica is a very vascular membrane, of a dark brown colour, the *choroid,* which is advanced behind the cornea under the form of a vertically-hung contractile curtain, the *iris,* in the centre of which is an aperture, the *pupil,* capable, by varying its size, of

regulating the quantity of light admitted to the retina. To allow of the movements of the iris, the transparent medium across which it is extended, and which fills the concavity of the cornea, is a *fluid* one, the *aqueous humor*. Behind the aqueous humor and the iris is the *crystalline lens*, the most solid and highly refracting of the media, imbedded in the front of the third humor, the *vitreous*, which itself occupies nearly four-fifths of the globe, and fills and supports the hollow of the retina. To hold the crystalline in its place, the choroid is fixed to the outer case at the junction of the sclerotica and cornea and sends inwards a circle of folds, the *ciliary processes*, which impress, and fasten themselves to, the vitreous humor all round the lens.

It is unnecessary that I should speak at present, even in general terms, of the mobility of the eye, of its outer protective appendages or of the source of its supply of blood. The limits to which I am confined oblige me to proceed at once to those points in the anatomy of the globe which more immediately concern our present object. And, first, of *the size and shape of the eyeball*.

Shape of the eyeball.—The human eye, when carefully separated by dissection from the muscles implanted in it, and from the surrounding fat and areolar tissue, is seen to be about spherical in shape, with this exception—that the cornea which forms the front clear part, whereby the light has access to the interior, bulges somewhat beyond the rest, is more convex, and is the segment of a smaller sphere. The sphere of the sclerotica, however, is not absolutely geometrically true in all cases, or even generally. I have found it many times slightly spheroidal, with the longer axis sometimes transverse, sometimes longitudinal; and even other and more irregular departures from the exact spherical shape occur, the lateral regions occasionally presenting trivial swellings, chiefly between the muscles, and not affecting the integrity of the organ as an optical instrument. Behind, where the retina is spread out, the sclerotica is thickest and stiffest, most completely retaining its proper curvature even after it has been cut into small pieces; and it is interesting to observe how carefully the exactness of its curvature in the posterior region has been provided for in the construction of the eye generally in the animal series: in some instances by extraordinary thickness and density of the fibrous tissue; in others by the development of very thick or highly elastic cartilage, and even bone, in its stead.

Size of the eyeball.—The size of the adult human eye varies within certain limits, as might have been expected. Nevertheless, as it is a part which, by reason of its complex mechanism, and the peculiarity of some of the textures it comprises, attains its complete development, like the internal ear, before most other organs of the body have reached their adult condition, these limits are very confined, if we except instances amounting to disease. Of many measurements which I have made, the general result is that the diameter of the sclerotica is from seven-eighths of an inch to an inch.

The transparent cornea forms by its anterior surface a portion of a sphere, the diameter of which is from $\frac{1}{3}\frac{2}{2}$ to $\frac{3}{3}\frac{1}{2}$ of an inch (that is, of usually less than two-thirds of an inch), and it often happens that the surface of the globe recedes, or is depressed, very superficially near the line of junction of the sclerotica and cornea. The cornea forms from one-sixth to one-seventh of the horizontal circumference of the whole globe.

In considering the size of the eye, I should guard you against judging of it in any degree by the size of the aperture of the eyelids; the latter, indeed, is that which most governs the *apparent* size of the ball, and is also of much importance to the practical surgeon, as enabling him more or less readily to manipulate in his operations on parts within the lids. Moreover, the cornea is often *apparently* smaller than it really is, in consequence of the formation of a ring of opacity close to its border in the declining stages of life.

Tension in health and disease.—The eyeball has naturally a certain tension, arising from the due repletion of the outer case with the tissues contained within. It gives a tight or resisting feel to the finger applied upon it, and the exact degree of this tension belonging to the healthy state it is essential for you to know, both that you may be aware of the resistance your instruments will encounter, and also that you may be able rightly to appreciate by the touch the departures from the healthy standard of tension which occur in the course of several diseases. When disorganizing processes have occurred in the interior, the eyeball frequently becomes soft, at other times hard, although, perhaps, the finger alone can inform you of these evidences of the impaired nutrition of the organ. Again, in inflammations of an acute kind attacking the globe, an unnatural hardness is perceptible on pressure, usually accompanied by that dull sickening pain which attends distension of the fibrous tissues, and referrible in this case, I

suppose, in a great measure to the sclerotica and cornea. The unyielding nature of these coats occasions all internal distending forces—as vascular engorgements, fibrinous or purulent effusions, if their accession has been sudden and rapid,—to react in the way of counter-pressure on the parts within, impairing their functions in the first instance, and soon irrecoverably destroying them, if allowed to continue unchecked. We have analogous phenomena in the case of other organs enveloped, like the eye, in a tunic incapable of hasty dilatation.

OF THE SCLEROTICA.

To proceed now to a more particular account of the sclerotica and cornea. And first of the sclerotica.

Structure of the sclerotica.—The sclerotica consists of a very dense and intricate interlacement of white fibrous tissue. The surface is not glistening, like most other examples of the tissue, but dead white, by reason of the working up of its fibres in an irregular way, into a web which exhibits little indication of their course. In tendons, in fasciæ, even in the dura mater, a silvery lustre results from the parallel course of contiguous fibres, and the small creases occurring on these confer a satiny surface, which is extremely characteristic and beautiful; but this is not the case with the sclerotica. Those parts of it which are exposed to view, as the white of the eye, have no lustre of their own: the brilliant reflection of light is rather from the moist surface of the investing conjunctiva, set off, it is true, by the opaque white foil of this tunic behind. The fibres of the sclerotica, when unravelled from one another, and examined in minute portions under a high magnifying power, do not quite resemble those of tendon and fascia: they are more straight and stiff, less wavy, less connected: they also tear and break more easily, so that you cannot run them out into such long shreds as in the case of tendon or ligament. Nevertheless, they swell out and become semi-transparent with acetic acid or the caustic alkalies, just as ordinary white fibrous tissue. You can best see the characteristic differences I have now alluded to in the posterior part of the sclerotica of the ox or sheep. This much resembles the thick coat of the air-bladder of the sturgeon, which I had once an opportunity of examining in the fresh state, and it is possible that it might even be made to yield isinglass like that

structure. There is also a good deal of delicate yellow elastic tissue intermixed with the white in the sclerotica.

But although it cannot be said that the fibres of the sclerotica are arranged with regularity, yet they appear to have a more or less determinate direction from behind forwards in the hinder and middle portion; and we may also sometimes observe on the inner surface, after the choroid has been removed, an appearance of arching fibres, having their convexities turned forwards; and, moreover, the anterior part usually presents a different arrangement on its outer and inner surfaces, the fibres of the former being more circular, following somewhat the border of the cornea, especially over the insertion of the recti muscles; while those of the latter are more obviously directed forwards.

Mode of implantation of the tendons of the recti muscles.—With reference to this subject, I may allude to the *mode of implantation of the tendons of the recti muscles into the sclerotica.* These, as is well known, become flattened and expanded somewhat before joining the sclerotica; and I believe it is a common opinion that they join side to side, and spread out as a kind of external investment to the front of the sclerotica, advancing up to the cornea, and constituting the white tunic which is visible between the lids. I do not find, however, that this description, as regards the human eye, agrees with nature. On the contrary, the tendons of the recti appear to be truly implanted into the sclerotica, penetrating its substance, so as to be buried from view, and leaving its exterior layers exposed under the conjunctiva. I have several times traced the continuation of these tendons for a considerable way forwards in the middle substance of the sclerotica, to a certain extent making a division of it into an inner and outer layer, and gradually becoming lost to view, as they break up into laminæ, and blend with the neighbouring structure very near the margin of the cornea.

Thickness of the sclerotica at different parts.—It may not seem very important in a practical point of view to inquire into the relative thickness of the sclerotica at different parts of its extent. It is interesting, however, in a physiological sense, especially with reference to comparative anatomy, and is really not without its practical bearings, since we find the effects of certain morbid actions to be limited or otherwise modified in correspondence with it. The sclerotica is thickest behind, for the support of the retina, and for the preser-

vation of its due curvature at the most material spot. Around the foramen by which the optic nerve enters to join the retina, and which is near the bottom of the eye, the sclerotica is about 1-25th of an inch thick. Hence it becomes thinner forwards as far as to a quarter of an inch behind the cornea, where it is only about 1-40th of an inch thick. From this line to the cornea it again increases in strength, and is from 1-30th to 1-35th of an inch thick, so as to be able to give greater support to some of the internal parts, which I sha'l have to speak of in a subsequent lecture. In the monkey, and in many of the smaller mammalia, I have found this front part the thickest of all.

The recti muscles being inserted as described, groove the sclerotica before entering it, and hence this membrane is rendered very thin mmediately behind their insertion; hardly, in fact, being more than 1-60th of an inch thick in those parts. These being, therefore, the weakest parts, are those which might be expected to yield earliest under any inward distending force; and accordingly I have observed that abscesses of the eyeball are prone to point in these situations.

While upon the subject of the insertion of the recti muscles, it may be mentioned that, in cases where the contents of the globe are diminished in quantity, as a result of pre-existing inflammation of a destructive kind, and the eye consequently shrinks to a smaller size, the softness of the organ allows the recti muscles to impress it in the lines of their transit, and to bulge it in their intervals, thus pinching it, as it were, into a quadrangular shape. In such examples the thinner parts of the sclerotica under the tendons of the recti, being pressed upon by those tendons, and unsupported from within, are sunk in or flattened.

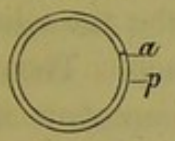
OF THE CORNEA.

We will now turn our attention in a more particular manner to the transparent portion of the outer case, the *cornea*, a part of which it would be difficult to exaggerate the importance in reference to the operative surgery, or the pathology of the eyeball, and which can hardly fail to attract your interest in a high degree, however imperfect my description of it may prove.

I shall not stop to inquire what light comparative anatomy, or the

early stages of its development, might throw on the true affinities and nature of this structure, but will merely observe that there is some reason to suppose that the cornea, considered from this point of view, comprises two orders of parts—one belonging to the nervous vesicle which forms the earliest indication of the appearance of the eye in the early embryo; the other, and the larger, pertaining to the outer integument. I prefer, on this occasion, remembering the object before us, to take the cornea as we find it in the adult human subject, and to describe it, layer by layer, as it actually exists in those in whom you will be called upon to study and relieve its morbid states.

Fig. 1.



Relative size of the two surfaces of the cornea in one instance: *a*, anterior surface; *p*, posterior surface.

The cornea is nearly circular in shape, though we often find it wider from side to side than from above downwards. Its anterior surface is generally less extensive than its posterior, sometimes considerably so. The edge, therefore, by which it is continuous with the sclerotica will be bevelled, so that the sclerotica will overlap a little. Sometimes, on looking at the surface of a vertical section carried through these parts at their junction, we see the cornea received, as it were, into a groove of the sclerotica; but even here the hinder surface of the cornea is almost nvariably the more extensive: and I cannot say that I have ever seen an instance in which the bevelling was reversed, so that the cornea should overlap the sclerotica.

The two surfaces of the human cornea are, as far as I can judge, perfectly parallel to one another; that is, their corresponding points are equidistant, and the substance of the cornea is of the same thickness throughout. This has been doubted by some anatomists, who have described the central part as thicker than the margins, and have supposed that the cornea was a meniscus-convergent lens, capable of magnifying objects. But the mode employed to prove this—viz. that of first dipping the detached cornea into water to smooth its surfaces, and then, holding it over objects, finding it act as a slight magnifier—seems open to fallacy, since the only way in which it can be conveniently held is with the convex edge downwards, in which position, the water still adhering would fall to the central part, and make a lens of it. But I have failed to find the membrane magnify when secured against this source of error; and, moreover, an exact vertical section of a recent cornea exhibits an uniformity of thickness. When the

part has been macerated, it swells somewhat, and bulges less at the sides, where it is tied to the sclerotica, than in the rest of its extent. I need not observe that the cornea, though not itself a lens, yet acts as a powerful converger of the rays of light by virtue of the aqueous humor, which differs little from it in density, filling up its concavity in the natural state. That the cornea is not thicker in the middle is indicated by the phenomena of the disease called *conical cornea*, in which the weak or bulging part is always at or near the central region. In fishes the cornea is much thinner in the middle, to allow for the very projecting lens.

The absolute thickness of the cornea is greater than that of the anterior region of the sclerotica, being, according to the measurements I have made, from about 1-22d to 1-32d of an inch. These measurements exhibit considerable variety, which it is important for the practical surgeon to be aware of.

The first portion of the cornea that comes under our review is the *cornea proper*, or the *lamellated tissue*. It is this which forms the greatest proportion of the thickness of the cornea, and gives it strength and toughness. This is bounded externally by a peculiar lamina, the *anterior elastic lamina*, on which rests the *anterior* or *conjunctival epithelium*, and it is bounded behind by another peculiar lamina, the *posterior elastic lamina*, behind which is the *epithelium of the aqueous humor*. It is the cornea proper alone which is strictly continuous with the sclerotica.

Of the lamellated tissue of the cornea.—That the cornea proper is lamellated has long been known, and may be shown in a variety of ways. If a flap be shaped out on its surface by superficial incision and then torn up, the surface of laceration will be nearly parallel to the outer surface, and in this way layer after layer may be removed, especially in the eyes of the larger domestic quadrupeds. The knife, too, especially if blunt, having once pierced this tissue, is found to pass more readily in a horizontal direction, at whatever depth. These are circumstances with which all should render themselves practically familiar, who propose to make the living eye the subject of their operations. This physical construction of the lamellated cornea makes it desirable for the surgeon, when about to penetrate the cornea, to thrust the knife somewhat perpendicularly into it, since the arrangement of the tissue tends to carry the instrument in a horizontal course.

The lamellated cornea is tough, unyielding, and almost perfectly trans-

parent; and it is interesting to study the precise nature of its lamellæ, because there are facts which show that its transparency is very easily impaired by any derangement of their relative position, or by an increase of their natural tension. For example, if a thin vertical section of this part be made, and laid upon a slip of glass moistened with water, it remains transparent; but if you attempt to stretch it, in whatever direction, or to compress its parts into a smaller space, it instantly becomes milky and opaque. Again, if you squeeze a fresh and perfect eye between the finger and thumb, the cornea, it is well known, becomes immediately opaque in your hand, but quite recovers itself as you remit the pressure: and in all cases the degree of opacity is proportionate to the pressure you exert. This is a very remarkable experiment, and may serve to illustrate in some measure the opacity or haze of the cornea, which is apt to occur at an early stage of acute internal inflammation of the eyeball, attended with great engorgement of its vessels—a state also elucidated by what occurs in artificial injections of the eye, for when the vessels become gorged, and the globe tense and hard, the cornea invariably grows dim, and shuts off the iris from view.

Now, that the lamellæ of the lamellated cornea are not individually co-extensive with the cornea itself, is easily proved by a vertical section, in which we see the lines bounding the lamellæ to be very limited and interrupted, not extending far along the cut surface; the same view proves the lamellæ to run into one another at very numerous points throughout the entire cornea, so that the interspaces are very limited in their superficial extent; though their number is correspondingly great. Moreover, in tearing up a flap in the way I have already alluded to, innumerable connections between the lamellæ are seen to be torn through, and the surface exposed is not smooth, but covered with numberless minute lacerations of tissue. It would, therefore, be most correct to say that the strength of the tissue lies in a horizontal rather than in a vertical direction—that the horizontally-extended elements are thicker, and stronger, and less easily lacerable, than the more delicate, more fragile, vertically-placed elements which connect them with one another. Now if we endeavour to count the superposed lamellæ, it is evident that we can arrive at no very exact result, in consequence of their mutual connexions and overlappings: but nevertheless it will be found in general, that on the surface of a vertical

section, somewhere about sixty intervene between any two corresponding points on the opposite surfaces of the tissue.

There is a fact of some interest to be learnt from such a section, if it be made extremely thin, and it is this:—that the connections between the horizontally-extended lamellæ of the cornea are themselves membranous or lamelliform, and not mere fibres; for on opening out the lamellæ, so as to enlarge their interspaces, very delicate membranes are seen passing from one to another, and it is but rarely that complete perforations exist, however thin the section have been made. In such specimens, viewed under a high power, we have a faintly fibrous texture apparent in even the *most delicate* of these films of membrane, the fibrous elements being held together in that form by an homogeneous intervening substance.

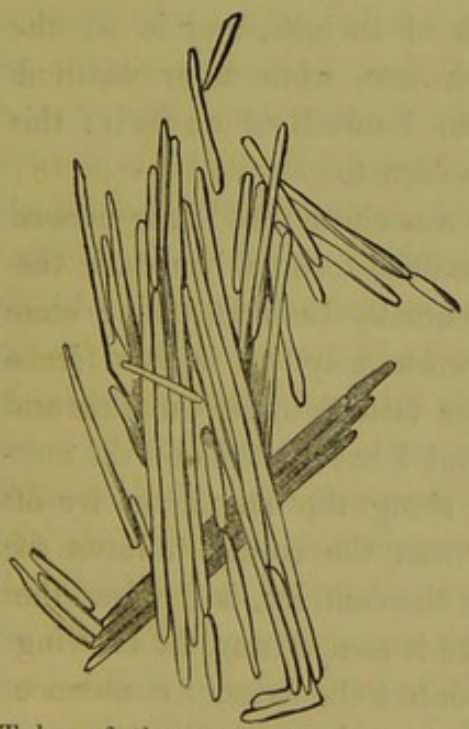
The nature of the *interstices* of the corneal tissue does not appear to have been particularly inquired into. It has been generally considered that the interlamellar spaces are themselves flattened or lamelliform, and that they contain fluid in sufficient quantity to fall easily from one part to another; and it has been imagined that inflammatory products, lymph or pus, might gravitate in such natural spaces to the most dependent part of the cornea. For the existence of fluid, stress has been justly laid on the fact, that if we lay bare the corneal tissue and make strong pressure on the globe, we shall observe first a dewy moisture, and then distinct drops of transparent fluid over the entire surface. But this shews the porosity of the entire cornea, rather than the existence of free fluid in its interspaces; for in the perfectly fresh eye the dew does not form until the pressure has been kept up for some time, and under continued pressure the aqueous humor gradually passes out; while if this humor have been previously evacuated by puncture and replaced by air, no dew forms upon the surface. Moreover, an incision into the lamellated cornea does not set free any visible fluid.

It has been sometimes thought that pressure produces opacity of the cornea, by driving out fluid from its interstices; but the return of transparency is so simultaneous over the whole surface, when the pressure is remitted, as to forbid the supposition of any fluid having escaped and re-entered at the border, while the presence or absence of the aqueous humor does not affect the result at all: pressure produces opacity if the chambers are filled with air. Hence it may be

concluded that the fluid existing in the corneal tissue is only sufficient to moisten its elements, not enough to lie free in its interstices: and further, that the elementary lamellæ are naturally in contact with one another, much in the same way that the filaments of the areolar tissue touch one another in other parts.

Of the corneal tubes.—Being desirous some years ago to discover whether the interstices of the cornea proper had any regular shape or arrangement, I made a small puncture near the border of the cornea of an ox, and, introducing the mouth of a mercurial injecting tube, was delighted to find the metal, under gentle pressure, running in a beautiful and curious manner, quite unlike anything that occurs in any other tissue, and from its constancy and peculiar figure evidently demonstrative of a natural structure. The mercury coursed rapidly along in perfectly parallel and very delicate lines for a short distance, then diverged at an angle into other similar tubes, which were found to cross the former either above or below. The tubular spaces thus injected appeared to be jointed or broken at varying intervals, and to present what in the nerve-tubes would be termed a varicose condition. The whole lamellated cornea was filled with such tubes, for at whatever depth or part the mercury was inserted, the same results followed; although, from the unnatural distension occasioned by even a small extent of such injection, it was impossible in a single specimen to fill the interstices of every portion of it, and at different depths, at one and the same time. These definitely-marked passages in the corneal tissue it seemed not very easy to force or burst; but when the mercury was urged to that extent, it separated the horizontal lamellæ for a greater or less space, and formed irregular flat patches, very similar in shape to those which are met with in the morbid state known as *onyx*, and which latter, I therefore conclude, is attended with a breaking down of the membranous connections between the horizontal lamellæ—con-

Fig. 2.



Tubes of the cornea of the ox, injected with mercury.

nections which form the side walls of the corneal tubes now described.

I found that I could inject the tubes with size and vermilion quite as definitely, though not so easily, or so as to form so beautiful an object, as with mercury; but this fact was sufficient to prove that the peculiar varicosities of the tubes were not a false appearance due to the tendency which mercury has to collect itself into the globular form.

What I have now mentioned is what occurred with the cornea of a large quadruped. I found it far more difficult to make a similar injection of the human cornea, or of that of the cat or smaller animals, and it is not probable that interstices of equal size—perhaps hardly of the same shape and arrangement—exist in the latter specimens. From the greater thinness of the membrane, and the greater proximity of the entire tissue to the vascular arches from which its nutrient supply is drawn, it may be supposed that such a free and ample system of canals may be dispensed with. In the human cornea, however, (as in fig. 3) I have clearly seen a tubular arrangement of the interstices under favourable circumstances: although, in general, the tissue too readily gives way under the distending force which it is requisite to employ. The length of the canals between the constrictions does not exceed the 12th of an inch, and is for the most part much less, while their width is from 1-500th to 1-600th of an inch: this is in the human cornea.

Fig. 3.

Tubes of the human cornea, injected with mercury. At *a a* extravasation has occurred.

It might be conceived that these corneal tubes were a modified form of lymphatic vessels, as it is generally thought that a close lymphatic net-work may be injected in a somewhat similar fashion under the skin and other parts. But I have not found the mercury escaping along the lymphatic trunks when pushed from the cornea towards the sclerotica. On the contrary, it requires hard pressure to make it escape from the cornea at all, and then it enters the anterior chamber of the eye, or the space between the sclerotica and choroid, or even subconjunctival blood-

vessels. Hence it is probable that the corneal tubes do not communicate *directly* with any other set of vessels or natural channels.

With regard to the use of these corneal tubes, we shall probably not be far wrong in supposing that they serve to promote and facilitate the permeation of this thick non-vascular structure by those fluid portions of the blood which alone have access to it. Whether the special arrangement of the tubes which I have described is concerned in endowing the cornea with its necessary transparency, it does not seem possible to determine. It might be imagined to contribute to hold all the lamellæ in place, and to prevent derangement of their relative position. A brief account of these, and other points which I shall notice, is given in the third part of the Physiological Anatomy and Physiology of Man, just published by Dr. Todd and myself.

Junction of the sclerotica and cornea.—I have already stated that the lamellated tissue of the cornea is the only one which, properly speaking, is continuous with the sclerotica. This continuity is so perfect that the two textures cannot be torn asunder, or in any way be shewn capable of detachment along the line of junction. Even maceration is not capable of effecting their separation; and if we consider the close affinities of the two structures, and their mode of union, it will be easy to understand the reason of this. In fact, both belong to the class of fibrous tissues, and have very similar physical and chemical properties. The fibrous bundles of the sclerotica, intricately interlaced and intermixed with threads of yellow elastic tissue, become continuous at the border with the laminæ of the cornea. The elementary parts of the one join on to those of the other; the interstices, which are irregular and open on all sides in the sclerotica, assume a regular arrangement, and become tubular in the cornea. On the surface of a very thin vertical section of the two structures, carried through their line of junction, the transition of one into the other can be very satisfactorily traced. By acetic acid the sclerotica swells and becomes transparent, and exhibits the yellow fibrous element of its structure, and also sparing nuclei, like those belonging to tendinous parts. By the same agent, the cornea first grows opaque as the arrangement of its parts is interfered with by the swelling of the tissue during the progress of the acid through it, but subsequently it all very nearly resumes its trans-

parency, merely displaying here and there on the surface of its lamellæ the elongated nuclei which were previously indistinctly seen, and which correspond closely with those of the sclerotica and other fibrous tissues.

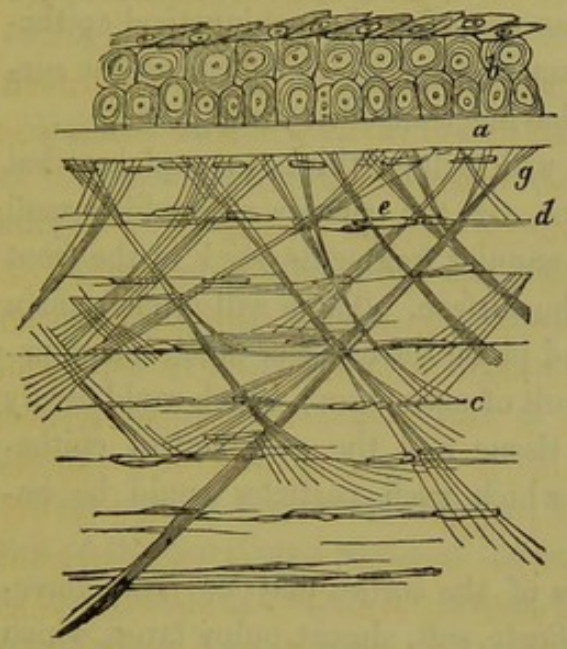
The description of the lamellated cornea will be most conveniently concluded in connexion with that of the *antertor elastic lamina ;* to which I shall, therefore, now direct your attention.

The *anterior elastic lamina* has not hitherto, as far as I know, been distinguished by anatomists, and yet it seems a structure of a very interesting kind, an acquaintance with which will perhaps enable us to discriminate some morbid phenomena from others with which they have been classed. It is a continuous sheet of homogeneous membrane, nearly similar in essential characters to the posterior elastic lamina of the cornea and the capsule of the lens, being perfectly transparent and glassy, without appearance of internal structure, and being very slightly or not at all influenced by acids. Its thickness in the human eye is from about 1-1200th to 1-2000th of an inch, and it forms an unbroken covering to the whole laminated cornea, giving it that smooth glistening surface which is exposed by scraping off the conjunctival epithelium. This latter rests upon it as the epithelium does upon the basement membrane in other situations; and I may observe that it appears to me to be strictly a highly-developed form of the basement membrane of the mucous system, remarkably modified in this particular part to answer a special purpose.

The manner in which the anterior elastic lamina is united to the lamellæ which it serves to cover, is very interesting. It must be borne in mind that the anterior surface of the cornea is convex, and that the maintenance of its exact curvature is of primary importance to vision, as it is there that the first inflexion of the rays of light falling on the eye takes place; and further, that the conjunctival epithelium being a soft and fragile substance, must take the figure of the surface on which its rests: hence, probably, the arrangement I am about to mention. The anterior elastic lamina, a firm, resisting, uniform layer, placed in front of the more soft and porous lamellated tissue, is tied down to the anterior lamellæ, at innumerable points, by filaments of similar texture to itself, which it sends in among them. These, as they penetrate the lamellæ, divide and expand in such a

manner as to take firm hold of them, and are thus gradually spent among the four or five lamellæ which lie nearest to the surface. It is singular, too, that these filaments are not set vertically, but everywhere in a slanting direction among the lamellæ, so that in a vertical section they appear to cross one another at right angles. This arrangement might, I imagine, be shown, on mechanical principles, to be the best possible for the maintenance of the convexity of the front of the cornea.

FIG. 4.



Vertical section of the human cornea near the surface. *a*, anterior elastic lamina; *b*, conjunctival epithelium; *c*, lamellated tissue; *d*, intervals between the lamellæ, showing the position of the corneal tubes collapsed; *e*, one of the nuclei of the lamellated tissue; *g*, fibrous cordage sent down from the anterior elastic lamina. Magnified 300 diameters.

It is obvious, from the elaborate manner in which the anterior elastic lamina is thus tied down to the lamellated texture, that it can hardly be raised as a separate layer; and hence, probably, the reason of its having been hitherto overlooked. In fact, it scarcely admits of being demonstrated, except on the face of a section of the cornea.

The anterior elastic lamina becomes exceedingly thin, and disappears, at the margin of the cornea, its attenuation being accompanied by an increase in the number and size of the filaments which it sends down to the lamellated tissue; so that it seems to expend itself by giving origin to these filaments. And from this extreme border, where it ceases to be distinguishable, a great abundance of them runs into the sclerotica, in that slanting course which the elastic lamina would have itself taken, if it had been prolonged in the direction of its own curvature. These filaments mingle with the elements of the sclerotica, and are gradually lost among its middle fibres. The artificial mode in which the margin of the anterior elastic lamina is thus fixed, may be roughly likened to that of the awning of a tent: it is rendered much more obvious if a thin vertical section of the parts at the junction of the sclerotica and cornea be treated with acetic acid.

That this lamina, although apparently homogeneous, like a sheet of glass, is very permeable to fluids, as is the capsule of the lens, may be readily shewn by squeezing an eye after the conjunctival epithelium has been scraped off: the small drops which collect on the surface rest upon this lamina after having transuded through it.

The existence of this lamina will help, I think, to explain, what must have often puzzled surgeons, viz. the tenacity with which small particles of steel, or other sharp angular fragments, stick in the front of the cornea only just within the surface. These will often remain for many days, or even weeks, and prove the cause of much inflammation, and yet still be found difficult of extraction; which could hardly be the case if the lamellated tissue and the conjunctival epithelium were the only textures in which such particles could be imbedded.

The *conjunctival epithelium* of the cornea may be now conveniently adverted to: it is that delicate, soft, almost pulpy layer, which forms the anterior surface of the cornea, and is so easily raised by the knife or needle. It is a continuation of the epithelium of the conjunctiva covering the front of the sclerotica and lining the lids, and consequently of the cuticular investment of the body.

In those animals which lose and renew the cuticle, by a constant process, unmarked by periods of intermission, the superficial particles are gradually shed after arriving at their mature state, while others are as gradually originated in the deepest region, on the tissue which serves as a basis of support, and near which lies the source of their nutriment. This is precisely what occurs on the outer surface of the cornea in the human eye. The epithelial particles are exceedingly transparent, but in position, form, and mode of growth and decay, they bear a close resemblance to the epidermis. In different animals the number of epithelial layers varies according to the size of the eye: in man, they constitute only a triple or quadruple series, altogether not exceeding the 1-500th of an inch in thickness. The deepest, which rest on the anterior elastic lamina as on a basement membrane, are slightly elongated vertically, and stand endwise; the next are angular or subglobular in shape, and the most superficial are flattened scales, more or less overlapping one another, and of a darker hue than the others when seen by transmitted light. The imbricated scales of the surface have their minute inequalities filled up in the natural state by the watery secretion of the lacrymal gland, so as to present a

nearly smooth refracting surface to the impinging rays of light; and by the frequent movements of the eyelids, the particles which are decaying and losing their place are brushed away, and escape by the nose. In a learned and interesting paper by Dr. Mackenzie,* you will find described a method of seeing in your own person the nature of the corneal surface. This epithelium is rapidly renewed, if scraped off.†

We may now, gentlemen, turn our attention to the *posterior elastic lamina of the cornea*, a layer which has been long known as the membrane of Demours or of Decemet, or as the elastic lamina of the cornea, or as the corneal part of the membrane of the aqueous humor.

This layer is very easily detached by scraping from the hinder surface of the lamellated tissue of the cornea, for it adheres but slightly to this tissue, and sends no filaments among the lamellæ, as the anterior elastic lamina does. It is a uniform, transparent, homogeneous layer, considerably thinner than the anterior elastic lamina (being only from 1-2000th to 1-3000th inch thick), but, like it, not affected by maceration, by boiling, or by the action of acids. Though very hard, and capable of resisting much pressure, and giving a crisp sound when divided by the scissors, yet it is very brittle and easily torn, and its fragments then show a remarkable tendency to curl up on all sides into rolls, and always with the anterior or naturally convex and attached surface inwards in the roll, so that it would appear to be formed or laid down *in situ* in a curve precisely the reverse of that which its elasticity inclines it to assume.

When an ulcer has destroyed the lamellated tissue, it sometimes happens that, for a short time, the posterior elastic lamina is thrown forwards into the breach, by the aqueous humour behind it, and forms there a small pellucid vesicle, which, however, almost always soon gives way by rupture, allowing the humor to escape, and the iris

* On the Vision of Objects on and in the Eye. Edinb. Medical and Surgical Journal, No. 164.

† Viz. in about three days. The instantaneousness with which the blood-vessels of the neighbouring conjunctiva, and even of the whole eye, dilate and become turgid with blood, when this epithelium is abraded, has often excited my astonishment. The share of the nervous system in this phenomenon is partly indicated by the severe and apparently inordinate pain which attends so slight an injury.

to fall forwards against the opening. This morbid state illustrates very well the properties of the layer now under consideration.*

With regard to the behaviour of this posterior lamina at the margin of the cornea, much difference of opinion—I might say, much uncertainty—prevails ; some holding that it is reflected in a modified form over the whole of the anterior and posterior chambers of the eye, others believing it to terminate with the cornea ; but none, as far as I am aware, having given a full and accurate account of its actual condition, which is one of considerable importance to a correct knowledge of the physiology of the organ, and to the understanding of some of its diseases.

Marginal plexiform tissue of this lamina.—This layer, then, will be found to terminate at the border of the cornea in the form of plexiform fibres of the yellow elastic kind, or that variety which is allied to itself in essential characters. In this respect it resembles the *anterior* elastic lamina. The plexiform fibres spring only from its anterior surface, or that towards the lamellated cornea. They begin to appear a very short distance from its edge, and, as they arise, the lamina itself becomes thinner, and is at last altogether spent. They all pass irregularly outwards, occupying, of course, a position between the posterior elastic lamina and the lamellated cornea ; and are finally reinforced by those fibres which come from the thin and extreme edge of the lamina. Immediately beyond this edge, therefore, at the rim of the anterior chamber, there is a layer of open plexiform fibres, passing outward, or from the axis of the eye, and

* In a case recently under my care, the posterior elastic lamina saved the ulcer from perforating. Mr. James M..... , æt. 52, had at the end of June a central ulcer, which was touched with lunar caustic, and he took quinine. By the middle of July it had gradually penetrated to the deepest layers of the cornea, and the posterior elastic lamina was laid bare, and bulged slightly into it from below, especially when trifling pressure was made upon the globe for the sake of testing the condition. Under a continuance of the tonic treatment this ulcer gradually filled up, the aqueous humor not having escaped ; and I saw him in February following with an opacity on a level with the rest of the cornea, but with its central portion (answering to the previously exposed posterior elastic lamina) of a denser white than the border.

When this lamina is thus exposed at the bottom of an opaque milky ulcer, centrally placed, the dark pupil may become visible through it, and look like a particle of dirt, deceiving the surgeon into an attempt to remove it, in making which he inevitably opens the anterior chamber.

being the continuation or representative of the posterior elastic lamina. The posterior of these fibres then curve backwards to the iris, and become inserted into its anterior surface at its greater circumference, in the form of small pillars; and near their insertion they begin to resemble the white fibrous rather than the yellow fibrous tissue in chemical and other qualities.

I have found these *pillars of the iris* much more evident in some animals than in others; but time will not allow me to enter on comparative details. They exist in all mammalia, and have their analogues in other classes. They are in contact with the aqueous humor, where they form the rim of the anterior chamber. A needle may be passed underneath them from the anterior chamber, so as to suspend by them a considerable fragment of the eyeball.

The great portion, however, of the fibrous continuation of the posterior elastic lamina goes not to the iris, but to the *ciliary circle*,—a name by which anatomists refer to a flattish circle of gray semi-transparent tissue, which intervenes between the ciliary processes of the choroid and the sclerotica, immediately behind its junction with the cornea, about which extraordinary differences of opinion prevail, but which I shall hope to show you, in a subsequent lecture, is muscular. For convenience, therefore, I will now assume that it is such, and term it the *ciliary muscle*. This muscle arises, then, from the fibrous tissue coming from the posterior elastic lamina,—the fibrous tissue passing in a sheet backwards to the anterior region of the ciliary processes, and giving origin on its outer surface, or that turned from the anterior chamber, to the fibres of the ciliary muscle, which then clothe the outer surface of the choroid for about one-eighth or one-tenth of an inch, as far as opposite to the *ora serrata*.

There are still other fibres derived from the posterior elastic lamina —viz. those placed most anteriorly, and which were the first to take origin from it. These, after a short course outwards, become separated from the sclerotica by a narrow space all round, known as the *sinus circularis iridis*, and which has been considered as a venous canal; afterwards they pass to be united firmly to the sclerotica beyond this sinus, and in so doing share principally in its formation. But there also exists here a series of *circular* fibres, those just described being more or less radiating: the circular lie outside the others, are opaque, white, and stiff, contributing to the formation of the circular sinus, and to that firm union, the *ciliary ligament*,

which subsists between the ciliary processes and the anterior rim of the sclerotica; and which, as a whole, effectually serves to prevent the aqueous humor from escaping into the space between the sclerotica and choroid.

I am aware of the difficulty I must experience in attempting to give you a clear description of this structure, before I have passed in review those others with which it is associated. What I have now said, however, must suffice for the present, and I shall return to it in connection with the iris and choroid and lens. A few words remain concerning the *posterior epithelium of the cornea*, or the *epithelium of the aqueous humor*.

This is so extremely delicate and so perishable a layer, that it has only of late years been recognised, and yet it is very easily prepared for examination. It is a single series of flat epithelial nucleated particles, placed side by side, and united by their margins. Even in large animals the epithelial cells are not in a double layer. It is coextensive with the posterior elastic lamina, which it separates from the aqueous humor. It would appear, however, from what has just been said concerning the conversion of the posterior elastic lamina at its border into fibrous tissue, which in part passes through the aqueous humor to the iris, that this epithelium must cease with the elastic lamina, since there is no longer any stratum on which it can rest. I have not been able to discover the smallest appearance of it upon the pillars of the iris, and I conceive, therefore, that it is limited to the cornea.

I have called this the epithelium of the aqueous humor, because it is the only true epithelium which can be found in contact with that fluid. I shall have to show in a future lecture that the front of the iris has no true epithelial investment, and that the front of the lens is also destitute of such a covering. It seems, therefore, incorrect to speak of the chambers of the eye as lined by a serous membrane, or of the aqueous humor as contained within a proper capsule; and I suppose that practitioners must abandon the *name*, at least, of that affection, which is now generally termed *aquo-capsulitis*, even if they continue to regard it as a distinct disease.

In my next lecture I shall proceed to notice some of the morbid states of the sclerotica and cornea; and shall endeavour to connect my remarks as far as I can with the anatomical, and, I fear, rather dry details, which I have had to dwell upon to-day.

LECTURE II.

Blood-vessels and nerves of the sclerotica and cornea—character of the nutritive process in these structures.—Morbid states of the sclerotica and cornea.—Sloughing of both corneæ from defective nutrition.—Reparative process in the cornea—Anatomy of a simple ulcer of the cornea—Formation of vessels in the cornea—Effect of general disease on the cornea.—Lymph or pus in the lamellated tissue.—Pustules.—Opacities of the cornea—Development of papillæ on the cornea—anatomy of Staphyloma corneæ.

Gentlemen,—In my last lecture I reviewed the structure of the outer tunic of the eyeball, consisting of the sclerotica and cornea, and described the several layers of which the latter is composed. It remains for me, before proceeding to the more internal parts, to make some observations on the nature of the process of nutrition, as it obtains in these structures, and on the bearing of their anatomical construction on the nature and progress of some of their more important diseases.

Both the sclerotica and the cornea are sparingly supplied with the materials of nutrition, as a glance at the arrangement of the blood-vessels will show. The sclerotica is obliquely pierced behind with numerous arteries derived from the ophthalmic, termed the *posterior ciliary;* but these go almost exclusively to the choroid, only giving a few minute twigs to the sclerotica as they pass. In front, too, the arteries which have supplied the muscles of the eyeball send forwards beyond the tendons small prolongations, which are visible under the conjunctiva, and lose themselves in the sclerotica, within an eighth of an inch from the margin of the cornea. These, however, traverse rather than supply the sclerotica, and anastomose with vessels of the ciliary muscle and iris. Hence, in the most successful injections, the sclerotica itself is with difficulty tinted by the artificial colour, and the

microscopic inspection of parts so prepared exhibits only a few slender capillaries coursing among the greatly preponderating mass of the white fibrous tissue. And if we pass from the sclerotica to the cornea, we shall find the most unequivocal proof that no blood-vessels at all encroach far beyond its border. The evidence which injections are capable of affording on this head is very decisive. We now know that the capillaries are, in almost every organ, definite and determinate tissues, having proper walls, which may be distinguished from the parts among which they lie; that they have a certain limit as regards minuteness, and that they form everywhere a closed system of tubes, porous, indeed, so as to be capable of transmitting fluid materials, both inwards and outwards, by a process of imbibition, but nevertheless having walls of unbroken membrane, without breach or orifice. Hence if an injected specimen exhibits a system of such canals, replete with artificial coloured contents—its ramifications regular, having margins formed by rounded, arched, entire capillaries—we may safely assert that the vascular net-work really terminates naturally at those margins, and that the tissue beyond has been as impermeable to the red particles of the circulating blood, as we find it to be to our prepared fluids. This is precisely what occurs in the case of the cornea. The vessels of the sclerotica, and of the conjunctiva covering the sclerotica, send numerous twigs towards the cornea; but all, on arriving within the corneal tissue, turn back, forming numerous arches, which run parallel to the margin of the cornea for some way, and then return from whence they came. Thus we have a striking difference between the sclerotica and cornea in addition to those before insisted on,—that the one is permeated by blood-vessels, the other is entirely devoid of them.

I may say a few words here on the *nervous supply of the two structures*. No doubt the nerves of both are few; the sclerotica gives passage to the ciliary nerves, and although they have not been demonstrated, it is possible that it receives some filaments from them. In a state of health it seems to be very insensible, but when inflamed, like many other dull and almost insensible parts, it appears to be capable of becoming the seat of very acute pain. In the cornea, nerves derived from the ciliary are said to have been discovered by more than one anatomist of trust: I cannot say that I have myself seen them, although I cannot doubt their existence; for when we remember that nerves in their peripheral distribution may lose their

tubular nature and their characteristic microscopic appearance thence derived, (and I have constantly found the ciliary nerves do this) we may well be content to receive *pain* as sufficient evidence that a part is not destitute of nerves. That the cornea has a degree of sensibility capable under some forms of irritation of being exalted to a considerable height, is matter of common experience.

From what has been said, it may be safely concluded that the sclerotica and cornea are slowly renewed in their elementary constitution by the process of nutrition. No doubt the presence in or near them of the materials of change is absolutely necessary for the continuance of their life; but what I would endeavour to impress upon your minds is this,—that their structure is feebly supplied with blood, or the nutrient part of that fluid—that the process of nutrition in them is therefore slow, inactive, and easily impaired, either by impoverishment of the nutrient material or by any mechanical interference with its due and regular supply. These observations apply more to the cornea than to the sclerotica, because the latter has vessels, the former has none; the latter, therefore, is supplied interstitially, as it were, with the power of life, growth, and nutrition; the latter must derive through the medium of its circumferential parts whatever is requisite to sustain the integrity of its more central portions.

Morbid states of the sclerotica.—I shall have but few observations to make, gentlemen, on the morbid states of the sclerotica, in their special relation to its structure: wounds of this part readily heal by the adhesive process, the cicatrix being semi-transparent as in tendon; and minute punctures are generally harmless, even when they penetrate not only this coat, but the choroid. It is possible that the readiness with which lacerations and incisions of the sclerotica heal, is ascribable to the thinness of the tissue, and to the fact that it has on both its surfaces an abundant supply of blood in the contiguous textures. The experience which surgeons have acquired in their operations on cataractous eyes, affords ample proof of the slight tendency which simple wounds of the sclerotica have to take on an unhealthy action. The form of inflammation which the sclerotica usually undergoes is the rheumatic. Into the nature and symptoms of this it would be out of place to enter, as we must limit ourselves at present to the anatomical condition.

In inflammation of the sclerotica, when least complicated with conjunctival disease, its vessels are seen to be unnaturally filled with

blood; its capillaries are distended, so as to become visible by imparting a tint to the fibrous tissue, and the minute arteries and veins enlarge and become tortuous. All these are distinguished by their purplish hue, compared with the more superficial vessels of the conjunctiva under inflammation.*

In some delicate persons the sclerotica is so thin in its anterior part as to derive a bluish tint from the choroid underneath. This is no disease, but in cases of old-standing choroidal or other disease within the globe, which has operated so as to cause a slow and gradual distension of the outer coat, the pigment is in like manner disclosed under the bulging and attenuated sclerotica; and I have observed in some cases that under this internal stretching force the sclerotica is apt to yield in lines passing backwards from the cornea, so as to form slits or chinks more or less radiating, through which the choroid is more obviously seen. This depends on the disposition of the fibres of the sclerotica, which I alluded to in the last lecture, viz. their passing at the anterior region rather in a radiating direction from the cornea than in any other arrangement.

Morbid states of the cornea.—To the surgeon, as to the anatomist, the cornea is a much more interesting and important texture than the sclerotica, and I therefore propose to be a little less brief in commenting on some of its principal morbid states, especially such as either illustrate, or are illustrated by its structure, as explained in the former lecture.

And first, gentlemen, in evidence of the comparative feebleness of the process of nutrition in this texture, I shall relate the following case which occurred at this hospital during the present spring.

Sloughing of both corneæ from defective nutrition.—On the 8th March, a mother, herself reduced in strength and looking ill, brought her infant, 13 months old, to the hospital, on account of its eyes. I found that both corneæ were in a state of slough, flaccid, of a pale yellow, like macerated leather; that this slough comprised the whole area, except a very narrow belt of about 1-20th of an inch nearest to the sclerotica, from which latter a few minute vessels were shooting towards the line of separation, which was already beginning to be established between the dead and the living parts. The conjunctiva exhibited very little vascularity, and had evidently not been suffering from inflammation. The infant was pallid and puny, with

* For a rare example of ulcers of the sclerotica, see Case A, in the Appendix.

a pinched and anxious countenance. I found that the mother had been suckling the child till seven weeks from the time I speak of, being herself ill and weak, and very insufficiently nourished; that on going into the workhouse they had been parted, and that she first noticed the eyes to look "weak" three weeks since. The bowels had been constantly purged for eight days; and she had been taking rhubarb and magnesia. The compound powder of chalk, with opium, was given every four hours, with the Liq. Cinch. of Battley, and beef-tea, with small quantities of brandy, and Mr. Heward kindly undertook to visit her at her own home. On the 11th (three days afterwards), I found more vascularity at the margin of the corneæ, and over the white of the eye, but with hardly any secretion. The bowels had been less relaxed, but the stools were still green and loose. She had taken some wine and bark, but would not touch the beef-tea. She was evidently weaker, and moaned constantly. In two days afterwards she died.

In this instance we find the cornea falling into a state of gangrene from defective nutrition; the impoverishment of the blood, manifested in various degrees in the other textures of the body, here leading to the complete destruction of a tissue which naturally has a very small supply of that necessary fluid, and which therefore is but too ready to yield its vitality when that supply is withheld. The case of this poor child finds a parallel in others which have been related, as occurring from actual starvation, or the privation of all sustenance, and perhaps still more aptly in those animals which Magendie confined to a diet of sugar and water, or other non-azotised food, and of which one of the more constant evidences of declining power was the sloughing of the corneæ, and the consequent destruction of the eyeballs.*

I may also mention the case of a woman who is now in attendance here, and who, on her first appearance some months ago, had a dull, hazy state of both corneæ; the surface having lost its brilliancy, and the whole texture being very uniformly obscured. The approach of this condition had been very gradual. It had been attended with no redness, nor was there, at that time, any excitement of the circulation in the neighbouring sclerotica or conjunctiva, or any development of new vessels in the cornea itself. She was pallid, but her muscular strength was not remarkably reduced, nor could I discover that she had been insufficiently fed in regard either to quantity or quality, or

* The corneæ may fall into slough in an analogous way after scarlatina. See Appendix, Cases B.

that she had any disease affecting a vital organ. Nevertheless, her pulse and countenance bespoke a system in which the powers of life, from some cause or other, were considerably depressed, and Mr. Dixon concurred with me in recommending a strictly tonic course of treatment, comprising steel and quinine, with such modifications in diet, place of abode, and mode of life, as her situation appeared to render desirable. Under this plan, which has been continued up to the present time, a steady improvement has taken place in the condition of the corneæ. The haze is clearing away in the most gradual manner, and without any unnatural vascularity of the part or neighbourhood, and her looks are much improved in every respect. I cannot help regarding this affection as simply the result of an impairment of the nutritive process in the whole body, showing itself in a special manner in this texture of feeble power.*

Reparative process in the cornea.—The cornea when healthy is readily repaired after injury; punctures and incisions being followed in general by speedy reunion of the divided parts, without suppuration or sloughing. The adhesive process is here presented to us in its simplest form, for it takes place in a structure which contains no blood-vessels, and therefore where none have been divided. But if we bear in mind that all tissues have a proper life of their own, of which their several properties and actions are the necessary manifestations, and that the blood-vessels are but ministerial to the proper life of the tissues they supply, by serving as the medium through which the materials essential to life are brought within their reach, and what is rejected by them is carried away, we shall readily understand how it is that a tissue which, like the cornea, originally grew, and has its ordinary life sustained without the presence of interstitial vessels, may be also repaired and renewed without them within certain limits. For the reparative actions, in their natural form, are nothing more than those of growth and nutrition, modified by the new conditions occasioned by external accident, and tending constantly to a removal of those new conditions, and the restoration of the normal state.

If we puncture or incíse the cornea, the first effect is a change wrought in the natural actions of nutrition then existing in the

* This patient, at the end of three months, had recovered the transparency of the corneæ, and was much improved in health. She has, however, on two subsequent occasions, had relapses, from the last of which she is now recovering, but with the right cornea considerably, and I fear permanently, clouded.

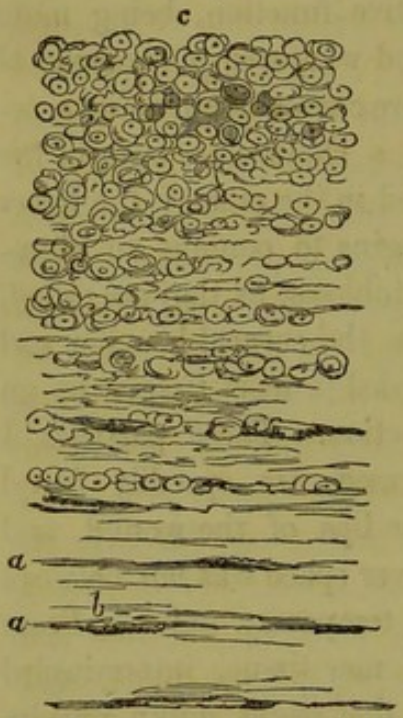
wounded part,—a change which can only be described as a mechanical interruption to those actions, and which, from the resultant train of phenomena, has been often called a stimulus. This is speedily followed by the presence of an increased quantity of blood in the vessels that are nearest to the wounded part—viz. in those of the conjunctiva and those of the sclerotica; and thus the materials from which the breach is to be made good are brought in greater abundance to the part that requires them. We cannot doubt that as these vessels, comparatively so remote, are thus affected, so the part of the corneal tissue intervening between them, and the exact seat of injury, is pervaded by a corresponding change, of which the general expression is this,—that it is one of exalted nutritive vigour; the play of forces, and the interchange of material, which mark the nutritive function, being more energetic and more rapid than before. And whatever phenomena of this kind occur in the intermediate tissue are concentrated in an especial manner about the wound itself. In a short time, even in the course of a few hours, as I have ascertained in the case of the lower animals, the vicinity of the injured part begins to contain in abundance those minute particles, nuclei, or cytoblasts, as they are called, which exist naturally, though sparingly, in the corneal lamellæ, and the relative quantity of which may be regarded in most tissues as an index of the intensity of the nutritive function. These particles, I say, hastily, indeed, and imperfectly formed, are speedily found choking the interstices of the tissues in the lips of the wound, and covering its surface, so as to occupy whatever space was left between its opposite sides, and bringing them into temporary union. From the presence of these embryo materials of new tissue, intermingled among the elements of the old, is derived that slight milky opacity which envelopes and marks the seat of wound, and which, if the injury be extensive, may engage a considerable extent of the cornea in the direction of the neighbouring blood-vessels. The subsequent changes I need not particularly dwell upon. The breach being filled, the new material is gradually transformed into products resembling those tissues among which it has been poured; the blood-vessels, at the border of the cornea, resume their size, and at length, in the most favourable instances, all vestige of the wonderful process which has taken place vanishes away.

Such is the progress of the actions which usually ensue when the surgeon punctures the cornea with his needle for the purpose of ope-

rating on a cataract; and the same takes place, in general, whenever there is no destruction of substance, where the wound is not too large, and where its margins have been accurately adapted. But it will readily be conceived that, in cases of wounds with loss of substance, or attended with extensive division of parts, the demands on a tissue so feebly nourished must exceed its limited powers. The result will then oftentimes be the failure of the adhesive process, with the establishment of a temporary ulcer or open breach, or with an actual sloughing of the lips of the wound. The reparative actions then advance more slowly, and in a modified form, by a species of granulation very similar to that which obtains in corresponding states of the skin or mucous membrane.

FIG. 5.

Free surface.



Vertical section of a minute ulcer on the surface of the cornea of a cat, three days after the application of caustic potass. *a*, *a*, indicate the position of the corneal tubes in the sound tissue below the bed of the ulcer; *b*, nucleus of the lamellated tissue. The surface of the ulcer is seen formed by a crowd of vesicular nuclei, most of them with a nucleolus. These were in various stages, and mingled with finely granular matter. Magn. 300 diameters.

I had an opportunity last year of examining a small ulcer which had been occasioned on the centre of the cornea of a cat, by the contact of a small piece of caustic potass, three days previously. The conjunctival epithelium and the anterior elastic lamina had been removed, and the superficial lamellæ of the cornea proper formed the bed of the ulcer. These were softened and semi-opaque, from the presence of great numbers of the nuclei already alluded to, in and around; and it was interesting to observe that their numbers were greatest on the surface of the ulcer, and diminished in proportion to their distance from it. In the section of the ulcer, represented in fig. 5, the nuclei are seen occupying chiefly the position of the corneal tubes, especially in the deeper part (Compare this with *d*, fig. 4). We have, in this example perhaps the simplest condition of an ulcer that can occur in any texture, and it is therefore well deserving your attention.

Development of vessels in the cornea.—Few things are more interesting in the

history of reparative processes in the cornea, than the fact which we observe every day, of its capacity of becoming furnished with blood-vessels derived from those of the conjunctiva and sclerotica. If any irritation is long kept up, or if any ulcer exists having to heal by a slow and gradual process, we usually find in the interval between it and the neighbouring vessels, a greyish, half-transparent tract, distinguishable from the healthy cornea; and in this there are soon developed a series of vessels which presently declare themselves as arteries, capillaries, and veins, carrying the blood in a circuit through and about the seat of reparative action.* It is obvious that these are produced out of new matter, laid down before their actual formation in the line which they are to occupy. As a punctured wound is made good by the simple transformation of the new matter into the natural tissue, without the formation of new vessels, so, when time allows, and the extent of repair requires it, a portion of the new material is developed into vessels, which may serve the temporary purpose of expediting and fortifying the reparative actions, by bringing to them an immediate and interstitial supply of blood. Thus is the cornea made dull and useless for a time, by the introduction of a structure destructive of its transparency, in order that its integrity may be restored according to the natural laws of growth. When its restoration is somewhat advanced, and less blood is required, these new vessels dwindle; their coats, which are at best imperfectly organised, soon disappear, and the cornea becomes once more permeable to light. I have a specimen in which these adventitious vessels are displayed injected with artificial colour. They pass into the cornea from the conjunctiva, and from the whole thickness of the sclerotica, and occupy, in this particular instance, almost the whole thickness of the lamellated tissue.

The cornea may further become vascular without ulcer or wound, and simply as a result of continued inflammatory action, and this in two principal ways: either the new vessels may form a network on the front of the cornea, anastomosing on all sides with those of the conjunctiva, and only obscuring the lustre of its surface; or they may pass in very close and more parallel series from the sclerotica, so as to

* This does not always happen, for some chronic ulcers of the cornea will heal in the most gradual manner without the formation of any vessels in their vicinity, as, *e. g.* in Case C, in the Appendix.

make the cornea uniformly of a dull red. The former state is the result of long-continued irritation of the conjunctival epithelium by granular lids or displaced lashes, and the vessels in all probability lie immediately beneath the anterior elastic lamina, in the more superficial lamellæ of the cornea proper; but I have never had an opportunity of actually ascertaining this. They can hardly lie over this lamina, and it is too thin to contain them in its substance. The latter condition results from chronic inflammation of the lamellated tissue, and is attended with an opaque deposition of new matter. The vessels run in among the lamellæ, and may occupy the entire thickness of the cornea proper, rendering it nearly impervious to light.

In both the forms of morbid vascularity now mentioned, the vessels are to be regarded as originally a result of diseased action, not as themselves the disease. They are developed under the salutary or conservative law of the organism, to enable a part of feeble vitality to sustain a morbid action to which it has become subject, and under which its vitality would otherwise sink. It is true that their presence marks the existence of disease, and is to a certain degree an index of its extent, but we must be on our guard against imagining that it constitutes its essence. Unless these vessels had been developed, the diseased process would long ago have terminated by the total destruction of the tissue. If, in the case of the impoverished infant which I related just now, there had been sufficient vigour in the nutritive and organising process to fill the corneal tissue with offshoots from the surrounding vessels, the eyes might not have perished.

The cornea, and other parts of low vitality, or of such a texture as cannot speedily develope new vessels, often fall into gangrene under any sudden inflammation, because their vascular supply is either very limited, or cannot expand in correspondence with the demands of the morbid action.* On the other hand, practical surgeons know that it is very difficult to induce destructive inflammation in erectile tumors, which are distinguished by the abundance of their vascular supply.

We may even go further, and maintain that these adventitious vessels are necessary to a cure, and to their own removal, which may seem a paradox, but is nevertheless a very sustainable proposition. For as the morbid products (including the vessels) laid down in the cornea, require for their existence a certain accession of new material,

* Appendix, Case D.

in the way of continuous nutrition, so they cannot be removed unless means are found for the absorption and removal of the old material of which they are composed, and these means are mainly the vascular channels. As long as the material capable of being removed remains, the vessels remain also, though gradually atrophied, and ready to disappear; and sometimes, when the morbid products have been so long laid down as to have become organized into permanent forms of morbid and opaque tissue, the vessels, in reduced number, are found to remain also, as being necessary for the existence of that which cannot now be taken away by any interstitial process of absorption, and which must therefore be either nourished or die.

The presence of these vessels in parts of the cornea that have been once inflamed, is often made evident by their sudden engorgement with blood, under any casual irritation, such as exposure to a strong light, or the puncture made by the surgeon's needle.

The unity which reigns throughout an organised body of so much complexity as our own, renders every part liable to be influenced by the state of the great organs subservient to nutrition; the digestive which provide, the respiratory which renovate, the circulating which distribute, and the excretory which purify the blood. The nutrition of every organ or tissue is subject to derangement, when the blood from which it derives its materials of renewal is impoverished or altered in quality, or when that healthy balance of the circulation is lost, to which Dr. Farre called your attention a short time ago.

It is not to be thought, therefore, that the morbid phenomena of any of the textures of the eye, or of the body at large, can be rightly comprehended by one who never has regard to the condition of what is termed "the *general health*," and, least of all, those of a texture like the cornea, which, being itself bloodless, and deriving its supply of nutriment by a frail tenure from surrounding parts, must necessarily be obnoxious in a peculiar degree to certain of those disturbances which another more favoured part might have sufficient vigour of life to disregard or overcome. It would be very easy to enlarge on so fertile a theme; but I must dismiss it with this simple allusion, or it would lead us too far from the proper subject of these lectures. It is perhaps of even greater importance still that these views should influence our minds in considering the propriety of an operation for cataract in any particular case, and especially of that of extraction, which involves an extensive division of the corneal tissue, and to the

success of which, reparation of the wound by the first intention so much contributes.

Lymph or pus in the lamellated tissue.—As a result of inflammation of the lamellated tissue, lymph or pus may be formed in the interstices of the lamellæ, attended, in the first instance, with irregular haze, and then with mottled or patchy opacity, as it accumulates in greater abundance in certain situations. If the inflammation be of an acute kind, and the effusion rapid, so as to gorge and distend and press upon the lamellæ too much before their supply of blood can be suitably augmented by newly-organised vessels, and especially if the system be at the same time in an enfeebled state from defective nourishment, or the scrofulous diathesis,—the lamellæ become irregularly separated from one another, their tissue is broken up and destroyed, and a slough results which is usually of a flattish form, often engaging a considerable area of the cornea, but not its entire thickness, *i. e.* following the direction of the lamellæ; or a simple abscess may form, which may discharge itself either backwards into the aqueous chambers, or on the external surface of the cornea. In either case it very commonly happens that the remaining part of the thickness of the cornea gives way, making a complete perforation, through which the aqueous humour escapes, and the iris prolapses. The injury done to the eye by such extensive disease is severe and permanent; a portion of the cornea has its place supplied by new matter, which becomes developed into an opaque tissue very different in constitution and elementary arrangement from that which has been removed, and the pupil is more or less distorted or dragged away from the axis of vision.

If, however, the inflammation of the lamellated tissue be less acute, and less disposed to run rapidly to destructive results, the lymph which is poured out collects in small portions among the lamellæ, giving an irregularly mottled aspect to the cornea, because some parts retain more of their transparency than the rest, though all are dim; and vessels are gradually formed in the corneal tissue, entering it at various depths from the neighbouring sclerotica. When this occurs, the sclerotica itself, for a short distance from the cornea, appears of a dull red, owing to the augmented quantity of blood passing through its vessels to supply this new demand. If the disposition to the formation of lymph in the corneal tissue continues, the enlargement of its vascular supply tends to accelerate the subsequent

changes, the whole tissue gets interfused with opaque matter and additional vessels, and the original lamellated structure becomes thickened, softened, and obscured.

After so delicate and important a part has been apparently spoiled by a serious disease, it is not a little interesting to notice how completely and how speedily, in many instances, its perfect transparency may be restored by timely and judicious treatment. For in such cases you will observe that the original tissue of the cornea is not in any measure destroyed, or its arrangement permanently altered, unless the duration of the morbid state have been considerable, and time have been thus afforded for the organization of permanent forms of unnatural tissue in its interstices.

Moreover, when once the inflammatory action and the inclination to the formation of morbid products have been subdued, the blood-vessels which pervade the deteriorated structure begin to assist largely in its restoration, by expediting the absorption and removal of the newly-deposited lymph; and in proportion as this clearance is effected the vessels themselves diminish in size, and finally disappear. The speed and completeness with which the cornea resumes its previous state will depend much on the promptness with which the treatment is undertaken, and the energy of the nutritive function in the part and in the whole body. In scrofulous subjects, who are especially prone to this affection, it is notorious that there exists in the constitution a grave and deep-seated defect, which manifests itself chiefly in imperfect or perverted nutrition; and until this is in some degree corrected, this disease can hardly be checked, or its consequences got rid of.

The cornea evinces its near alliance with the integumental tissues, by its disposition to the formation of small pimples, or *phlyctenulæ*, on its anterior surface. These, too, are most common in young strumous subjects: they are generally situated at or near the margin, and appear on the conjunctiva at the same time. They are slow in their progress, and ere they have reached their full size are generally provided with a leash of conjunctival vessels, which give a characteristic appearance to the eye. They are formed on the *front* of the cornea, and, I should suppose, immediately under the anterior elastic lamina, and the vessels they acquire also, of course, lie under that lamina, and come from the sub-conjunctival tissue.

These pimples may contain a minute quantity of lymph, which may

become organized into a raised vascular tubercle, or they may advance into the pustular stage, and form ulcers by opening on the surface, with a destruction of the anterior elastic lamina and the conjunctival epithelium. An opacity remains after they are healed, which is usually proportionate to the previous depth of the ulcer; but it is gradually lessened with the growth of the little patient, and often altogether disappears. Occasionally such an ulcer will heal with a depressed but nearly transparent surface, leaving a mark only apparent to others in certain positions of the eye, when the light is reflected from the part; but for the same reason painfully obvious to the patient himself (if it happen to be situated near the pupil) by the distortion of objects which it occasions.*

Of opacities of the cornea.—I shall now, gentlemen, say a few words concerning *opacities of the cornea,* such as are commonly left by a variety of causes in different portions of the corneal tissue, and shall endeavour to explain their nature and seat according to the particular tissue they affect.

We have already seen that the proper laminated tissue is capable of enlarging its vascular resources for its support under disease, and for the subsequent removal of diseased products, to such an extent that if it have itself escaped disorganization, it is able, under favourable circumstances, to completely resume its transparency. The nature of the nutritive process in the laminated tissue is such that this tissue recovers itself in a great measure, by timely treatment, from almost any amount of inflammation and consequent effusion which falls short of actual destruction of its elements. But when these elements are at all displaced or consumed under the morbid process, then permanent opacity is very likely, and indeed almost certain, to follow; for so artificial is the mechanical arrangement of the elementary lamellæ, on which the transparency of the cornea depends, that when their substance is once removed its place cannot be supplied with a tissue of an equally elaborate organization. The new material, though its bulk and strength may be equivalent to those of the old, is fibrous instead of being lamellated, and opaque instead of being translucent. It contains a considerable quantity of yellow tissue, intimately mixed with the white, and both most iregularly

* For some varieties of corneal ulceration, and other morbid conditions, see Appendix, Cases E, F, G, and H.

interwoven and ill-developed—ready to become the nidus of small granules of earthy* or fatty matter, such as readily settle in parts of deteriorated structure. From this condition recovery is not possible; the blemish has become indelible.

It is to be observed, however, that during the progress of the reparative process, there exists in the part and its immediate vicinity a quantity of fresh material of that kind which denotes an over-activity of the nutritive function, and which, not being employed for conversion into permanent tissue, will in due course be absorbed. This augments the opacity while it lasts; and it is not till a certain time has been allowed for its removal, after the healing of the breach, that we can say how extensive or deep the permanent opacity may prove; we may generally venture to predict a gradual improvement during some time, in a recent opacity, particularly in young subjects.

What I have now said applies to the greater part of the more common opacities of the cornea: I may allude to one or two other forms which may prove interesting in regard to the question of their precise seat. There are some varieties which appear to be on or near the very surface of the cornea, and which it is probable may occupy the anterior elastic lamina. The very opaque chalky-looking films which often follow the application of quicklime or new mortar to the eye, seem to be of this kind, and so, also, do those which have been supposed by some to be stainings of the surface of the corneal tissue by a deposit from the lead lotion in common use. Occasionally we have a superficial excoriation of the cornea—one can hardly call it an ulcer—which the epithelium limits with abrupt edges, thus favouring the accumulation, on the depressed surface, of the frothy mucus or sud which the movements of the lid furnish. The opacity thus produced is often very opaque, and unless you were aware of its cause, might

* The following is an example of ossification occurring in the centre of a dense leucoma. A girl, æt. 14, was brought to me last autumn, suffering from severe inflammation of the eye, which had been partially sunk several years before, and in which no perception of light remained. The irritation was very great, especially on every movement of the lid; and, on examination, I perceived a hard angular piece of bone imbedded in the front of a dense opacity of the cornea, and projecting beyond it, quite bare. It was easily removed with a pair of forceps, and the patient speedily got well. The fragment was the size of a large pin's-head.

seem more serious than it really is. A lens, or the point of a needle, will inform you of its real nature.

There is another form of opacity, which I believe to have its seat in the anterior elastic lamina, although it is vain to endeavour to prove it, except by a section of the parts. It has a silvery lustre, and a very fine texture of interweaving striæ, and it creeps very gradually from near the border, over the surface of the cornea, towards the centre. The epithelial surface retains its smoothness and lustre, and the opacity does not appear to have much depth. Other varieties of opacity, very chronic in their course, and evidently not inflammatory, are liable to form, as I believe, in the same tissue. They may be of a brown tint, with an indefinite margin, and may affect both corneæ at the same time. I am not aware that these are particularly described in books, nor whether they admit of removal, or even arrest. They are probably connected with an imperfect nutrition of the eyeball, and must be left to take their course.*

There is a variety of opacity consisting of minute dots, sometimes so small as not to be distinguished separately without a lens; at others, as large as a small pin's head. These are evidently seated on the posterior part of the cornea, and may be referred to the posterior elastic lamina. They accompany an inflammatory affection in which the walls of the aqueous chambers seem to be chiefly involved, in which the iris is usually mottled and dull, the pupil inactive, and the sclerotica more or less injected. Such a dotted opacity was long since pointed out by Mr. Wardrop, and admits of removal, provided the proper treatment is commenced early enough. It probably consists of an ordinary inflammatory deposit of lymph.

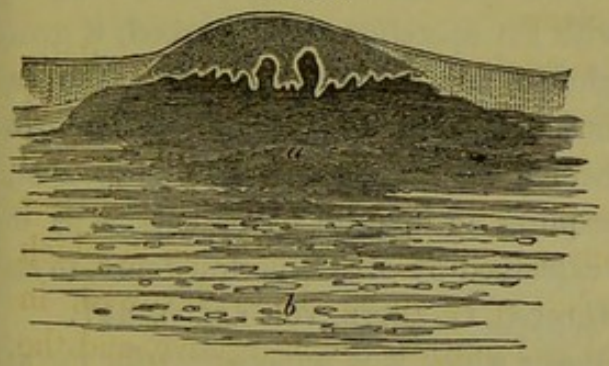
There is still another kind of dotted opacity, occurring in the posterior elastic lamina (sometimes in the anterior also) which I would distinguish from all those yet mentioned, and which is met with in eyes which have suffered a slow disorganizing process, through sympathy with the opposite organ previously lost by operation or accident. In this the dots are remarkably round and separate from one

* For a case of opacity of the kind above alluded to, which I had lately the good fortune to remove by an operation, and thus to obtain the means of minutely examining, at the same time that the patient was restored to sight, I would direct the reader to the Appendix, Case I. The opacity consisted of osseous or earthy deposit. See also Case J.

another, often brownish, and therefore overlooked, and scattered pretty uniformly over a portion or the whole of the cornea. Though these sometimes grow fainter under appropriate treatment, I have never seen them altogether removed.*

Warty opacity of the cornea.—It will readily be conceived that opportunities but seldom offer of submitting specimens of the several forms of opacity to exact scrutiny by the microscope. On this account I shall make no apology for describing the appearances of an opaque spot which occurred on the front of the cornea of an ox, and which I examined in the fresh state. It was about an eighth of an inch across, slightly raised, and densely opaque, and it seemed to have been the result of an ulcer, for the lamellated tissue was involved to a slight depth, and had been replaced by new tissue, as represented in Fig. 6. This new tissue was dense and fibrous, and hardly admitted the light to pass through it even when cut very thin. It contained a large admixture of irregular nuclei and elastic tissue passing in all directions. But what was most remarkable was, that this substitute for the proper corneal tissue was thrown up under the conjunctival epithelium in the form of numerous *papillæ*, arranged in much the same way as we find them in the more highly developed parts of the skin, though apparently without vessels, and of a texture too opaque to be precisely described. The *epithelium* over these papillæ was likewise opaque and diseased, being composed of a compact aggregation of nucleated particles, which contained numerous opaque granules, and failed to present that regular gradation from the spheroidal to the scaly figure, which is natural in this situation. The extreme surface only was scaly. I cannot help regarding this morbid condition as one of considerable interest, both as a proof of the affinities of the anterior part of the cornea to the integumental

FIG. 6.



Vertical section of an opacity of the cornea of an ox. *a*, new tissue in place of destroyed lamellated tissue: papillæ are developed on it, surmounted by opaque and thick conjunctival epithelium, or, as it might be here called, epidermis. *b*, healthy lamellated tissue below the opaque spot. (Magnified slightly.)

* Appendix, Case K.

tissues, and as an example of the definite organization of the new materials into persistent forms, opaque and otherwise different from the original structure which they supplant, and incapable of remedy.*

I shall conclude the present lecture with a short description of the structure which replaces the cornea when wholly or partially destroyed, and which is liable to become bulged, so as to constitute the state known as *staphyloma corneæ*.

The whole thickness of the cornea, in a larger or smaller extent, having perished from any cause, the iris is exposed, and occupies the breach, becoming adherent to the border of the gap formed by the removal of the lost part. If the contents of the globe do not further escape, and the eyeball consequently collapse, time is afforded for reparative processes to take place, by which the opening is filled with new material by granulation. At first this new material is soft, vascular, and nearly on a level with the surrounding parts; and, if nature is allowed to proceed with her operations undisturbed, it gradually acquires firmness, toughness, and considerable density, so as to appear not unlike the original cornea, except that it is opaque. It becomes covered with an epithelium continuous with the conjunctival, just as an ulcer of the skin acquires an investment of cuticle as it heals. This process was first explained by Mr. Wharton Jones, in an able paper published in the Medical Gazette, vol. xxi. p. 847.

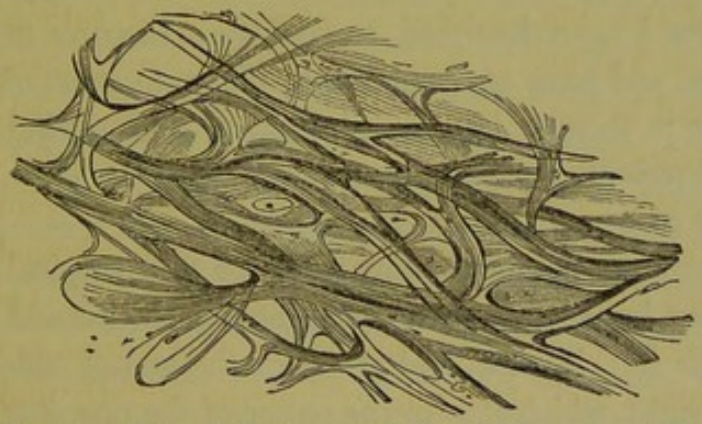
Now, in some cases, from causes which it is unnecessary for me at present to specify, this cicatrix contracts more or less, and continues to retain the contents of the globe within their proper bounds, the patient experiencing little inconvenience beyond the loss of vision;† but in other instances the new material begins after a time to evince its want of coherence and strength, by bulging slightly under the pressure occasioned by the accumulation of fluid behind it,—that is, of course, behind the iris, in the posterior chamber of the eye. Should the projection increase beyond a certain size, it assumes an unsightly appearance, interferes with the movements of the lids, so as at last even to prevent their closure, and, in a word, grows into such a source of annoyance and irritation, that it requires to be got rid of. This is usually done by the knife, and the lens being allowed to escape, the eyeball permanently shrinks to a small size.

* For a case, which has since occurred to me, of warty opacity in the human subject, relieved by shaving it off, see Appendix, Case L.

† Appendix, Case D.

The whole substance of the cicatrix being shaved off from the front of the globe, affords us, now and then, the opportunity of examining its structure in the perfectly recent state, which we can seldom do with any other of the morbid tissues of which this organ is the seat. I had such an opportunity last summer, in the case of a little girl; and the following, in few words, is a description of the structure of the tough opaque membrane which occupied the place of the lost cornea:—Its thickness was very unequal; its posterior surface, to which portions of the iris adhered, being irregularly pitted, or, as it were, worm-eaten; its anterior surface was formed by a thickish coating of epithelium, somewhat resembling cuticle, being composed of eight or ten layers of cells, the deep ones globular, the superficial ones scaly, and more like epidermic cells than those of the healthy cornea. There was no anterior elastic lamina, and no posterior elastic lamina. The entire remaining portion of the thickness of the staphyloma consisted of a dense and most irregular interweaving of white and yellow fibrous tissue, with imperfectly developed nuclei intermingled, and the meshes of the tissues large, unequal, and open on all sides.

Fig. 7.



Section of staphyloma; treated with acetic acid: from a girl. (Slightly magnified.)

In this condition we have an eminent example of those results of the reparative action, after loss of substance of the cornea, which we have already had occasion to notice as the consequence of ulcers or small sloughs, the chief difference being that here the new material is derived in a great measure, or wholly, from the vascular iris, rather than from the cornea itself. We see how far the reparative powers fall short of restoring the complex and elaborate structure of the cornea as it is originally laid down in the development of the body. The thickness of the new cuticle is attributable in part to the constant friction of the lids.

LECTURE III.

Structure of the choroid coat—its inflammatory products poured out on its inner surface, and why ?—Choroidal epithelium.—Ciliary body and processes.—Course of the needle in the operations on the lens through the sclerotica. Internal structure of the ciliary processes—their influence on the nutrition of the vitreous and lens.—The Iris—description of the iris in an albino.—Contractile tissue.—Vessels and nerves.—Mobility of the iris. Ciliary muscle—ciliary nerves.—The Vitreous humor.—Suspensory ligament of the lens—its attachment to the capsule of the lens, with a description of the latter.—Relation of the suspensory ligament to the hyaloid membrane.—Mode of formation of the canal of Petit.—Adjustment of the eye to distinct vision at different distances.

In the preceding lectures I have described to you the structures of the sclerotica and cornea, and have endeavoured to illustrate some of the processes that occur in them in the living subject, both during health and disease. At present I propose to proceed with the parts that lie within the outer case.

Of the internal structures, the most important for the surgical student to acquire an exact knowledge of are, undoubtedly. the iris and the lens, as these both lie full in view, and are often the seat of mechanical hindrances to sight, which it is in the power of the operator to remove.

To understand the position and arrangement of these two structures it will be necessary for me to speak briefly of the choroid membrane (of which the iris may be regarded as a production), and its ciliary processes, and of the aqueous and vitreous humors.

OF THE CHOROID MEMBRANE.

The delicate choroid membrane, placed within the sclerotica, between that coat and the retina, has, of course, the same general shape

and curvature that these have. It is essentially a vascular coat, and consists chiefly of blood-vessels, amongst which, however, in most cases an abundant pigment is interspersed in nucleated cells, which diverge into very irregular, often branching, processes, variously inclined as regards the other tissues. A peculiar fibrous tissue is added, which holds all in place, and confers some little toughness upon the membrane.

If we remove the sclerotica and cornea from a recent human eye under water, we find that the choroid is of a dark sepia colour, slightly adherent to the outer case, near where the optic nerve passes through them both to terminate in the retina, but in the rest of its extent hardly, if at all, united to that dense fibrous membrane; except, indeed, at the anterior margin, where the sclerotica joins the cornea, and where the adhesion of the choroid is of such a kind as to require a separate description afterwards.

The exposed surface of the choroid is slightly flocculent, and some of the pigment easily separates and diffuses itself in the water. The ciliary nerves, which have pierced the sclerotica a little in front of the optic nerve, are seen now taking a forward course (having become flattened), and dividing sparingly into branches till they enter the *ciliary muscle*, which presents itself as a broad semi-transparent greyish belt intervening between the sclerotica and choroid for about an eighth of an inch all round the cornea. When the choroid has been so fully injected through the ciliary arteries that the fluid has traversed the capillaries, and also the veins, we see its outer surface to be composed of the arterial and venous branches, and its inner surface of the capillaries. The arteries, comparatively small, take a meandering course forwards between the veins, while the veins run in curves, *vasa vorticosa*, to four or five principal trunks, by which the blood leaves the organ. The capillaries form on the inner surface of the choroid a plane plexus with close meshes, known as the *tunica Ruyschiana*. This network is closer, *i. e.* its meshes are smaller in the hinder part than in front, and the vessels finer. It is the most important part of the choroid, because the capillaries are a more important structure than either arteries or veins—more important, I mean, in regard to the function of the membrane, and also as respects its diseases. In no other part of the body are the arteries and veins so separated by a natural disposition from their own capillaries; and it is most interesting to notice, in accordance with this circumstance,

that when the choroid is inflamed so that inflammatory products result, they are poured out from its inner surface rather than from its outer.*

Covering the inner surface of the choroid is a layer of *epithelium*, with more or less regular hexagonal nucleated particles, and in most cases loaded with grains of pigment. This is the *choroidal epithelium*, known also as the *membrane of the black pigment;* so called by Mr. Wharton Jones, who first observed its hexagonal arrangement. The pigment, however, you will observe, is not limited to this epithelium, but exists also in the substance of the choroid, though there the cells which hold it are irregularly star-shaped and furnished with diverging processes. In perfect albinos the same epithelium contains no pigment; while in imperfect albinos, I have observed that it contains pigment, though no other tissue in the body does. The choroidal epithelium has an organic connexion with the outer layer of the retina, to be referred to in a subsequent lecture.

What has now been said is intended to apply to the choroid only as far forwards as a circular line about an eighth of an inch distant from the cornea. In front of this line the choroid is covered, and more or less concealed from view, by the ciliary muscle which lies on its outer surface ; and if we divide the globe from side to side, so as to look at the inner surface of the choroid through the vitreous humor, we shall see the retina lining it as far forwards as this line, but there ceasing by a finely jagged border, *ora serrata,* in front of which the choroid is modified in appearance, assumes the name of *ciliary body,* and *appears* to come into immediate contact with the vitreous humor.

Tracing the choroid forwards, then, from the ora serrata, we find it leaving the sclerotica, being separated from it by the thin ciliary muscle, and inclining gradually inwards towards the axis of the eye, so as to encroach upon the vitreous more and more, as the ciliary muscle increases in thickness forwards.

If we examine the *inner surface* of this part of the choroid, or that towards the vitreous humour, it appears marked by striæ which are in reality very slight foldings, but are made more evident by variations in the depth of the pigment. The striæ pass from the ora serrata about 3-4ths of the way towards the lens. This is the *pars*

* See Appendix, Cases M and N.

striata of Zinn. Then commence the *ciliary processes* of the choroid, which run as far as the edge of the lens, and often a little beyond the edge, so as to overlap it, but not to touch it. These ciliary processes, the *pars plicata,* are true and very decided foldings of the choroid, running in between corresponding folds of the vitreous humor, and thus taking firm hold of it. They are from 60 to 65 in number; but it is impossible to enumerate them with exactness, because there intervene smaller ones of various size, some of which may be either counted or not with the rest. Examining the ciliary processes individually, each commences gradually from the striæ already mentioned, and projects into the cleft between two corresponding folds of the vitreous, increasing in depth forwards, until close to the border of the lens as it lies imbedded in the front of the vitreous humor. Arrived here, each ciliary fold attains its greatest depth, and terminates abruptly by its extreme edge changing its direction and turning forwards and outwards from the lens towards the back of the iris, with which latter it becomes continuous and then suddenly ceases. In thus bending away from the lens, each ciliary process, of course, leaves the vitreous humor, and is no longer buried in its surface and united to it, but leaves a very narrow space around the lens, in which the vitreous humour *appears* to contribute to bound the posterior chamber of the eye; the remainder of each ciliary process, in passing to the back of the iris, likewise helping to limit the same chamber near its rim.

Thus you will observe, looking at the eye in the living subject, that a needle passed through the sclerotica towards the axis of the eye at any distance within an eighth of an inch of the cornea, would first pierce the ciliary muscle; then, if in the hinder part of this space, it would traverse the pars striata and enter the vitreous humor; if in the fore part, it would pass through or between the ciliary processes of the choroid, and according to the direction given to it might be made to enter the vitreous humor behind the lens, or the lens itself, for the posterior chamber of the eye; but that to enter the latter without wounding the lens would be almost impossible, so narrow is the space.

Internal structure of the ciliary processes.—The ciliary processes are covered with a modification of the choroidal epithelium, of a dark brown colour, which is deepest in the clefts between them, their tips being generally pale in the adult human eye, though not in

animals generally. Under this is spread out a close network of vessels, continuous with those of the choroid behind, but more capacious, and therefore having a coarser appearance in an injected specimen. Their meshes follow the line of the folds. These vessels must have a great influence on the nutrition of the vitreous body and of the lens itself, from their proximity to both, and from the multiplied surface of the vitreous which they are in relation to: of which I shall give you this proof derived from a morbid process—viz. that in a case of destructive inflammation of the eye attended with the formation of lymph in large quantity on the inner surface of the choroid generally, forcing the retina inwards upon the vitreous humor, this humor itself contained throughout a multitude of those particles which appear under inflammation, and which I alluded to in my last lecture; but while the superficial parts of the vitreous were every where more loaded than the central parts, in no portion was there so dense a deposit of this morbid material, the result of inflammatory action, as opposite the ciliary processes and around the lens. The morbid state of the choroid was uniform, but the vitreous was chiefly contaminated in those regions in which the natural process of nutrition is most actively conducted, in consequence of their contiguity to the supply of blood.*

Such is the complexity of the parts which we are now endeavouring to understand the disposition of, that I am at some loss to determine which it will be best to place next in the order of description. Perhaps on the whole it will be most convenient for us now to turn our attention to the iris.

OF THE IRIS.

The iris, as you are aware, is a contractile curtain, suspended in the aqueous humor before the lens, with the pupillary aperture near the centre (though rather to the inner side), to give passage to the light. It may be regarded from its position as a process of the choroid membrane, although its texture is in a great degree different therefrom: still it is continuous with that coat by its vessels and its surfaces, and it is besides convenient to the learner to consider it in this relation.

* Case M, in the Appendix.

To understand the position of the iris, we will revert for a moment, if you please, to that most important region, that key to the anatomy of these parts, the line of junction of the sclerotica and cornea, on their inner surface. Here, you will remember, the posterior elastic lamina of the cornea terminates in a network of plexiform elastic fibres which run backwards so as to form a threefold connexion—some to the sclerotica, on the further side of the circular sinus; a large quantity to furnish the origin of the ciliary muscle; and, lastly, a smaller set, which, after bounding the aqueous humor at the rim of the anterior chamber, implant themselves into the anterior surface of the iris at its circumference. By these, then, the iris in part arises, or acquires an attachment to the outer case.

These are what I have termed the *pillars of the iris;* they are much more developed in some animals than in man, but in the human eye they nevertheless are very distinct, and to be seen without difficulty. I have drawings on the table of their appearance in several of the lower animals. In the bird they are very largely developed, and come not merely from the posterior elastic lamina, which is not thick in that class, but also from the posterior lamellæ of the cornea proper. Behind the pillars the iris is fixed to some of the fibres from which the ciliary muscle arises, and which are there passing almost directly backwards towards the tips of the ciliary processes, which last abut in the posterior chamber against the iris, and become continuous with its posterior surface. The iris is, therefore, intimately connected at its origin with the ciliary muscle; a fact important to remember with reference to some of the functions of these parts.

The iris has two *surfaces*, which are nearly parallel; the anterior is that which we see so elegantly bright through the cornea; the posterior, commonly known as the *uvea*, is always dark brown, with pigment disposed in cells which form a layer easily detached, and of the nature of an epithelium, traceable into that covering the ciliary processes of the choroid. This epithelium I have seen raised in blisters by the imbibition of water after death. In the fœtus the particles are fusiform, and early loaded with pigment, except at the transparent nuclei. The posterior surface of the iris usually presents small folds converging towards the pupil, especially when that aperture is contracted. It forms the anterior wall of the posterior chamber of the eye.

On the anterior surface of the iris are to be seen many varieties of colour and even of texture, with some of which every one is familiar; but it is not till the attention has been minutely drawn for some time to the appearances of this part that the extent of these varieties will be suspected. Much depends on the pigment, which is not only in some individuals disposed in considerable quantity on the front surface of the iris, but in all cases (excepting albinos, where no organ possesses it), is intermixed more or less with the elementary tissue of the iris, not only so as to modify the aspect of its surface, but even making it very difficult to trace the exact nature of the proper contractile material which we are quite sure exists in the membrane. And it is for this reason that albino specimens are the best adapted for examination of the iris.

Looking, then, at the eye of an albino, we observe on the front of the iris, when the pupil is contracted so as to bring the texture most completely into view, a number of elevated lines or fibres converging towards the pupil, and becoming more prominent as they approach it. As these lines are irregular in size and length, and run somewhat into one another, it is impossible to count them accurately, but they are about 40 in number. Arrived at about 1-10th of an inch from the margin of the pupil, they terminate in an irregular series of knotty prominences of similar texture, which are also joined to one another, so as to form a kind of zigzag, irregular ring, beyond which the iris is usually thinner, and marked with very fine converging and anastomosing lines which run on to the extreme edge of the pupil. In some examples, and it was so in that from which the diagram before you was taken (fig. 8), there is at the very verge of the pupil an appearance of a set of circular fibres, delicate and narrow, but sufficiently distinct, while in the majority of those specimens which I have examined, even under high powers of the microscope, I have been unable to discover, and feel sure that there do not exist, any such constrictor fibres of the pupil. The fibres, however, in all cases, as they run to the edge of the pupil, join one another in a plexiform manner, and I am disposed to be-

FIG. 8.

Inner side.

Front view of the iris of an albino, with the pupil contracted in a strong sun-light. The appearances illustrate the verbal description given in the text. Slightly magnified.

lieve that this lateral junction of fibre with fibre may in effect answer the same purpose—viz. that of diminishing the central aperture of the iris—as a belt of circular fibres would do.

Fibres of the iris.—The fibres which make up the proper substance of the iris are of a peculiar kind, very nearly allied to the ordinary unstriped muscle, but not by any means identical with it. They are pale, soft, easily torn and separated from one another, and are intermixed with very numerous nuclei or cyto-blasts, either circular or elongated, according to the direction of the fibres, and, indeed, very probably changing their shape in correspondence with the contracted or relaxed condition of the fibres themselves, as I have observed those to do which exist on and within the striped kind of elementary muscular fibre. In the iris we find abundance of fibres of a peculiar kind, extremely slender, looking under high powers like very fine hairs, and apparently not branching. Among these are numerous circular nuclei, and I do not know whether they are to be regarded as contractile or not.

The fibres which we see on the front of the iris, with the ring of knotty elevations in which they join each other near the margin of the pupil, all consist of fibres loaded with nuclei, and must be regarded as of a contractile nature, although they are not in all respects the same as fibres which we know to be muscular in other parts. We have, however, the certainty that there is a structure in the iris which enables it to change its form. That this is not of an erectile nature I shall be able to show you, and we have no other resource, therefore, than to consider the fibres contractile of which we find it to consist. When we further discover that the corresponding fibres in birds and reptiles are of the striped variety of muscle, we need not hesitate to admit the muscularity of the unstriped fibres of the mammalian iris; for we have the same general grounds for doing so as for admitting the muscularity of unstriped muscle in other parts, and the latter confirmatory argument in addition.

Vessels of the iris.—The iris is vascular—about as vascular as unstriped muscle in general, and the vessels very similar in size and arrangement to those found elsewhere in like structures. They are slender, distributed among and along with the fibres, so that in a dry injected specimen you might infer the direction of the fibres from that of the vessels. Having already described the general course of the fibres, I need not detain you with that of the blood-vessels, but

shall only remark that they are derived chiefly from the two long ciliary arteries, which, piercing the sclerotica behind, advance over the choroid, one on each side, in the horizontal plane of the eye, over the ciliary muscle as far as the border of the iris, near which they bifurcate, so as to encircle that part with a vascular ring, from which both it and the ciliary muscle are mainly supplied.

At a small distance from the margin of the pupil, on the anterior surface, a delicate circle of anastomosing vessels marks the line from which the membrana pupillaris passed in fœtal life, and from which it was supplied with blood. Small brown shreds or spurs of this membrane sometimes remain through life, hanging free in the aqueous humor. At the pupillary edge of the iris a minute circlet is formed by the junction of vessels of almost capillary size. From what has now been said of the vessels of the iris, it is evidently not an erectile tissue. If a doubt still remained, it would be dispelled by the fact that the iris will contract and dilate several times after death under favourable circumstances.

Nerves of the iris.—The iris is likewise supplied with nerves, which are abundant compared with its bulk. They are branches of the ciliary nerves, which, passing through the ciliary muscle, are prolonged into the iris. Arrived here, it is not easy to trace their further distribution, on account of the pigment scattered amongst the several tissues, and also because they appear to lose that constituent which gives them their most recognizable character—viz. their double dark contour. The latter circumstance is, I think, more common in several tissues (and among them is the unstriped muscle) than anatomists have generally held; still, as the nerve-fibres do not lose their dark border all at once, they may be traced for some distance, especially in albino animals: and I have frequently found them inclining across the muscular fibres before they break up into their terminal branches, and become lost to view.

FIG. 9.

Front view of the same iris as that represented in the last figure; but here with the pupil dilated to the utmost by atropine. Magnified as before.

Mobility of the iris.—The great extent to which the iris is capable of moving, so as to vary the size of its pupillary orifice, is very remarkable, and is well illustrated by fig. 8 compared with fig. 9. Both these represent the same iris of a male albino, with the pupil at first much contracted under a strong

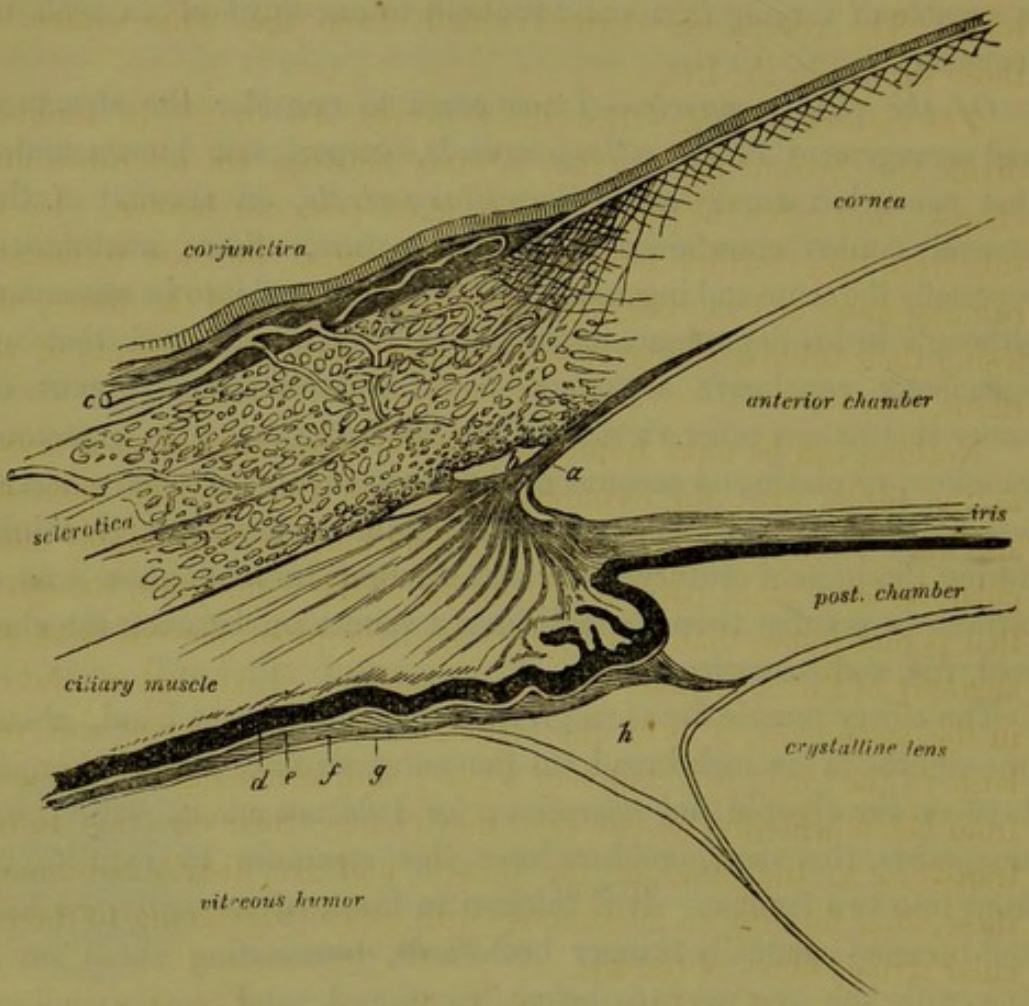
sunlight, and then fully dilated by the application of a solution of atropine to the front of the eye. I have already described the appearance of the iris in the former of the two states. The distance from the greater circumference to the margin of the pupil is about one-fourth of an inch; in the latter state, it is hardly one-twelfth of an inch; while the converging striæ, and circle of knotty elevations near the pupil, are thrown into a wavy, slack condition, in which they can be but imperfectly traced. At the same time, the tissue immediately bounding the pupil is so extremely attenuated by the stretching it has undergone, as to be hardly any longer visible. The pupil itself is capable of varying from one-twentieth to one-third of an inch in diameter.

Of the ciliary muscle.—I now come to consider the structure and arrangement of the *ciliary muscle,*—a part not known under that name, but usually called the *ciliary circle,* on account of the general doubts entertained of its real nature. Some anatomists, especially the acute and ingenious Porterfield, deemed it to be muscular, although in his day minute anatomy was so little advanced that no sufficiently conclusive arguments could be advanced in support of either that or any other view. Others have regarded it as a nervous ganglion, or plexus, on account of the large supply of ciliary nerves which it receives; while the greater number, especially, I think, during the present century, have been content to look upon it as a cellular or peculiar tissue, establishing a connexion between the choroid, iris, and sclerotica.

The ciliary muscle forms a greyish semi-transparent band, about one-eighth of an inch broad, on the outer surface of the choroid, between the choroid and sclerotica; for I do not admit, with some anatomists, that the choroid encloses this structure by splitting in front into two laminæ. It is thickest in front, at its anterior edge, and becomes gradually thinner backwards, terminating about on a line with the *ora serrata* before mentioned, and corresponding, therefore, on its inner surface to that striated and plicated part of the choroid in front of the retina, where the choroid takes hold of the vitreous body. The outer surface of the muscle, when exposed by the removal of the outer case, looks soft, and almost gelatinous, and it is not easy to distinguish in it any thing like fibrous texture. This is partly because it is really less firm than many other muscular parts, and its fibres less separated into bundles; but partly, also, because its

fibres are arranged rather in layers, of which the outer and larger, which goes from the origin of the muscle to its posterior edge, covers and conceals all the rest. But if a piece be a little raised by the knife, and then torn up by the forceps, the texture is found to give way in lines diverging from the border of the cornea more readily than in any other direction; and further, if a successful vertical section of it be made in a backward direction from the cornea, it will be seen to present more or less evidently the superposed layers as they are represented in the diagram.

Fig. 10.



General section, illustrating the arrangement of the parts treated of in the present lecture. *a*, Fibrous plexiform tissue derived from the posterior elastic lamina of the cornea, passing to the iris, ciliary muscle, and sclerotica; *b*, circular sinus; *c*, conjunctival vessels, running up to the margin of the cornea, and entering the anterior portion of the sclerotica: these become enlarged in inflammation of the cornea. *d*, Choroidal epithelium on the ciliary body; *e* and *f*, the two elements of the suspensory ligament of the lens; *g*, hyaloid membrane; *f* and *g* may be traced towards the lens, forming the anterior and posterior walls of (*h*) the canal of Petit. The capsule of the lens is seen becoming thinner behind the attachment of the suspensory ligament.

Moreover, if we examine with a high microscopic power the texture of this part, we discover a fibrous arrangement in the same direction, which would be more obvious if the fibres were more separate from one another than they really are. The fibres are then seen to be loaded with roundish or oval nuclei, often precisely similar to those of the best marked examples of the unstriped muscle. Lastly, the vessels of the ciliary muscle resemble those of unstriped muscle in abundance and arrangement, and indicate in the most decided manner the backward direction of the fibres, from their origin at the junction of the cornea and sclerotica, towards the anterior region of the choroid. The vessels are derived chiefly from the same source as those supplying the iris.

The ciliary nerves.—The ciliary nerves, 16 or 20 in number, divide and become flat* as they advance between the sclerotica and choroid, and enter the ciliary muscle at its posterior border. In its substance they further branch, and in a great measure terminate, running more or less evidently across the direction of the fibres, and losing their tubular character as they blend with the elements of the tissue.

Nothing can be more beautiful than the appearance of these nerves in the bird's eye; for example, in one of the common domestic species. Here the structure we are describing is indisputably muscular, as long since pointed out by Sir Philip Crampton, though at that period (more than thirty years ago) the proof derived from the anatomy of the elementary fibre was wanting. Like that of the iris in the same class, it is of the striped kind. The nerves are very large in the bird's eye, and very white; and, advancing to the muscle from behind, chiefly on one side, they change their direction to one transverse to the fibres of the muscle, and are distributed among these, after forming an anastomosis with other twigs going to the circular striped fibres of the iris.

It is interesting to notice in the human eye, and in that of other animals, an uniform correspondence between the size of the ciliary

* Near the ciliary muscle, many of the fine filaments of the ciliary nerves can be seen to consist of a single layer of nerve-tubules, arranged side by side in the substance of a very delicate layer of hyaline substance, in which is included a fine lacework of anastomosing threads of yellow elastic tissue, with brown stelliform pigment cells. The last twigs of the nerve are thus protected in their flattened and attenuated form.

nerves on the one hand, and that of the ciliary muscle on the other, though no doubt the amount of contractile material in the iris likewise shares in governing the size of these nerves. All such considerations as I have now enumerated concur in indicating the *muscularity* of the structure, thence called the ciliary *muscle*.

With regard to the use of the ciliary muscle, this is not the time to descant: but it appears to be so placed as to be likely to advance the lens, by drawing the ciliary processes towards the line of junction of the sclerotica and cornea, and also, perhaps, at the same time by exercising compression on the sides of the vitreous body. Such a movement of the lens would tend to adjust the optical mechanism of the eye to vision of near objects.

OF THE VITREOUS BODY.

We may now, gentlemen, briefly turn to the *vitreous body or humor*,—a part of considerable importance to the surgeon, in consequence of its relation to the lens. We have already seen that it occupies four-fifths of the entire globe, filling the concavity of the retina, and that the lens is encased, as it were, in its front part. We shall find, however, that this humor, delicate and almost diffluent as it is, is not the only, or even the principal agent, that holds the dense and comparatively solid lens in place, but that an additional structure, the *suspensory ligament of the lens*, is in reality the chief suspender of that organ, while the vitreous humor itself affords it little more than a bed or support for it to rest upon.

The vitreous humor is perfectly transparent, and of the consistence of thin jelly; indeed, some portions of it appear to be hardly more coherent than white of egg. It is enveloped in a very delicate, transparent, homogeneous membrane, *the hyaloid membrane*, which enables it to retain its figure after removal from the globe, provided it be placed in water. The hyaloid membrane has a few delicate nuclei on its inner surface, and by this surface it adheres intimately to the vitreous substance. No vessels in the adult eye penetrate the hyaloid membrane, so that the nutrition of the humor is carried on by the vessels of the retina, and of the ciliary processes situated on its exterior.

With regard to the structure or intimate physical constitution of

the vitreous humor, the general opinion has been that it is made up of an infinite number of interlacing fibres traversing it throughout, and holding water in their meshes. In favour of this view, it is said, with truth, that, if the hyaloid be punctured, the water rapidly drains off, leaving a vestige of solid animal matters; while the escape of its water is much more slow when its texture is not cut into. If the globe be frozen, the vitreous is found divided into a number of small portions, which might be supposed to be thus separated by the organic network. When, moreover, the vitreous humor is immersed for a long period in certain fluids, such as alcohol or dilute nitric acid, it becomes more or less opaque throughout, and gives some indications of such a fibrous structure as I have just alluded to. These appear to be the chief grounds on which this notion rests. It seems to me, however, impossible to discern in the fresh state, and with the best instruments, the faintest trace of fibres in this humor. I was formerly of a different opinion, but believe I was deceived by the fibrous aspect of the suspensory ligament of the lens, which is in close contact with the front of the vitreous humor. In the examination of parts so delicate and transparent, the greatest care is requisite to avoid error. The texture of the specimens rendered opaque is not fibrous, but homogeneous, and finely granular.*

The fluid collected from the vitreous humor by suspending it over a glass differs but little from water: it contains a little albumen, and some salts.

The vitreous body is in contact with the retina as far forwards as the retina extends, viz. up to the *ora serrata*, and presents a smooth surface, having but a slight connection with the retina, by means of a layer of very transparent cells. Near the bottom of the eye, however, at that part of the vitreous which corresponds to the entrance of the optic nerve, a more intimate union subsists between the hyaloid and the outer case, by an inflection of it inwards upon a structure which advances into the vitreous towards the lens, and which, in the earlier periods of development, appears to have been a process of the retina, together with the vessels, now altogether atrophied, which supplied the lens with blood.

* For more recent information concerning the vitreous body, see the paper on the structure of the vitreous humor in the present volume; also Appendix, Cases M and N.

Suspensory ligament of the lens.—But in front of the *ora serrata,* the vitreous humor comes into intimate relation with the ciliary body of the choroid, and presents a circle of folds and intervening sulci, which, for some way towards the lens, correspond accurately to, and receive those of the choroid. Nevertheless, there intervenes here between the vitreous and the choroid a special structure, which is best distinguished by the term applied to it by that excellent anatomist, Professor Retzius, of Stockholm, viz. *suspensory ligament of the lens.* This may be described as consisting of two layers—1st. a tough granular milky-looking membrane, clothing the inner surface of the ciliary body, within the choroidal epithelium, continuous behind, at the *ora serrata,* with the retina, but clearly not nervous in structure; and becoming gradually attenuated and lost at the tips of the ciliary processes, as these subside into the posterior surface of the iris (fig. 10, *e*); and 2nd. of an elastic, transparent, fibro-membranous structure, a production from the whole inner surface of the first, and extending as far as the capsule of the lens (fig. 10, *f*). This second fibro-membranous part of the suspensory ligament is the main support or suspender of the lens, attaching it to the whole circle of the processes of the ciliary body. It is essentially a membrane, which in its course to the lens assists in bounding the posterior chamber of the eye, separating the aqueous humor from the vitreous. But there are in connection with this membrane a large number of flat, stiff, elastic fibres, which bend angularly like straws, and which are implanted separately into the capsule of the lens. These fibres are tough and strong, if such terms may be applied to parts so delicate; but I use them in a comparative sense.

Mode of attachment of suspensory ligament to the capsule of the lens.—To enable you to understand how the suspensory ligament takes hold of the lens, it will be advisable to advert to the anatomy of its capsule. You are doubtless aware that the lens is a solid body of very complicated structure, enclosed in an entire and everywhere closed capsule. This capsule is the same in chemical and physical characters with the posterior elastic lamina of the cornea, with which you are already acquainted. The fibro-membranous element of the suspensory ligament is also very similar indeed in chemical characters, and I cannot help regarding it as having the like relation to the capsule of the lens as the fibrous cordage has to the posterior elastic lamina. They are intimately united, or, if you please, one is in both cases derived

from, or a process of, the other. The capsule of the lens is much thicker in front than it is behind: and I shall now mention a circumstance that I believe has not been noticed before, but which bears on the view I have just expressed. It is this: that the capsule diminishes very suddenly in thickness at the line of attachment of the suspensory ligament, just as if a portion of its substance passed off in that shape,—or, in other words, as if the suspensory ligament, on becoming fixed into the anterior portion of the capsule, a little way from the rim, added its own substance to that of the capsule, so as to strengthen all that lay in front of the line of its attachment. It appears that the greatest strength is needed in the front part of the capsule, as there its surface is free, and the aqueous humor can scarcely afford it so good a support as the vitreous. If we trace the capsule of the lens backwards, we find it still getting gradually thinner till beyond the rim of the hinder surface, where it becomes so attenuated as in many cases not to exceed one-quarter, or even one-sixth part of the thickness of the anterior portion.

Thus the suspensory ligament of the lens commences behind at the *ora serrata*, where its outer or granular layer seems to be continuous with the edge of the retina; it increases in substance forwards by fibro-membranous tissue derived from the inner surface of its granular layer, which layer is in intimate union with the ciliary body of the choroid; and it finally leaves the ciliary processes near their summits, to pass to the anterior part of the capsule of the lens a little within the rim, where it is fixed.*

Now, what is its relation to the vitreous body, or rather to the hyaloid membrane which bounds that body?

Relation of the suspensory ligament of the lens to the hyaloid membrane.—The relation appears to be this; and I state it with diffidence, because the parts we are now upon are extremely difficult of investigation, and have been the source of much difference of opinion among anatomists of the greatest acumen and industry. The account of what I am now going to speak of, as well as of the struc-

* The strength of the suspensory ligament and capsule of the lens, considered as one structure, is manifested in the not uncommon fact of the retention of the vitreous humor and lens, where the cornea has sloughed away, and where the iris, suspensory ligament, and capsule, consequently come to form the face of the organ until they are coated with lymph. Two examples of this will be found in the Appendix, Cases D and H.

tures which I have already treated of, is based upon what I have myself been able to see; and where I have succeeded in obtaining a clear view of the parts, I naturally am more disposed to rely on the conclusions I have myself formed than on those of others. I think, then, that the suspensory ligament of the lens is adherent to the hyaloid only opposite to the hinder part of the ciliary body, and that near the lens it leaves the hyaloid in order to pass to its attachment in front of the lens. The hyaloid, on the suspensory ligament leaving it, passes towards the posterior surface of the lens, and comes into contact with its capsule a little way beyond the rim, so that the rim itself, with a narrow belt of the anterior and of the posterior surface, is *free*, and a cavity is left all round the lens, bounded in front by the suspensory ligament, and behind by the hyaloid membrane. This cavity is the *canal of Petit* (fig. 10, *h*), long since discovered by the illustrious French anatomist, but about the formation of which various views continue to be held. In the description of parts so delicate it is perhaps hardly to be expected that discrepancies should not exist. In some specimens I have thought that the hyaloid grew thicker as it formed the hinder wall of this canal, and subsequently as it approached the lens, became thinner, and finally even altogether vanished from view as the observer approached the central region of the back of the lens. I do not myself believe that the hyaloid passes behind the entire lens. The substance of the vitreous seems there to touch the capsule.

Of the *canal of Petit* now mentioned, a good view may be obtained in the fresh eye of one of the larger quadrupeds, by making an aperture in the suspensory ligament, between the tips of the ciliary processes and the lens. We can then easily throw into the canal mercury, air, or coloured size (the latter is the best); the injected material runs round the edge of the lens, swelling out those parts of the anterior wall which dovetail with the ciliary processes of the choroid, and assuming a somewhat beaded appearance. The same thing may be effected from behind by running the point of the syringe through the vitreous humour and hyaloid into the canal. Either mode of preparation shows that while the anterior wall of the canal is attached to the capsule of the lens, not at its border, but a little way on its anterior surface, so the posterior wall, which separates it from the proper vitreous humor, goes to be fixed all round a little way on the posterior surface, so that the exact rim of the lens projects

into the canal; forms, in fact, its inner wall, and is free, as I before stated. I say free, and it is so in the main, but I have several times seen isolated elastic fibres of the suspensory ligament passing from the ciliary processes to the very margin of the lens, and there implanted. The width of the canal of Petit is about 1-10th or 1-12th of an inch.*

I find that I shall not be able to give a full description of the crystalline lens in the remaining part of the time allotted to the present lecture, and I shall therefore defer that subject, and now merely detain you for a few moments with some remarks on one part of the mechanism which the eye appears to contain for its adjustment to distinct vision at different distances.

Adjustment of the eye to vision of objects at different distances.—You are aware that when we look at a distant object, the intervening ones at a less distance appear indistinct, but that when by a voluntary effort we render near objects distinct, distant ones become confused. If we use both eyes, the distant or near object which is indistinct, is at the same time double, but, with one eye, it is merely confused. In the former case the convergence of the optic axes can only be towards one of the objects at once, and the image of the other consequently falls on non-corresponding parts of the two retina, and is seen double. But in the latter case it is clear that the confusion arises simply from the rays from one of the objects not coming to an exact focus in the retina, while those from the other object meet exactly there, and form a distinct image, to which the attention is at the same time directed. This results from optical laws; and hence the necessity of a power in the eye to adjust its dioptric apparatus, so that objects at various distances may be brought successively into distinct view.

To enter upon a discussion of the several modes in which it has been supposed that this adjustment is or might be effected, would be now impossible. It has been thought that the antero-posterior axis of the eye is capable of elongation,—that the cornea, or lens, may become more convex, or that the lens may be advanced towards the

* For some cases in which the attachments of the lens became destroyed during life, especially for a very remarkable instance in which the lens became loosened from its connexions, except at one point, and yet retained its transparency, see Appendix, Cases O, P, Q, and R.

cornea by a kind of erection of the iris or ciliary processes during near vision. It is manifest that numerous purely optical considerations must occur in the examination of such a question, but on the present occasion I am concerned rather with such arguments as the anatomical construction of the eye may contribute, towards the solution of the difficulty; and I may be allowed to insist on the extreme and primary importance of such arguments in all similar questions, provided they are grounded on a correct appreciation of the facts.

We have, then, it appears, within the globe of the eye a structure which is in all probability muscular, and which is undeniably so in certain animals. It has the arrangement of a muscle, very much the structure of a muscle, and is largely supplied with nerves, which are in great part derived from a motor source—the third pair. This muscle arises, or has its most fixed attachment, at the junction of the sclerotica and cornea, as much in front of the lens as is possible consistently with the preservation of the transparency of the cornea. That it may act more freely, a canal, the *circular sinus*, is interposed between its origin and the portion of the sclerotica which it lies against. Beyond this point it is hardly at all attached to the sclerotica, over which its fibres may be supposed to move in contraction, but it covers, and is inserted into, the anterior one-eighth of an inch of the choroid membrane, which is in this part tougher and firmer than elsewhere, and united in a very special manner to the lens by the ciliary processes, through the medium of a firm tough membrane, and of a strong elastic fibrous membrane proceeding from it to the margin of the lens. And yet not quite to the margin, for an elegant arrangement exists, the canal of Petit, by which traction is made, not on the vitreous around the lens, nor on the edge of the lens itself, so much as on its anterior surface. I confess it seems to me very difficult to doubt that this complicated system of parts is intended to advance the lens towards the cornea, so as to bring forwards, up to the retina, the focus of a near object, which would otherwise fall behind the nervous sheet. It is possible, also, I think, from the peculiar direction taken by the ciliary muscle, that it may compress the front of the vitreous, and thus help to throw forwards the lens.

LECTURE IV.

Of the Crystalline Lens.—Position, shape, size—Anterior chamber small in infancy—Occasional consequence of this. Capsule of the Lens—Experiment illustrating its endosmodic power and its elasticity—Thickness not uniform—Proneness to opacity during life—Characters of the opacity. Body of the lens—Its fibres and laminæ—Nucleus—Central planes—their use—their complexity in the human lens—Mode of union of the fibres—Use of the toothed margins—Intracapsular cells—The "liquor Morgagni" a result of disease or post-mortem change—The "capsule of the aqueous humor" does not exist—Remarks on some appearances of cataractous lenses.

Gentlemen,—We proceed to-day with the consideration of the structure of the crystalline lens and its capsule; a subject not more interesting to the anatomist than to the ophthalmic surgeon, on account of the large share of his attention which that important and common disease, the cataract, must always engross.

The crystalline lens, you will remember, is placed at the front of the vitreous body behind the iris, and is held in place there chiefly by a special fibro-membranous suspensory apparatus passing between its capsule and the ciliary processes, but partly by its adhesion to that portion of the vitreous body which is hollowed out to receive it.

Size and shape.—The lens is an almost perfectly transparent structure, about one-third of an inch wide, and one-sixth of an inch thick, more convex behind than in front. It has been doubted whether the curves of the lens are spherical or spheroidal; a question of much interest with reference to the corrections of an optical nature of which the eye is the seat, but not strictly bearing on the object before us in these lectures. The most accurate admeasurements, however, of the mammalian lens, which are those of Chossat, make it

probable that the figure of the human lens is like that generated by an ellipse revolving round its lesser axis, the curvature being greater for the lateral than for the central parts.

The lens in early life is soft and nearly spherical, and grows larger and flatter with age, as well as harder, and somewhat amber-coloured. These circumstances should be remembered with reference to the diseases of the part at the several periods of life. The globular shape of the infant's lens renders the aqueous chambers small, and brings the iris almost into contact with the cornea; but in the adult the iris is usually not at all thrown forwards by the prominent centre of the lens. Nevertheless, in persons of full or declining age, who are the common subjects of hard cataract, the surgeon is accustomed to meet with very varying dimensions of the anterior chamber. This, however, depends rather on variation in the size of the lens than in its shape, and sometimes a prominent iris betokens an enlarged vitreous body, or chronic engorgement of the ciliary body of the choroid.

In consequence of the prominence of the lens in infancy, it sometimes acquires a minute opacity in the very centre or most prominent point of its anterior surface, from coming in contact with the cornea, where this membrane is inflamed in cases of purulent ophthalm a. There is often a corresponding speck on the posterior surface of the cornea, precisely opposite.*

Of the capsule of the lens.—The lens is enclosed in a capsule of perfectly transparent, homogeneous, and very elastic membrane—a part that should engage the special study of every one who proposes to operate on the eye. It is an entire unbroken layer, separating the lens from all that surrounds it, but very permeable by fluids, and, therefore, the medium through which the nutrition of the lens is carried on. Its elasticity, which is one of its most remarkable properties, is evinced by a curious experiment which presented itself to me accidentally when I was occupied in a series of researches into the anatomy of these parts. When removed from the eye, and placed in water, the lens imbibes fluid through its capsule, which thereby becomes distended and separated from the contained lens, being raised in the form of a vesicle. If it be taken from the water, and punctured with a needle, the fluid is ejected with violence by the resilience of the distended capsule, which instantly contracts to its former

* See Cases S, in the Appendix.

bulk, and grasps the lens closely. The capsule is also very brittle, is easily torn in any direction when once a breach is made in it, and yet very tough, so as to offer considerable resistance to a blunt instrument which may be thrust against it.

We see these points exemplified in the operations for cataract and artificial pupil. In the former, when the sharp-pointed needle touches the capsule (provided the membrane be sound), it enters and tears it with the utmost facility; while in the latter, the blunt hook often used to engage and draw aside the pupillary margin of the iris seldom does any injury to the capsule, though it must almost always touch it, and that sometimes somewhat rudely, in spite of the operator's caution. When ruptured, the capsule rolls up at the edges, whatever the direction of the laceration, and it is curious that the outer or convex surface always lies innermost in the roll, so that, like the posterior elastic lamina of the cornea, which it nearly resembles in other respects, it appears to be developed or laid down in a curve contrary to that which its elasticity inclines it to assume.* It is a hard and dense structure, and determines the exact outline of the lens.

Thickness of the capsule not uniform.—The thickness of the capsule of the lens is different in different parts: particularly it is thicker in front than behind. This I alluded to in the last lecture, in speaking of the suspensory ligament or zonule; but I shall here repeat it, because of its importance. The anterior part of the capsule in the greater portion of its extent, in all its central region, and as far outwards as to within one-sixteenth of an inch of its margin, where the suspensory ligament is attached, is four or five times thicker than the posterior part. The diminution in thickness commences rather suddenly at the attachment of the zonule, and continues gradually as you proceed over the border to the posterior surface, where the minimum thickness is soon attained. This I have ascertained by careful examination. I need hardly point out to you how a knowledge of this fact may help us to understand some of the morbid processes met with in this part, and, by indicating with precision the direction in which lies the chief strength of the support of the lens in its position, may aid the surgeon, and give him confidence in certain of his nice and delicate manipulations.

* For a post-mortem examination of an eye in which the operation of solution had been performed, see Case T, in the Appendix.

The capsule retains its transparency after death, but is prone to lose it during life.—The capsule of the lens retains its transparency under the action of acids, of alcohol, and of boiling water, and will resist the putrefactive process for a great length of time: at least, I have frequently found it remain transparent after the lens itself had been completely destroyed by putrefaction, and the centre of the lens is itself very slow to putrefy. But, however difficult it may be to render the capsule opaque after removal, it is rather prone to become so in the living body. An injury, such as laceration or puncture, is there almost sure to be followed sooner or later by a loss of its transparency, and we often see it of a decided dead white. The same also occurs in many cases where the opacity is primarily in the lens itself. After the operation for cataract by the needle, this opaque capsule is a not infrequent source of annoyance to the surgeon, obstructing the access of light to the retina, and demanding removal.

This proneness of the capsule to become opaque only while it continues a part of the living body, seems to shew that, hard and structureless as it appears, it is yet the seat of unceasing nutritional change—that its substance is in continual flux; for we can only regard the opacity as a result of depraved nutrition, the new material being laid down in an abnormal form.

In some rare examples, one of which presented itself here during the present summer, minute vessels are developed upon the capsule, probably in lymph previously deposited there as a consequence of inflammation. They are continuous with those of the ciliary processes or adherent iris.

It is interesting to observe that the opacity is usually denser when it takes place in the anterior part of the capsule, than when in the posterior, because of the greater thickness of the former portion. But, besides this, the anterior seems more prone to become opaque than the posterior.* When opacity occurs, the capsule usually loses its brittleness and becomes tough. The opacity assumes an irregular figure, in flakes or patches, if the body of the lens remains, and may thus be distinguished from a similar change in the lenticular substance; but the opacity is more uniform if the capsule has been rent and the body of the lens absorbed. The opaque parts may even

* See Case T, in the Appendix.

become so completely altered from their original texture as to be the seat of earthy deposits; but this is rare.

Of the structure of the body of the lens.—If we now turn our attention to the lens itself, that solid transparent mass thus enclosed and protected, we find it to be soft and pulpy in the outer portions, more firm, dense, and glutinous towards the centre, which is distinguished as the nucleus. Not that there is any special plane of division between the nucleus of the lens and its exterior or superficial portions: the change to more and more density is very gradual. No language derived from other objects can adequately describe the precise texture of the lens, as appreciated by the finger, simply because it is not a homogeneous texture, but one highly complicated and peculiar, which it will require some attention to understand.

Fibres of the lens.—The lens is composed of flattish riband-like albuminous fibres, having an average thickness of $\frac{1}{5000}$ of an inch, united side by side, so as to form plates, which are placed one within the other, somewhat like the leaves of an onion. The fibres all pass from the front to the back, so that each has two extremities, an anterior and posterior; and a middle part, which is directed towards the side or rim of the lens. In the lens of simplest construction—the spherical or spheroidal lens of many fishes, reptiles, and birds—the ends of the fibres all meet in the antero-posterior axis; and the surface of such a lens, viewed either before or behind, has the appearance of a globe marked by the lines of longitude passing from pole to pole. The same appearance, too, is seen after removing any number of the layers of fibres down to the centre. The individual fibres are of course narrower at the extremities and broader in the middle; and they would come to quite a point in the axis were it not that their lateral union becomes so intimate as they approach it, that the eye can no longer distinguish them individually, nor the skill of the anatomist isolate them. Moreover, it would appear that those coming from opposite sides do not form a firm junction across the axis, but rather that the axis is occupied by a substance of less density than the fibres themselves; so that, under ordinary circumstances, the lens may be made to break up, and its opposite sides to fall asunder along that line. In the lenses I am now referring to it is not uncommon to find a cup-shaped depression—a kind of crater at each pole; but I have never seen this so large as in the prolate-spheroidal lens of the cuttle-fish.

Nucleus of the lens.—It is further to be observed that the individual fibres become narrower and denser, as well as more intimately held together, as they approach the centre of the lens; and it is obvious that they must also become shorter and shorter. The degree in which their density augments varies, however, very widely: in the bird, for instance, it is far less than in the fish; so that the lens of the former is soft and pulpy, even to the centre, while the nucleus of the latter is often of almost stony hardness.

What I have now said as to the shape and texture of the lenticular fibres applies in general to the eyes of most animals. These fibres are always narrowest at their ends, shorter and denser towards the centre of the lens. The mode, however, in which their extremities are arranged at the poles, exhibits many very curious modifications, of the use and meaning of which I am not aware that any explanation has hitherto been offered.

Central planes.—The first departure from the simple arrangement already mentioned—in which all the fibres diverge from, and terminate in, the antero-posterior axis of the lens—is met with in some fishes and some mammalia, of which the porpoise is one. Looking at the front of the lens, we see a straight line passing through the pole, and reaching about one-quarter or one-third of the way towards the margin or equator on each side. From this line the fibres diverge in an uniform manner, and passing over the edge, may be traced converging on the opposite surface to a line of similar length passing through the pole, but at right angles to the first,—so that if the one is vertical the other is horizontal. This being so, a moment's consideration will enable you to understand that none of the fibres reach half round the lens—that, for instance, one which starts from the anterior pole (or the centre of the anterior line) cannot reach the posterior pole, but terminates at the extremity of the posterior line; while one which starts from the end of the anterior line is necessarily brought to the posterior pole; and the intermediate ones in a similar manner, according to their position. Now, if we remove the more superficial strata of fibres, we still find the deeper-seated fibres diverging from similar lines, and discover, in fact, that the lines seen on the surfaces are but the edges of planes which penetrate even to the central region of the lens,—these planes being productions or expansions of that axis in which, in the spherical variety of lens, all the fibres meet.

Object of the central planes.—These planes are widest where they appear on the surface of the lens, and are gradually narrower inwards; and those of opposite sides meet, although at right angles, somewhere in the antero-posterior axis, at a point the position of which (or, in other words, the respective depth attained by the planes), is determined by the various curvatures of the opposite surfaces of the lens. But as every fibre has in each plane a point answering to one of its extremities, it follows that the area of the two planes must in all probability be equal, and therefore that where one plane passes from the surface more deeply into the lens, the other must extend from the pole more widely towards the margin.

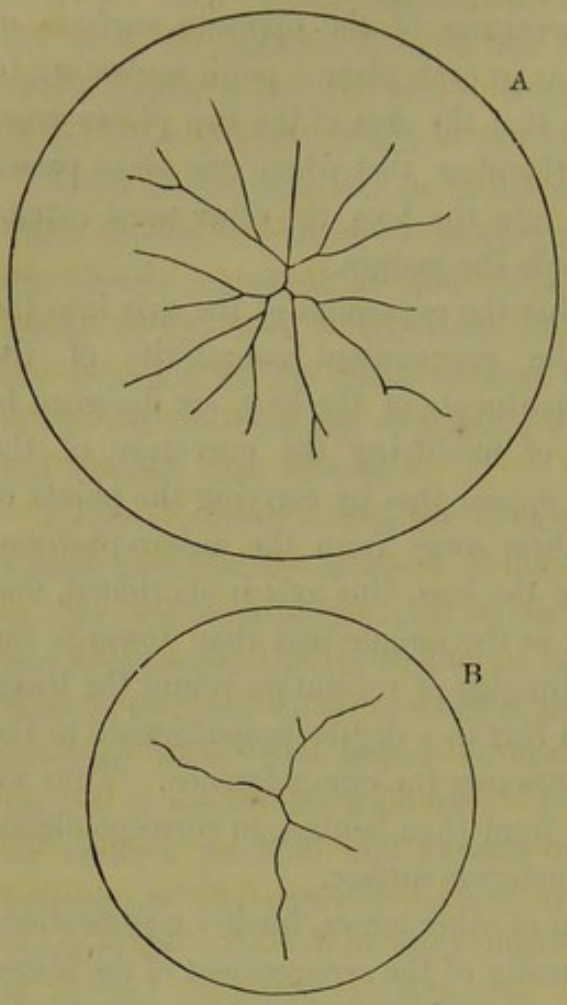
It certainly appears to me that the expansion of the axis into the planes now described, and the concomitant complexity of the arrangement of the fibrous constituents of the lens, are designed to furnish the mechanical means of modifying the curvature of the surfaces of the lens. It would appear that by carrying the points of termination of many of the fibres away from the antero-posterior axis, and towards the margin of the lens, this axis is shortened, and the surfaces are rendered flatter in the middle part than towards the edge; are made to resemble ellipsoids of revolution round the lesser axis, rather than spheres; and this in a degree proportionate to the extension of the central planes towards the circumference. Thus we have the central planes wider in front than behind, in correspondence with the greater flatness of the anterior surface.

If we pass to the examination of other lenses, further modifications of the axial planes, and consequently of the arrangement of the fibres, are met with. For example, in some of the cetacea I have found the planes to bifurcate irregularly, and to a variable extent, towards the margin of the lens—a disposition not, I believe, before observed; but the most elegant arrangement is certainly that well known one of the mammalia in general, in which three equidistant planes diverge from the axis,—those of the front and back holding intermediate positions, precisely as in the more simple case already described.

Their complexity in the adult human lens.—But of all the specimens that have come under my own observation, those of the adult human lens have presented the greatest multiplication or subdivision of these planes; for while our own lens adheres to the ordinary mammalian type in possessing a triple divergence from the pole, each of the three planes is almost immediately branched, if I may use

the term, and this not once only, but twice or more,—so that instead of three segments we have as many as twelve or sixteen, the numbers being irregular no less than the course, direction, and extent of each.

Fig. 11.



A. Division of central planes as seen on posterior surface of an adult human lens.
B. Same from the fœtus of nine months.

Fig. 11, A, copied with accuracy from an adult human lens, will convey a better idea of the arrangement of these planes than mere words can express; and if you will endeavour to picture the opposite surface as if seen through this one, and intersected with a somewhat similar radiation of planes, placed intermediately to these and receiving the opposite ends of the fibres, you will understand the extraordinary intricacy of the construction of this organ in our own eye.

Their simplicity in the human fœtus.—I may mention in this place an interesting fact which I noticed in comparing the fibres of the fœtal and adult lens in the human subject. It is this—that as development proceeds, and the lens becomes wider and flatter, the central planes extend themselves further and further from the axis, and at the same time branch again and again, so as to multiply the segments, into which they divide the lens.—See fig. 11, B.

From this it may be inferred that the multiplication of the mesial planes outwards is a process necessary to the expansion and flattening of the organ, and takes place by the deposition of new fibres on the old; and also, that even in the adult lens the planes remain simply tripartite in the nucleus, being only multiplied in the more superficial layers.

Having thus endeavoured to convey to you some general idea of

the arrangement of the lenticular fibres, we will consider briefly the mode in which they are united into the forms I have described, and organically attached to the capsule; for it would be a mistake to regard them, as we are apt to do, simply in the light of independent parts placed in artificial juxtaposition. And more especially is it necessary to consider the lens as a whole, if we would form a correct notion of the actions which contribute to the maintenance of its organic life, and comprehend the reason of the alterations of texture which it exhibits under accident or disease.

Mode of union of the fibres.—As the ends of the fibres approach the central planes in which they terminate, they are found to be more or less fused together into a solid hyaline mass, which retains only for a short way a trace of the interval between the contiguous fibres. Sometimes the fibres may be torn up as far as the central planes; at others they break off short, rather than split up, as they approach the planes: and this is more the case towards the nucleus. Near the planes, therefore, we cannot properly say that they have a well-defined border or limit; but in the intermediate portions of their extent their edges are found to be doubly bevilled, so that one fibre is adapted by each of its edges to two other fibres—one a little above, and the other a little below it; and if we consider these bevillings as separate sides, each fibre would be six-sided. But we further remark that the bevilled margins are more or less jagged, and that the projections and sinuosities of the opposed fibres mutually interlock. Thus each fibre is intimately united by its toothed edges to four others, and by its smooth flattened surfaces it touches two others —one over and the other under it. The lateral union of the fibres, being the more intimate, determines the division of the lens into layers enclosed one within another, rather than into segments. But if we obtain a fortunate view of the fibres *in situ* and in section, it is easy to perceive that the lateral junctions of the fibres of successive layers lie in regular order one within another; and that if the splitting of the lens could be made to follow these joinings, we should reduce the organ to a number of segments, the thickness of which would correspond with the width of one fibre.

The indented margins of the fibres are much more obvious, and are no doubt really much more developed, in some classes of animals than in others. It was in the eye of the cod that Sir David Brewster first detected them, and they are nowhere more evident. The teeth

have a certain average size; but, like those of the cranial sutures, they are irregular in shape, and have been manifestly formed by the shooting together of contiguous parts during growth. In the lens of the bird, and in that of mammalia and man, they are even less regular in shape, and far less defined; and it is often difficult to see more than a soft gelatinous margin. The toothed borders are usually most apparent when the albuminous basis of the fibres has been hardened by heat, or a chemical reagent.

Use of the toothed margins of the fibres.—What, now, is the use of the serrations of the fibres of the lens, and why do they exist only at the sides? In the fish, which has the fibres very flat, and consequently with thin edges, and a small surface for lateral contact, the teeth are large, stiff, and well-defined; whereas in the higher animals, where the fibres are thicker, and their bevilled edges present a broader surface of union with those on either hand, the teeth are softer and less developed; and in all cases the broad surfaces of the fibres are not toothed at all. We may therefore regard the serrations simply as an artificial mode of increasing the points of union between the edges of the fibres according as their thickness or thinness renders necessary. If the fibres had been six-sided, and the sides equal, we may suppose, either that there would have been no teeth at all, or, if any, that they would have been developed to an equal extent on all the sides. Thus far, perhaps, it is legitimate to speculate on the final cause of this remarkable and elegant structure.

Intra-capsular cells of the lens.—Immediately within the capsule, separating it from the superficial fibres, is a layer of cells, extremely thin and transparent, of unequal size, and nucleated. These cells form an organic union between the body of the lens and its capsule, and it is through them that the nutrition of the fibrous part is conducted. It is by the multiplication and successive transformation of these cells into fibres that the body of the lens increases in size; and when its growth is complete, a single layer of them remains. The superficial fibres, even of the adult, often retain some of the nuclei, in an extremely transparent form, at pretty regular distances in their substance.

The "liquor Morgagni" a result of disease or post-mortem change.—When, after death, the lens is placed in water, or allowed to lie in contact with the aqueous humor, the water passes through the capsule, and distends and bursts these cells, collecting between

the lens and the capsule, and raising the capsule as I mentioned at an earlier period of the lecture; but no fluid exists during life between the capsule and fibres of the lens, except what belongs to the texture of the cells. There is, then, no such fluid as the *liquor Morgagni* in the healthy lens. When this fluid exists in the cataractous lens, between the body and the capsule, or when it is found there after death, it is to be regarded as a morbid or false condition, indicative of the destruction of the layer of cells which has been just described.

The "capsule of the aqueous humor" does not exist.—Some authors speak of another layer of cells on that portion of the outer surface of the capsule which contributes to form the posterior chamber of the aqueous humor behind the iris, and they consider it to resemble, and to be a continuation of, the epithelium lining the back of the cornea, and which I have termed the epithelium of the aqueous humor. Such a layer has been imagined necessary to the completion of that serous sac which has been very generally supposed to enclose the aqueous humor, and which has passed under the name of the *aqueous capsule, or capsule of the aqueous humor*. Now, with regard to its existence on the front of the lens, I can only say that I have sought for it with great care, but in vain; and I therefore do not believe that it exists. Taking the perfectly fresh eye of a large animal, I have removed the cornea by a circular cut with scissors, without allowing the cornea to touch or rub against the lens. I have then, with equal caution, cut away the iris, so as fully to expose the front of the lens; I have then most carefully made a circular incision in the front of the capsule, near its rim, and have placed the portion so detached on glass, flat or variously folded, and always without being able to distinguish any trace of such cells. Now, with far less nicety, it is most easy to see the posterior epithelium of the cornea, and the intra-capsular cells of the lens; and the evidence, therefore, seems to me sufficient for disbelieving in the existence of the layer now spoken of; particularly as I am not aware that any author who has described it has stated that he has actually seen it.

I shall now say a few words on some varieties of cataract, the appearances of which (capable of being discriminated during life) derive illustration from what I have now explained of the structure and arrangement of the lenticular fibres.

REMARKS ON SOME APPEARANCES OF CATARACTOUS LENSES.

1. The congenital opacity of the lens, so frequent in children, affects the entire substance. We may sometimes, though rarely, observe upon its front surface the simple trilinear division into segments which, in the human subject, is peculiar to early life.

2. In the commencing cataract of middle or declining age, we not uncommonly find the posterior surface of the lens first affected, so that we look through the transparent lens upon an obviously concave opacity. This opacity sometimes, and indeed generally, encroaches from the margin in distinct streaks of irregular thickness, length, number, and distance apart; and we usually find that, when the pupil is widely dilated by belladonna, some at least of these streaks are traceable round the margin for some way over the anterior surface. So long as small portions of the hinder surface of the lens remain clear, the body and front being also clear, it is surprising how much visual power may remain. At a subsequent period, the centre of the lens begins to be cloudy, and then the progress towards blindness is more rapid. Now I can entertain no doubt that the streaks in these cases are sets or bundles of the superficial layer of lenticular fibres, reduced to a state of opacity by some nutritional change. There seems to be a disposition in the fibres of the lens to become opaque in their entire length when once they are morbidly altered at a single point: and hence the linear figure of the opacity. The opacity probably commences in the middle part of the fibres near the margin of the lens; and the arrangement of the fibres would account for the different length of the streaks, some approaching nearer than others to the central point on the surface.

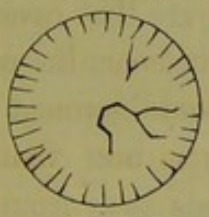
3. In another variety of opacity in adults, there are streaks visible, either on the anterior or posterior surface, before the nucleus manifests any tendency towards dulness, but instead of converging from the border of the lens, they rather diverge from the central point. These streaks are also irregular in number and direction; and it has never occurred to me to distinguish in them any exact representation of the edges of the mesial planes as they are seen on the surface of the prepared lens: never, certainly, any trilinear figure. But a glance at the representation above given of the complex arrangement of the mesial planes in the adult human lens, will suffice to explain why

they are rarely seen in such opacities. In the healthy lens they are in reality too near together, and too irregular, to be detected without a glass. The triple divergence from the axis can, even then, only be recognised for a short distance, beyond which the planes seem to diverge and branch without any attempt at geometrical precision. We cannot, therefore, wonder that an opacity, spreading from the centre of the surface of the lens, and which consists of broad, ill-shapen streaks, should fail to disclose the radiation of the mesial planes: although it seems highly probable that its seat is, primarily and essentially, rather in the edges of those planes than in the fibres themselves.*

4. In the lenticular cataract of adults, the glistening, silky, fibrillation of the lens may be often seen; but you will fail, even in the best-marked of these cases, to discover, with the naked eye, any thing like regularity in the mode in which the fibres pass off from the central region. Before becoming acquainted with the complex arrangement of the planes of the human lens, I could not satisfy myself why the triple line of the mammalian lens should be unseen; but the actual complexity is a sufficient reason. It explains, too, the appearances of many cases of opacity of the body of the lens, where the fibrous texture is in general obvious enough, but where, towards the centre, an amorphous, indefinable obscurity exists.

* Since this lecture was delivered, I have seen two cases (one under the care of Mr. Dixon) in which the opacity radiated from the centre in clearly-defined branching lines, corresponding exactly in character with the branchings of the central planes. The opacity was confined to the surface of the lens, and did not dip in the direction of the planes; neither did it occupy all the divisions of the central planes. It was accompanied, in both cases, with other streaks of opacity at the border of the lens, evidently in some of the fibres.

FIG. 12.



Cataractous lens, in which the opacity follows some of the divisions of the central planes of the lens, and some of the fibres at the circumference. The pupil dilated by atropine. Magnified two diameters.

LECTURE IV.

Concluded.

Of the aqueous chambers—morbid cyst of the iris—aqueous fluid—its source—removal of blood effused—if coagulated or not—if chambers are occupied by serum. Of the retina—vascular and non-vascular coats. Common elements. 1. Gray fibres, and their evolution from the optic nerve. 2. Gray vesicular matter. 3. Caudate nucleated vesicles. 4. Agglomerated granules, divided into granular and nummular layers, with intervening pale stratum. Peculiar elements. 5. Rods. 6. Bulbs, in man and animals. Of the Yellow Spot—modification of the layers of the yellow spot—colour where situated.

Having concluded what I had to say on the structure and arrangement of all the parts which bound and form the aqueous chambers of the eye, we may proceed to consider very briefly the shape and contents of these chambers themselves.

Of the aqueous chambers.—The chambers are that cavity in the eye occupied by the aqueous humor, and lying between the cornea in front and the lens with a portion of its suspensory ligament behind, and they are divided from each other by the iris, but communicate through the pupil. The cornea bulging forwards away from the iris, and the lens bulging forwards towards it, or even up to it, cause respectively the large and small size of the anterior and posterior chambers; but, besides this, the circumference of the anterior chamber is much wider than that of the posterior, by reason of the much nearer approach of the ciliary processes than of the pillars of the iris, towards the axis of the humors.

To speak more particularly of the limits of the two chambers, the *anterior* is bounded in front by the posterior epithelium of the cornea coating the posterior elastic lamina of that structure. At the border it is limited by the passage of a part of this lamina to the

front of the iris, the epithelium being very imperfectly, or not at all, continued over that part. Behind, it has the anterior surface of the iris, which I believe is not invested with any definite epithelial structure distinguishable from its own peculiar fibrous and nucleated tissue, but is, as it were, bare and exposed to the contact of the aqueous fluid,—so that in cases where we are able to perceive the delicate fibrous cordage of the iris, as if elegantly dissected, in the natural and living eye, this cordage is not seen through a film of epithelium; and, in those instances, especially of the darkly-tinted eye, where the interior arrangement of the iridial fibres is unseen, it is simply concealed from view by the quantity of pigmentary particles accumulated both in its interior and on its surface, not more on the latter than in the former, and not on the latter in the nature of an epithelial lamina.

In the fœtal eye, previous to the seventh month, and imperfectly at a later period, the *membrana pupillaris* passes across the pupil, and closes the anterior chamber, then very small. It passes from a circle on the front of the iris, a short way from the true pupil, where the knotted appearance of the fibres is so often visible in the adult eye, and where it sometimes leaves faint traces of its existence throughout life, in the form of minute threads or spurs standing off from the original line of attachment into the aqueous humor.

The *posterior* chamber is bounded in front by the surface of the iris, on which is a layer of epithelium, loaded with dark-brown pigment, and easily separable from the proper tissue of the iris. If we place a fresh human eye in water after having divided it through the middle, it is not uncommon to find this layer of pigmented epithelium rising in the form of a small blister from the surface of the iris, in consequence of the imbibition of the water; and sometimes after death the same thing occurs, from the imbibition of the aqueous humor itself, just as the aqueous humor is generally absorbed into the capsule of the lens, and distends it under the like circumstances.

Cyst of the iris.—I may here mention a very remarkable and interesting, but rare disease of the iris, which appears to me to consist in the morbid formation of transparent fluid between the iris and this posterior layer of epithelium (the *uvea*, as I omitted to say it is called). This disease is not accompanied by any other, is of slow progress, and appears first as a bulge of a portion of the iris towards the cornea. I imagine that the first formation of the fluid is attended with a swelling of the uvea backwards towards the suspensory liga-

ment and lens ; but, as the contact of these resisting parts must very speedily arrest any further advance in that direction, the accumulating fluid next begins to push forward the proper tissue of the iris, which separates it from the anterior chamber. Here it meets with less resistance. The highly extensile fibres of the iris slowly yield, until in the course of months they bulge to a large extent before the fluid, and come into contact with the cornea, and that sometimes so widely as to throw the pupil towards the opposite side, and even to put it out of sight, by becoming rolled in front of it. A case of the disease is given by Dr. Mackenzie (Case 263, Practical Treatise on Diseases of the Eye). If the cyst be punctured in front, the transparent contents are ejaculated with force by the undiminished contractility of the distended iris, and in the course of a few minutes there remains no trace of the pre-existing disease, the iris having in all respects resumed its natural aspect. The cavity, however, is apt to refill more than once. In Dr. Mackenzie's case, it was punctured a second and third time, at intervals of six or eight weeks, and afterwards never returned, vision being perfectly restored.

It is evident in this disease, that the muscular tissue of the iris is expanded over the fluid, and, therefore, the characters of the disease give no support to the opinion that the iris is invested in front with a serous membrane (aqueous capsule). If the wall of the vesicle were simply a serous membrane, it would not so immediately contract on being punctured ; and besides, during the process of contraction the membrane can be seen gradually assuming the well-known fibrous aspect of the iris. It is also evident that the uvea (which is always dark) is not protruded with the muscular tissue, but separated and thrown posteriorly ; for, if it were in front of the fluid of the vesicle, its pigment would be obvious enough in the attenuated tissue, whereas it is not visible there.

But to return from this digression : the uvea thus bounding the posterior chamber in front, does not line the iris or the posterior chamber after the manner of a serous membrane, *i. e.* it is not reflected from one part of the chamber wall to another, but appears to be a continuation of the epithelium of the choroid, as it may be traced to the iris from the ciliary processes. In the adult it has not usually so regular a form as where it lines the choroid, but in the fœtus it consists of spindle-shaped cells, with central transparent nuclei, and with dark pigment filling up all their other part.

Between the tips of the ciliary processes and the lens, the suspensory ligament of the lens, forming the anterior wall of the canal of Petit, bounds the posterior chamber, which is completed by the front of the capsule of the lens. Neither of these structures is covered by any epithelium, both being in immediate contact with the aqueous fluid.

Aqueous humor: its source.—The aqueous humor itself is little more than water, less than one-fiftieth of its weight being solid matters (chiefly chloride of sodium). Thus, it is very different from the serum of blood, and may be strictly regarded as a secretion, depending for its integrity on a healthy state of the parts which furnish it. What these parts are, it is difficult to define with accuracy, although doubtless they are a portion of the walls of the chambers in which the fluid lies. It seems to me to be certain that portions of both anterior and posterior chamber secrete this fluid, not merely because it is found in both before the removal of the membrana pupillaris, but also from the fact, which we see in practice, that after the complete closure of the pupil by adhesive deposit, both anterior and posterior chambers may retain their aqueous fluid.* When the pupillary margin has become adherent to the lens, we very frequently find the contents of the anterior chamber recovering their natural condition. But it may not be so generally known, that in some cases of slow enlargement of the globe, and distension of the anterior portion of the sclerotica, consequent on perforating ulcer of the cornea, and obliteration of the anterior chamber by adhesion of the iris to the corneal cicatrix, the aqueous humor, secreted into the posterior chamber in too great abundance, but in a natural state as regards its quality, is the occasion of the enlargement. It appears probable from their structure, that the posterior surface of the cornea, and both surfaces of the iris, with the tips of the ciliary processes, are all concerned in the formation of the aqueous humor, and that the suspensory ligament of the lens, and the anterior capsule, do not share in this function.

Blood effused into the chambers.—It is a wonderful thing to see blood which has been poured into the aqueous chambers by some accidental blow upon the eye, disappear in the course of a few days by solution in the aqueous fluid and absorption. If the organ escapes active or disorganizing inflammation, a week or ten days are often

* See Appendix, Case U.

sufficient for the removal of blood which has nearly filled the chambers: but something even then will depend on circumstances. If the blood has coagulated into a firm clot, its absorption is retarded. I had recently a case in which a young man had an injury to the eye late in the evening, but soon after went to bed and slept soundly. When I saw him next morning, I observed that he had been sleeping on his right side, for the blood had formed a clot, occupying about the right two-thirds of the chamber, and bounded by a very sharp but somewhat concave or cupped edge, placed vertically. It was remarkable that the iris (at least the uncovered portion of it) remained freely moveable. When the pupil was contracted by a strong light, he was blind with this eye, but the eclipse of the pupil became only partial when he turned with his back to the window, so as to dilate it in concert with the opposite one, and he could then see. This clot was absorbed in about a fortnight. On the other hand, when the blood is diffused through the aqueous humor, by frequent change of posture during the period when it might coagulate, it does not form a solid clot, and is more speedily absorbed,—sometimes, if in small quantity, in three days.

I imagine that the blood in such cases mixes with, and its red particles swell in, and give up their colouring matter to, the aqueous humor as they would in and to water, and that this is the occasion of their very rapid disappearance; for a most remarkable difference is noticeable between the result of these instances, as compared with those in which blood escapes into the chambers, when they are already occupied by yellow serum, the consequence of pre-existing disease. For here the blood may remain for many months, almost entirely unchanged either in colour or quantity, just as it might do in a bottle of serum, excluded from the action of the air. The serum does not dissolve either the red particles or the coagulated fibrin; how, then, could we expect these to be absorbed? Nevertheless, a very slow change does go on; some slight differences are constantly taking place between the variable serum of the blood and that occupying the chamber, owing to which, a very gradual interchange is wrought between them, and the clot becomes paler. I have watched a small clot during six months, under these circumstances, ere it lost its shape or characteristic hue.* Time does not allow me to allude to the changes in the aqueous chambers occasioned by inflammation, many

* See Case V. in the Appendix.

of which are of the most interesting character, and most instructive to the student of pathology.

I propose now to pass from the review of those parts of the eye which lie within the range of the operations usually performed on the globe, and to devote the rest of this lecture to a brief sketch of the structure of the retina; for I should be unwilling to conclude the present short course without some account, however imperfect, of that portion of the eye, which, in a physiological sense, is the most essential of all, and which will be found to be as wonderful and elaborate in structure as it is important in function.

OF THE RETINA.

The retina is that peripheral nervous sheet on which the images of external objects are received. It is continuous with the optic nerve, and is expanded within the globe between the choroid and vitreous humor, as far forwards as the *ora serrata*, the situation of which has been already pointed out. Its surfaces may be styled choroidal or outer, and hyaloid or inner; and by these surfaces it is organically connected, on the one hand with the choroidal epithelium, on the other with the hyaloid membrane. It has the pinkish-gray colour of the surface of the cerebral convolutions, is very soft and easily torn, and is arranged in certain layers, the inner of which contain the blood-vessels that impart the pink tint to the whole, while the outer are non-vascular. All the superposed layers of the retina are thicker at the bottom of the eye, around the entrance of the optic nerve, than in front, near the ora serrata; and the entire nervous sheet becomes gradually thinner forwards, until it ends abruptly at the line indicated, being there continuous with that granular tissue which lines the ciliary processes of the choroid, and gives origin to the fibrous part of the suspensory ligament of the lens.

Constituents of the retina.—Now, the retina contains in itself all the structural elements which are to be found in other parts of the system, *except nerve-tubules*, which are not present in the human retina, nor in the retina of the higher animals, but only in the optic nerve; and it moreover contains, besides these, other structural elements not elsewhere met with, but peculiar to this part, and which

we are therefore led to suspect may be in some way or other subservient to the proper action of the retina as a recipient of the vibratory impressions of light.

The *elements common to the retina with other portions of the nervous system* are placed internally, or towards the hyaloid surface. These are:—1. *Gray fibres,* radiating on all sides from the entrance of the optic nerve, towards the anterior border of the retina, and being a continuation of the nerve-tubules of the optic nerve. They are gradually less abundant forwards, terminating in succession among the next mentioned elements. 2. *Gray nervous matter, similar to the cineritious part of the cerebral convolutions* (being an amorphous, finely granular matrix, containing nucleated nerve-vesicles). 3. *Caudate nucleated globules,* analogous to those found in the ganglia, spinal cord, and certain parts of the brain. 4. *Agglomerated granules,* usually highly refractive, with very little intervening material, and allied to the nuclei of cells, such as are met with in some portions of the encephalon. Capillary bloodvessels are distributed among all but the last of these.

The *elements peculiar to the retina* are situated externally, and together form the coat commonly known as Jacob's membrane. They are of two kinds—5. *Columnar particles, or rods,* arranged vertically in a single series; and 6. *Bulbous particles,* interspersed at regular intervals among the former. Both of these are found among the lower animals in many most remarkable modifications, some few of which I shall presently mention, on account of their singularity, and to shew that they probably play an important part in the physiology of vision, though into the nature of their function we have as yet no particular insight. These elements, like the agglomerated granules, have no bloodvessels proper to them.

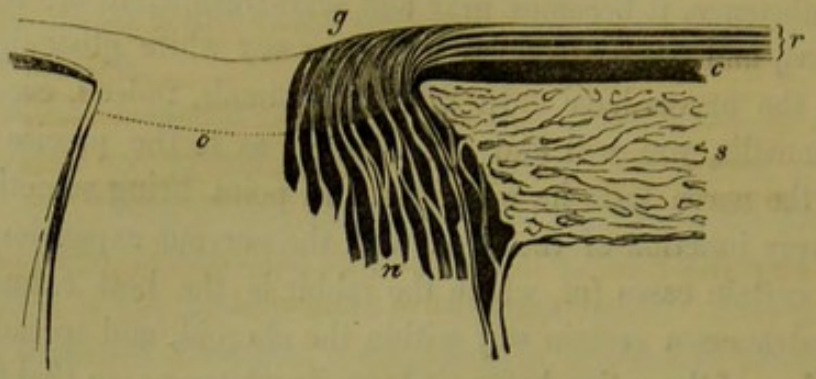
Of the gray fibres of the retina.—We may now pass these several elements more distinctly in review: and first, of the gray fibres. If we make a section of the coats of the eyeball through the part at which the optic nerve traverses them to join the retina, we see that this nerve becomes reduced in bulk as it is passing through the sclerotica, so that a transverse section of it, where it approaches the sclerotica, has nearly double the area of its intra-sclerotic termination, and the sclerotic canal is a truncated cone. We also observe that whereas the nerve behind, and for a little way within, the sclerotic

canal, is opaque white, the tubules having their proper investment of white substance, it becomes gray and semi-transparent ere it touches the retina, and the retina itself has never any white glistening aspect such as the nerves have. In different animals, indeed, even among the mammalia, you will find great variety as to the precise point at which the nerve loses its whiteness, this point being sometimes only at the very junction of the nerve with the nervous expansion within; and in certain cases (of which the rabbit is the best example) the nerve advances a certain way within the choroid, and spreads out on the surface of the retina before it loses its whiteness, so that the retina in these animals appears to present a white area of an oval shape, and an eighth of an inch long, at the sclerotic aperture; and in some animals yet lower in the scale, nerve-tubes, with a very delicate layer of white substance, can be traced even further, and in more uniform distribution over the retina. But still it remains true, as I believe, for all, and certainly for man, that nerve-tubules, such as form the optic nerve, do not exist as a part of the retina, and that where they enter within the sclerotica, they are to be regarded as still the optic nerve in its course to the retina.

Now, what is the nature of the change in the constituent tubules of the optic nerve by which they lose their whiteness as they penetrate the sclerotica? They certainly do not terminate in the sclerotic canal; they cease to be characterized by their dark outline, and by their tendency to fall into the varicose or beaded state, but remain fibrous; in a word, they lose their white substance, but retain their axis or central fibre, and these fibrous parts coming together, advance and form the gray fibres of the retina. I have made many very thin sections through the nerve and retina in connection; and you will find, if you do the same, that these fibres, on entering the globe and encountering the hyaloid, pour themselves as it were on all sides in bundles over the hyaloid surface of the retina, and become coated at once, on their opposite or choroidal surface, with the elementary structures which I have enumerated as forming the other strata of the retina.

It follows, of course, that in the space occupied by the evolution of these grey fibres from the optic nerve, *i. e.* for the area of the inner orifice of the optic foramen or sclerotic canal, these other strata of the retina do not exist—that *the retina,* in fact, does not exist; therefore it is no wonder that this spot should be blind—insusceptible

Fig. 13.



Section of the coats of the human eye at the entrance of the optic nerve, to shew the mode of origin of the layers of the retina. *s*, sclerotica; *c*, choroid; *n*, plexiform bundles of optic nerve; *o*, line at which these lose their white substance; *g*, grey fibres advancing to the retina, and becoming clothed on their choroidal surface with other layers, constituting *r*, the retina.

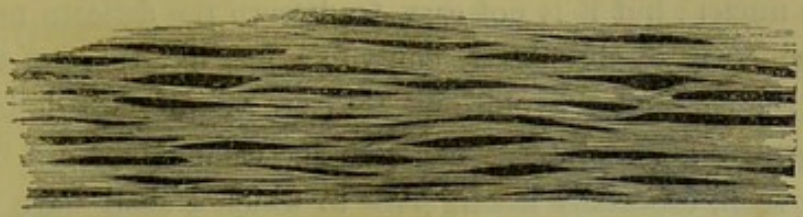
of stimulation by light. The blindness of the spot (proved by a well-known experiment), in connection with the anatomical fact which I now point out, shows how essential to the visual power of the retina are its non-fibrous parts, so that we might almost say that the visual impression is received by the non-fibrous parts, and merely propagated by the fibrous; that the true retina is not an expansion of the optic nerve, but a nervous organ of independent structure, brought into co-operation with the brain through the nerve. But to proceed with the anatomy of the grey fibrous stratum.

In some animals (I allude particularly to some fishes) their radiation over the whole retina may be very easily made evident to any one by a slight maceration, for the retina shaken in water becomes divested of all but these fibres, and they seem to form a brush directly continuous with the nerve.

But in the higher animals it is usually more difficult to demonstrate such a disposition; both because this layer is much less readily detached from the rest, and because its fibres are disposed in bundles, which, after anastomosing together for some way, become blended with each other into a uniform lamina, and are lost among the grey nervous matter (2). In the fresh human retina they may be seen by looking directly on the inner surface, near the optic nerve, with a power of 50 diam. (fig. 14.)

The bundles there are large, but of different sizes, and anastomose so as to form very elongated meshes, in which large nucleated vesicles soon begin to appear. The bundles of the plexus are not cylindrical,

Fig. 14.



Anastomosing grey fibres of human retina, seen on their hyaloid surface, near the optic nerve: magnified.

but much compressed on their contiguous sides, so that, on a vertical section, they appear oval; otherwise this plexiform arrangement is a mere continuation of that of the bundles of tubules in the optic nerve, now spread out as a sheet, instead of being gathered up into a cylindrical cord.

Of the central artery and vein.—While speaking of the manner of evolution of the optic nerve at its coalition with the retina, it may be mentioned that the blood-vessels of the retina enter and leave it along the centre of the optic nerve, by two fibrous canals there provided, among the fibrous meshes in which the plexiform nerve-bundles lie. Arrived within the sclerotica, they subdivide and ramify upon the retina, the large branches which they form being, for a short way, interposed between the hyaloid and the plexiform grey fibres, but very speedily sinking in among these, and breaking up, by successive divisions, into the capillaries which supply and occupy the substance of those layers to which I have already described them to belong. Just within the *ora serrata* the plexus terminates by a marginal vessel.

2. *Of the grey vesicular matter of the retina.*—This lies contiguous to the hyaloid surface, in close relation with the last mentioned layer. It is the most vascular coat of the retina, and, in fact, receives the greater portion of the blood brought by the retinal artery. The capillaries form a very beautiful plexus, with meshes about as close as those of the grey matter of the cerebral convolutions, though arranged nearly on one plane. The walls of the capillaries are a simple membrane, with nuclei at intervals. It is easy, at a suitable period after death, to wash out the nervous matter from their intervals, and to obtain a separate view of the whole vascular system of the retina; and in a perfectly recent specimen, also, the capillaries can be discerned among the matter of the layer now under consideration, often with the red corpuscles still within them. The finely granular matter of this

layer is readily seen with a sufficient magnifying power, and also numerous nuclei; but it is not easy to discern the delicate nucleated vesicles, which it so abundantly contains; for, like those of the grey matter of the cerebral convolutions, they are very rapidly destroyed or altered by pressure or water. On some occasions they can be most distinctly seen, especially in one part to which I shall have to refer presently; and it is almost always possible enough to discover their clear globular vesicular nuclei, in a detached state, floating about the fragment examined.

3. *Of the caudate nucleated vesicles.*—It is most interesting to meet with these very singular forms of nervous tissue in the retina, though we at present know little of their use. We have, now, ample proof of their being centres, from which, in many parts at least, nerve-tubules pass, the slender processes of the vesicles becoming continuous with the axes of the tubules, and acquiring, at a certain distance from their origin, a coating of white substance.

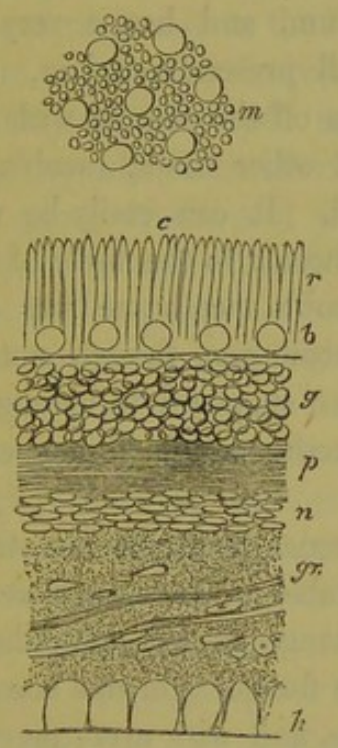
I am not aware that any one else has yet discovered this kind of vesicle in the retina. In man, and the higher animals, it is by no means easily distinguished, for the examples of it are small, and hard to detach from the substance of the last layer, with which they are in connection, and yet so similar in texture to that substance as not to be visible in it without separation. Nor have they here any pigment, as in so many other parts of the nervous system. That they do exist, however, is certain; for, on different occasions, I have seen many unequivocal examples of them, and especially in two or three specimens of diseased retina, in which the texture was somewhat broken down by a morbid process. Among the mammalia, I have seen them in the human subject and in the horse; but I have never witnessed so satisfactory a demonstration of them *in sitû* as in the retina of the turtle, where they lie at or near the hyaloid surface, dispersed at pretty equal distances, and with long and branching arms, which spread abroad indifferently in all directions, so widely as to approach each other near enough to anastomose together, though I have never seen them actually coalesce.

In making a vertical section of the retina in the higher animals, we very generally find an ill-defined, dark, but broken line, running parallel with the surface, in the substance of the vascular portion; and it has often occurred to me that this may be an indication of the position of a layer of these caudate vesicles intervening between the

fibrous and the gray vesicular matter (1 and 2); but this explanation of the appearance requires confirmation.

It would not be difficult to hazard conjectures as to the connections of these caudate vesicles with the fibrous elements, and as to some special purpose they may serve in the economy of the retina; such, for example, as that of bringing into functional relation the several parts which their caudæ may connect, &c., but such conjectures can at present lead to nothing. When we come to know the general history of the caudate corpuscles in the several organs, and in the animal scale, we shall probably obtain some clearer insight into the meaning of their existence in the retina.

Fig. 15.



Vertical section of human retina (previously dried when quite fresh) half an inch from the *ora serrata*. *r*, Rods detached at the line *c* from the choroidal epithelium; *b*, bulbs; *g*, outer layer of globular agglomerated granules; *p*, intermediate more transparent layer, obscurely fibrous; *n*, inner layer of flattened agglomerated granules (nummular); *gr*, grey nervous layer, fibrous and vesicular, and containing capillary vessel; *h*, hyaloid; *m*, deep or inner surface of Jacob's membrane, shewing rods and bulbs. The appearances in this specimen were beautifully distinct, precisely as represented. (320 diam.)

4. *Of the agglomerated granules.*—Lying externally to those already described, the agglomerated granules form a very considerable proportion of the entire thickness of the retina, viz. about one-fourth or one-third. They lie in *two layers*, (fig. 15, *n* and *g*), between which intervenes a thin layer, *p*, of which I am able to give no definite account, except that it is more transparent, exhibits no globules, nor any distinct texture, though sometimes looking finely fibrous, and that it apparently contains no blood-vessels. The inner of the two layers (*n*) is always much thinner than the outer, and often consists of but two or three series of granules, which are also different in figure from the others, being flattened, with their surfaces more or less corresponding to those of the retina, and often looking much like pieces of money seen edgeways. From this fanciful resemblance,

and for distinction sake, I have sometimes termed this the *nummular layer*. The outer layer (*g*), or *granular layer*, is much thicker: its constituent granules are globular, closely packed, with little sign of any surrounding cells, though a matrix, or inter-granular substance, can be seen on a broken edge. The granules cohere intimately, and when placed in water generally refract the light in a decided manner, quite different from that of the other elements of the retina. They have no blood-vessels.

Of the peculiar elements of the retina.—These constitute that extremely delicate film on the exterior of the retina, first distinguished by Dr. Jacob, and since commonly called by his name. This film is in contact with the choroidal epithelium, and has a very slight organic connection with it, which I shall presently explain. Sometimes this epithelium is partially drawn off the choroid with the retina in consequence of this adhesion; at other times, Jacob's membrane separates in part with the choroid. It can easily be washed away from the rest of the retina, its adhesion to the layer of agglomerated granules being but slight. Jacob's membrane was at one time generally regarded as a serous membrane, though not by its discoverer himself. By some it has been supposed to belong rather to the choroidal epithelium than to the retina; while Hannover styles it *the retina properly so called*.

Much disagreement exists with reference to the precise structure of this singular part, which is attributable in some measure to the great proneness its elements have to change after death, either with or without contact with water or various fluids. On this account, it should be examined as fresh as possible, and with every precaution. The changes it undergoes are, however, very well worth studying in themselves, since they exhibit the peculiar properties of its elements, as tests do those of a chemical compound; and these properties may, I think, elucidate some morbid actions now most obscure. The elements may be distinguished as *rods* and *bulbs*.

Of the rods.—These are placed perpendicularly between the granular layer and the choroidal epithelium, are in close contact with each other, except where the bulbs intervene, and their length determines the thickness of the layer. They are transparent and solid, and either cylinders or six-sided prisms: at the inner end they are attached to the granular layer, and when detached from it terminate by a square extremity; at the opposite end, they run off into a

slight cone or pyramidal process, which is received into a corresponding recess in the contiguous particle of the choroidal epithelium, each particle of this pigmentary epithelium thus imbedding the pointed extremities of many of the rods. The shaft of the rod is very apt, a short time after death, to become separated by a sharp transverse line, from the pointed process or leg, and the leg will then gather itself into a ball and disintegrate, while the shaft will bend into a hook at the outer end, or roll into a globule, or split up into transverse plates, or be reduced to a shapeless granular mass. These changes are assisted by immersion in water.

These points in the anatomy of the rods could, with difficulty, have been made out in the human retina, without the indications of structure provided in the corresponding parts of the lower vertebrata, where they are developed to a much greater size. Hannover has given a very admirable description of them in the vertebrate class, in all the great divisions of which they are constantly present; being very large in some fishes, especially the pike, and in batrachian reptiles.

From a careful examination of a perfectly recent human eye, I ascertained that the rods were longest, and consequently Jacob's membrane thickest, at the hinder part of the globe, and that anteriorly, close to the ora serrata, they gradually shortened by more than a half, still retaining their general characteristics.

Of the bulbs.—These, in the human retina, are very much less numerous than the rods, among which they are scattered at even distances. On looking at the outer surface of Jacob's membrane with a sufficient power, (fig. 15, *m*,) we see an infinite number of minute globules (the ends of the rods), and among these, but at a deeper level, *i. e.* not coming quite up to the outer surface, solitary, larger, transparent, rounded objects, which are the bulbs. When fortunate enough to obtain a view of the whole layer in section, cut or torn across, we see the bulbs sessile upon the layer of agglomerated granules, and distributed, at their proper intervals, among the rods, where these rest upon the granules. They appear to be globular or egg-shaped, and sometimes to have a small blunt spur upon them, turned towards the choroid. When looking down upon the choroidal surface of the retina, the bulbs, when best seen, have a small clear circle within their proper outline, and this seems referable to this projecting part.

Some light is thrown upon the nature of these bulbs by what seems to be a very large development of them in fishes, and here they present themselves in a very remarkable form, and with no less remarkable properties, as Hannover has well portrayed.* They are divisible into legs and a body, of about equal lengthr; the body directed inwards—the legs outwards; the body implanted vertically among the rods—the legs tapering in the opposite direction, and imbedded among the pyramidal processes of the rods, and, in a similar manner, within sheaths furnished by fibrous prolongations of the particles of the choroidal epithelium. The body is thicker than the legs, and has an oval or circular section. It is also partially subdivided into two lobes: it has a distinct membranous covering, enclosing a colourless, transparent, highly refracting material, which soon changes after death. The legs are also double, one descending from each lobe and tapering to a point; and where they join the body, there is a transverse line of division, at which they readily break off. When placed in water, the body swells and shortens, assuming the form of a somewhat flattened balloon, which retains the bilobate form, and sometimes looks not unlike a coffee berry. The investing membrane readily gives way; the clear contents become coarsely granular, and may break up into irregular masses, or disintegrate. By the same medium there is occasioned first a transparent line of division between the body and legs, and then the legs curl up at the end, or split into many transverse pieces, having a high refracting power.

Hannover supposes that these bodies (which he terms *cônes jumeaux*) do not exist in reptiles (except chelonian). I have, however, met with objects which appear very similar to the bulbs of the human retina in the frog. Examining it quite fresh, under albumen, we find the appearances represented in Fig. 16 The bulbs seem nearly as numerous as the rods, among which they lie: they rest upon their proper base, are globular, with a projecting process, ascending towards the choroidal epithelium, and, near the root of this process or leg, contain a minute colourless oil-globule.

This leads me to a very interesting point in the structure of both rods and bulbs in many animals, viz. the occurrence, in their outer or choroidal ends, of globules resembling oil, either colourless or

* Recherches microscopiques sur le système nerveux, 1844, pl. iv.

FIG. 16.

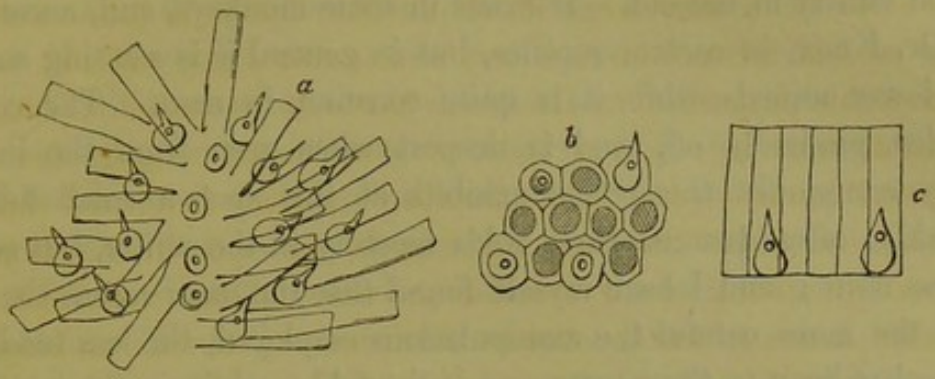


FIG. 16. - *a*, Bulbs and rods of Jacob's membrane in the frog, looking on the outer surface, the choroidal epithelium being removed. The rods are thrown down in various directions, so as to expose the bulbs among them at their base. The bulbs have a spur and pellucid globule. *b*, A similar view, but where the rods are upright, and not displaced; their base, with the bulbs, being brought into focus. The outer ends of the rods are out of focus, and appear dark shades in the centres. *c*, Same in vertical section.

possessing most brilliant tints of yellow or crimson. In the chelonian reptiles, and in birds, these are the most beautiful, I shall shew you, after lecture, the outer aspect of a portion of the retina of the tortoise, in which you will perceive a most elegant array of pale, of yellow, and of crimson globules, scattered with regularity over the surface, the first being the smallest, and the last the largest, but all enclosed within the substance of the particles now described. It is not satisfactorily made out what is the precise relation of these globules to the rods and bulbs respectively, partly because the distinction between these elements in these animals is not fully determined; but Hannover considers the crimson globules to belong to the bulbs or *cones*, and all to be properly not globular, but of the nature of sheaths to the particles where inserted into the choroidal epithelium.

In birds we have even a more beautiful pattern of colours. In the sturgeon, among fishes, I have found the globules large, but colourless. In mammalia they are either very small, or wanting.

Of the yellow spot of the retina, or spot of Soemmerring.— If we cut across a fresh human eye, so as to look at the hyaloid surface of the retina, or if we carefully remove the sclerotic and choroid coats, so as to expose to view its choroidal aspect, we are struck with the rich yellow colour of one small spot about one-twelfth of an inch in diameter, situated at the very bottom of the eye, in the exact axis of the humors, *i. e.* at about one-tenth of an

inch from the optic nerve. The colour is deepest in the young adult, much fainter in the old. It exists in some monkeys, and, according to Dr. Knox, in certain reptiles, but in general it is wanting among the lower animals, while it is quite constant in man. The colour shades gradually off, and is deepest when seen from the inside. Very commonly the retina exhibits at this spot a small fold or wrinkle, often two or three folds meeting in the centre, but sometimes none; and I have myself found that the more recent the eye, and the more careful the manipulations employed, the less tendency there has been to the appearance of the fold; while in the instances in which it has been present. it has been always possible to obliterate it by delicate traction in the requisite direction. I am therefore disposed to regard this fold as a false appearance. All who are accustomed to dissect this organ are aware with how much facility any part of the retina is thrown into folds by slight violence done to the vitreous humor in exposing the inside of the eye, owing principally to the extremely feeble union existing between the retina and the choroidal epithelium. We have already seen, too, how readily the elements of Jacob's membrane absorb water. Now it appears to me that the texture of the retina at the yellow spot allows of a freer post-mortem transmission of the water of the vitreous humor through to Jacob's membrane than at other parts; and, consequently, that this part of the retina is earlier loosened from the choroid, and rendered liable to be thrown into accidental folds, than the rest; and in this way I account for the plicæ at the yellow spot, which some anatomists have regarded as a natural condition.

On removing the sclerotica and choroid with care from the back of an eye, so as to expose the outside of the retina, the yellow spot seems more transparent than the rest of the nervous sheet; no fold appears, but in its centre a minute dot, which seems like a circular hole, through which we can look into the vitreous humor. I have on some occasions seen this hole so distinctly, and with so definite a margin, that it seems impossible to deny its reality; but whether it occupies the whole thickness of the retina, being a deficiency in all the layers, I am unable positively to say. I have in one instance deemed it wanting in Jacob's membrane, which wore the appearance of passing uninterruptedly over it; but the difficulty of bringing the part under examination by sufficiently high powers, without mutilation or disturbance, and without swelling of the parts from imbibition,

is such, that I would not speak too confidently on this point.* The adhesion of the hyaloid to the retina is more intimate than that of the choroid to the same part; and, therefore, it is even more difficult to examine the hyaloid surface of the yellow spot with high magnifying powers, without disturbance of it, than the choroidal; for if the vitreous be detached from over the yellow spot, some derangement of it is sure to occur: and to cut through the vitreous, so as to leave a thin film of it *in situ* upon the yellow spot, is a very nice matter. When this is satisfactorily done, we observe the border of the spot to rise into a gentle eminence, so that its middle part projects a little towards the vitreous humor; and in its centre is an oval or slit-like hollow, formed by the hyaloid surface dipping on all sides from the hyaloid, and the opposite sides coming into contact, the vitreous not entering the hollow. Thus the surface of the retina at the yellow spot appears to present a slanting surface to the rays of light.

Modification of the retinal layers at the yellow spot.—The texture of the several layers at the yellow spot is much modified. In particular, the grey fibres do not pass over it in a direct course from the optic nerve to the side of the retina beyond the spot, but take a circuitous course, so as to avoid the spot, and only that small number approach the spot which properly belong to it, and terminate in it. In this respect it differs from the rest of the deeper portion of the retina, and must be regarded as more perfectly organized. In the same way, as is well known, this portion of the retina, though so near the main vessels, is not encumbered by any of the large branches, but the branches which supply the spot and the regions beyond it arch above and below it at such a distance as not to interfere with its perfection, and the spot itself has only capillaries,

* I had lately an opportunity of examining the yellow spot in the recent eye of a monkey, and found a space in the centre of the spot, about the size of a small pin's head, almost perfectly transparent, contrasting strongly with the surrounding nervous matter, which was but slightly yellow for a short space from this apparent hole. The nervous elements could not be seen over this transparent part, but only a membrane with a few granules and nuclei, as though the several layers had been atrophied there, leaving only a residual web, continuous with the borders of the circumambient yellow matter, and separating the choroidal epithelium from the hyaloid.

I would also refer to a notice of a preparation of this region in a human fœtal eye, in the paper on the vitreous body, *infrà*, p. 100.

which communicate with the arterial and venous twigs on all sides. This arrangement of the blood-vessels occurs also in animals which have no yellow spot.

The plexiform fasciculi of grey fibres approaching the spot have nucleated vesicles of large size interposed in the meshes; and as the fibres gradually lose themselves from view, these vesicles increase in number so as at length to occupy the whole surface. It is possible to see the fibres reduced to smaller and smaller bundles, and become mingled with the vesicles; but I have never been able to distinguish any special relation subsisting between the individual fibres and the vesicular elements. The nucleated vesicles of which I now speak are not exactly like those met with in the retina generally; and whether they are a modification of those of the layer (2) or of the caudate vesicles, I cannot say; for at the yellow spot the inner layers are less distinguishable from one another than elsewhere: on a vertical section they are more confused, and present, in common, a rather obscure, dark, yellow aspect. I am inclined to believe, however, that the vesicular nervous matter (2) is here in a high state of development, the vesicles being very numerous, and of more stable constitution than elsewhere. The layer, which I suggested (p. 84) might be that of the caudate corpuscles, appears to be considerably thicker, and to blend with the vesicular on the surface of the yellow spot. The layers of the agglomerated granules pass into the yellow spot. the granular layer *g*, being thinner, the nummular, *n*, thicker than elsewhere. The two elements of Jacob's membrane are found over the yellow spot as on the surrounding parts of the retina; the rods are of the same length, but thicker, and the bulb-like bodies are nearer together.

The colour of the spot does not appear to be confined to any single texture, but appears to bathe all the textures, except those of Jacob's membrane, in a common cloud of rich yellow, deepening towards the centre. The colour is here and there in minute grains of deeper hue; but in general it does not seem to lie in proper pigment cells, but to stain fibres, vesicles, and granules alike. The colour soon disappears after death, or in water. I recently, however, left a retina in water for a fortnight, and still found it retaining some of its original hue at this spot: in the dried retina it is permanently retained.

Such, gentlemen, is a brief account of the retina as I have found it in numerous examinations in man and animals during the last four

or five years. If you take the trouble to compare it with the accounts which have been published, you will find it to correspond in most points with the most recent descriptions furnished by Hannover, Pacini, and others, but to differ from all in a few particulars. It has not been my object to discuss disputed points, but to combine in one view what seemed most consistent with the truth of nature. I would venture earnestly to advise those of you who have the opportunity, to examine this elaborate structure for yourselves, as it contains within a small compass a most admirable and orderly arrangement of parts, some having the common characters of nervous elements, but others of so singular an aspect and properties, as to present questions of great interest, upon which a more extended study may be expected to throw much light.

OBSERVATIONS

ON THE

STRUCTURE OF THE VITREOUS HUMOR.

(*Reprinted from* The Dublin Quarterly Journal of Medical Science *of August* 1848.)

During the last few years considerable attention has been given in Germany to the anatomical structure of the vitreous body. This part has been hitherto loosely held to consist of an extremely delicate filamentous tissue, so interlaced as to inclose cellular spaces, in which the water was supposed to be retained, which slowly escaped when the hyaloid investment was punctured. Not that any anatomist had seen these filaments or cells, but their existence was deduced from the fragmentary form taken by the contained water when frozen, particularly as it afforded a plausible explanation of the more obvious properties of the structure, by a fancied analogy with common areolar tissue. When, however, more perfect means of investigation came to be applied without success to the detection of the filamentary substratum, there was room for new researches of a different kind, with a view to the discovery of some other structural cause of the curious and very peculiar physical properties exhibited by the fresh and healthy vitreous body. Pappenheim appears to have been the first to call attention to the fact that evidence may be obtained of an internal artificial arrangement of parts. He announced that the vitreous body, treated with a solution of carbonate of potass, exhibited a succession of concentric layers, something like those of an onion.* Brücke, in the following year,† pursued this hint, imagining that

* Specielle Geweblehre des Auges, Breslau, 1842, s. 182.

† Müller's Archiv, 1843, s. 346.

there might exist in the substance of the vitreous body a series of membranes capable of anatomical demonstration; and he thought it probable that, by steeping the humor in a solution which would furnish a precipitate as it permeated the vitreous substance, these membranes might arrest the precipitate, and thus become apparent to the eye. He accordingly exposed the surface of the vitreous in a sheep's eye, by removing the sclerotic, choroid, and retina, about as far forward as the ora serrata, and placed it in a concentrated solution of acetate of lead. The surface became immediately covered with a white crust, and when, after some hours, he cut a small slice from the hinder region, he found the cut surface marked with fine milk-white lines, running parallel to the original surface, and presenting throughout the appearance of a finely striped agate. He soon satisfied himself that these stripes proceeded from milk-white layers traversing the vitreous substance in suchwise that the outermost was almost parallel to the retina or hyaloid, and the innermost to the back of the crystalline lens; the intervals being consequently greatest in the axis of the eye, and least towards the zone of Zinn (suspensory ligament). Here the outer layers were closely approximated, and terminated by uniting with that portion of the hyaloid which lies against the zone; but as respects the middle and inner layers, he was unable to satisfy himself how they ended. Proceeding onwards, he examined the texture of these layers. With the naked eye or an ordinary lens they appeared simply to consist of a milky, transparent membrane, but with a higher magnifying power a fine granular precipitate (probably chloride of lead) became visible in the position of the white lines, and in their intervals either a perfectly transparent space, or else a smaller quantity of a more delicate and similar granular deposit. Brücke further observed that the vitreous body thus prepared tore most easily in the direction of these layers; and he noticed that the transparent spaces between the white layers were occupied by an apparently gelatinous mass, similar in constitution to the rest, and were not free spaces containing fluid. He offered no explanation why the aqueous fluid of the vitreous escapes so readily on a puncture, which, he rightly remarks, never happens from a true jelly.

In a subsequent communication* the same anatomist observes, that the frozen vitreous body, far from affording ground for the idea of a

* Müller's Archiv, 1845, s. 130.

cellular constitution, in reality accords with, and even favours that which he had previously advocated—viz. that the vitreous body is made up of concentric membranes, enclosed one with another. He states that if a well-frozen eye be brought into a warm room, so as to thaw the tunics investing the vitreous, and if these be then carefully removed, the frozen vitreous body appears as a coherent mass of ice, from the surface of which minute flakes may be detached with the point of a scalpel, as the external warmth gradually acts upon it. These flakes he has traced to near the lens, and as they seem to him to have the same direction as those exhibited by the aid of the metallic salt, he concludes that they are the result of the same membranous stratification which he had before demonstrated.

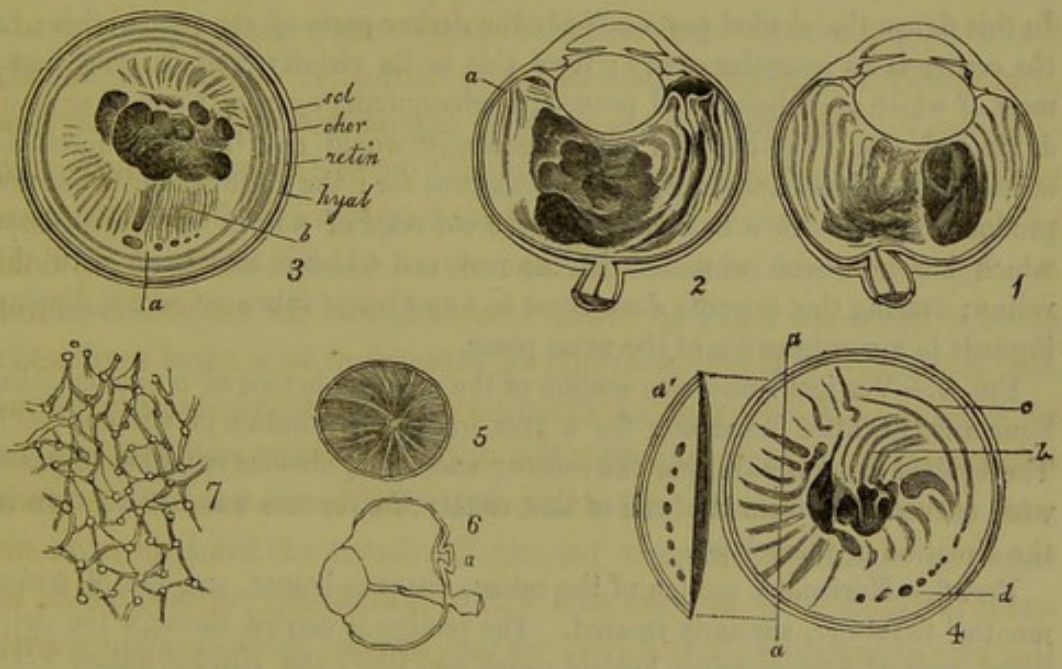
Another distinguished physiologist has also devoted a paper to this interesting subject.* He made his observations on the eyes of mammalia, after immersing them for at least six months in a solution of chromic acid. He describes somewhat more particularly the concentric layers which had been noticed by the previous authors, and states that if the eye be divided by a median transverse section the appearance is that of an onion similarly cut; and this he finds in the cat, dog, ox, and sheep. But in *man* he says that a different structure obtains, rudely comparable to that of an orange, there being segments, of which the convexities are turned outwards, while the angles converge towards, but do not reach, the axis of the eye, where the hyaloid canal exists in infants. In two specimens Hannover was able to count 180 rays, and he therefore concludes upon that number of segments: he was unable to ascertain whether each segment had its proper containing membrane, or whether a single membrane was common to two contiguous segments. Examined with the microscope, he finds the walls of the segments to present the aspect of transparent membrane without structure, covered with numberless granules, which he thinks are probably the result of a precipitation. He concludes with an account of the exact arrangement of the parts about the zone of Zinn, into which it is unnecessary here to follow him.

As I am not aware that these researches have been at all prosecuted as yet by any anatomist in this country, and as it seems probable from my own investigations that much difference of opinion is likely to exist with regard to the true interpretation of the appearances

* Hannover, Entdeckung des Baues des Glaskörper's, Müller's Archiv, 1845.

which have been above briefly described, I am desirous to communicate in a simple form the result of my own observations on the vitreous humor of man and other mammalia, and of birds and fishes. In doing so, I am very sensible how much is still wanted to render them complete.

Action of chromic acid on the human vitreous body.— Having more than a year ago placed several *human* eyes, as fresh as possible (*i. e.* within twenty-four hours after death), and which had been removed from the orbits with special care, to avoid compression of the humors, in dilute solution of chromic acid (the strength indicated by a light straw colour), I soon found them to have become distended and tense, and the outer coat hardened, and I recently made sections of them in various directions, with a very sharp knife, taking care in making the the sections that the globes were not squeezed or cut unevenly. The best marked examples are delineated in figs. 1 to 7.*



* Sections of the human vitreous body, made after being immersed for upwards of a year in weak solution of chromic acid. Immersion commenced within twenty-four hours after death, and every care being taken to avoid injury.

Fig. 1.—Horizontal section of the globe. The dark lines in the figure indicate the situation of the white lines in the preparation; in the centre is an irregular cavity.

Fig. 2.—Vertical antero-posterior section of the globe; *a*, white lines running up to the hyaloid at the ora serrata.

Fig. 3.—Vertical transverse section of the globe, anterior half seen from be-

The vitreous body in all was rendered semi-opaque throughout, but the opacity was more obvious and decided in some directions. Most of the sections dividing the eye into an anterior and posterior half (figs. 3, 4) exhibited faint lines of greater opacity, parallel to the retina, running partly or altogether round the section. These lines were more opaque when the observer looked at them in certain directions, and with a little care it was easy to see that they were the edges of opaque lamellæ which followed the curvature of the retina. In no case did these circular lines extend more than about one-third of the way from the retina to the centre of the vitreous, and when they ceased they were replaced by others of a straight or slightly waved character,

hind. Within the hyaloid, concentric light and dark lines are seen; within these, at *a*, are several dark dots, which are tubular spaces cut across, which dip inwards and approach the central irregular cavity in a curved course. The radiating lines, *b*, are dark in the preparation, and the substance is not interrupted where they occur, as far as I could ascertain.

Fig. 4. – Similar section from another eye ; posterior half seen from the front. In this figure the shaded parts indicate the darker parts of the preparation ; in the centre is an irregular cavity ; from this or its vicinity, radiate many lines, most of which are tubular, as I proved by subsequently carrying a second section, *á*, through *a a*. The cause of what a geologist would call the unconformable arrangement of the lines at *b*, I cannot account for : the knife evidently has not produced them. At *c* is a dark line, the cut edge of a layer of the vitreous which has not been whitened like the rest, and which is concentric with the retina ; tracing this towards *d* we come to a number of tubes cut across, dipping inwards in a continuation of the same plane.

Fig. 5.—Vertical transverse section of the vitreous humor of a nine months' human fœtus, after immersion for a year in a dilute solution of chromic acid. The hyaloid canal is seen near the centre ; and a very obvious radiation of somewhat curved lines from the wall of that canal : the texture was apt to tear in the direction of these lines.

Fig. 6.—Horizontal section of the retina, vitreous humor, and lens of a nine months' fœtal eye, similarly treated. The section is carried through the optic nerve, spot of Soemmerring, hyaloid canal, and lens : the vitreous humor exhibited an uniform opacity in this section. The spot of Soemmerring is represented at *a*, where the retina is seen to recede from the vitreous body, and form a follicular pouch with a narrow neck, over which the hyaloid passes without entering ; the hyaloid canal has been cut open in its hinder half, while the anterior portion remains tubular on the very surface of the preparation. No stem from the extremity of the optic nerve entering the canal can be distinguished in the actual specimen.

Fig. 7.—Fragment of the vitreous substance of the same eye, seen under a power of 300 diameters.

which had more or less of a convergent direction towards the centre. In the centre, in all the specimens, was an irregular cavity of variable size, apparently formed by breaking up of the tissue. In some specimens, where the circular lines were deficient, more transparent lines, of from one-twentieth to one-eightieth of an inch wide, traversed the otherwise homogeneous substance, from the central cavity or its vicinity towards or even up to the hyaloid. These were straight or slightly curved, and of unequal width, and were proved to be tubular channels by cutting them across, when their orifices became clearly visible. In one specimen there were nearly twenty of these near the surface of the section, and in all probability many more too deep for view. Other tubular spaces were seen in one case (fig. 4, *d*) passing in the curve of the concentric layers.

In the sections carried through the optic nerve and lens, and dividing the eye into an upper and lower, or into two lateral halves (figs. 1, 2), a few lines of greater opacity were seen, preserving a more or less exact parallelism with the cut edge of the retina, and obviously the edges of laminæ more opaque than the rest. A very slight touch with a pin sufficed to tear the vitreous in the direction of these lines, and to convert the laminæ into separate sheets, and this has been done to a slight extent in one of the specimens figured (fig. 2). In these specimens the broken central cavity comes so near the optic nerve that the layers are hardly to be seen there, but in front their disposition is not doubtful. Several, and those the outer ones, run towards the ciliary body, and there seem to approach the very surface of the vitreous near the ora serrata, probably uniting with the hyaloid in contact with the zone of Zinn, as described by Brücke. Then those next within bend inwards towards the margin and back of the lens, of course behind the canal of Petit, and they appear rather to cease in succession at the surface of the lens than to be continued concentrically behind it, though on this point the preparations do not speak positively. Between the layers that pass towards the ora serrata and those inclining to the lens the texture seems less coherent, for in some of the specimens the central cavity has spread here and there in this direction, so as even to reach the ciliary processes and expose them to view from behind when the cavity is laid open by a vertical transverse incision.

Viewed with a high power these specimens exhibit no special texture; nothing but a finely granular mass appears, which is merely

rather darker and more obscure where the naked eye detects the opaque lines. No definite streak bounds the light and dark spaces; there is no evidence of a true membrane discoverable by the microscope within the hyaloid: as far as we can see, the light and dark layers have the same amorphous structure.

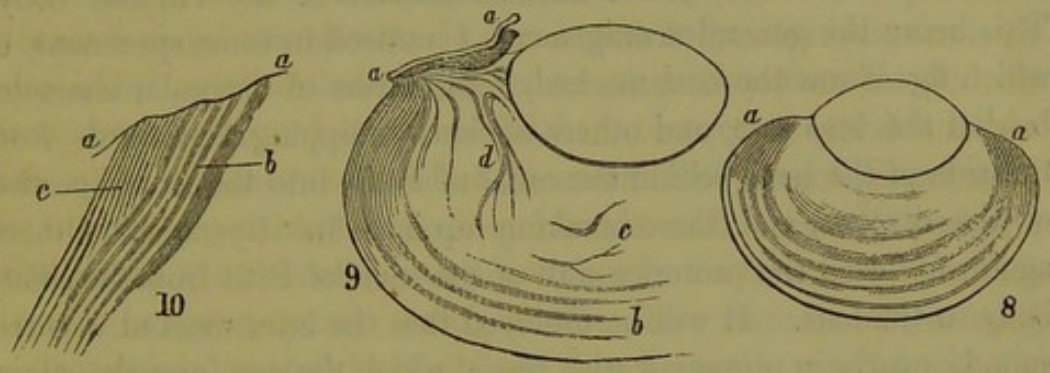
Structure of the vitreous humor in the fœtus.—Among human eyes were those of a still-born fœtus. The vertical transverse section of one of them is represented in fig. 5, to the description of which the reader is referred. It seems to accord with the observations of Hannover. No vestige of layers concentric with the retina was to be found in this or the other eye. The other was cut horizontally, and the knife, fortunately, passed through the optic nerve, spot of Soemmerring, and hyaloid canal, so as to show all these at once. The description of fig. 6 contains what was observed on this section. That there was no streakiness, no radiating lines in this section, is favourable (taken in conjunction with the appearance of the other section) to Hannover's view of segments or their plates radiating from the central axis. If they really exist, they would probably be invisible in the horizontal section, or in any antero-posterior section running along the axis, because they would be then seen flat-wise, whereas they would be presented edgewise in a transverse section.

With a power of 300 diameters these specimens of the vitreous show a very well-marked but peculiar fibrous texture (fig. 7), not at all unlike that of the enamel pulp described by Dr. Todd and myself.* The fibres join in numerous points, at which are minute nuclear granules, resembling oil-particles, but not soluble in ether.

Action of the diacetate of lead on the vitreous body.—Having repeated the experiments of Brücke by immersing the vitreous body of several animals in a strong solution of diacetate of lead, I am enabled to corroborate the accuracy of his descriptions, though not the deductions he has drawn from the phenomena observed. I followed his directions by removing from the fresh eyes of the sheep, lamb, and ox, the sclerotica, choroid, and retina, as far forwards as the ora serrata, using the utmost care to avoid rupture or injury of any kind to the vitreous body: the eyes were then placed in the metallic solution. The hyaloid surface immediately became milky,

* Physiological Anatomy, vol. ii. p. 175.

from precipitation of the lead, and in the course of a short time it was of a dead white, and the vitreous humor began gradually to diminish in size. Some of the specimens were cut into after a few hours' immersion, while others were allowed to remain forty-eight hours in the solution. The time elapsing before the sections were made had no influence on the changes wrought within, except as regards the depth to which they had reached, and the result may therefore be given in a few words. However the vitreous was cut into, white lines were seen



on the cut surface, parallel to the exterior; these lines were, therefore, the divided edges of white layers concentric with that surface.*

In exact accordance with Brücke's account, I found the white lines in the hinder and lateral parts more intense, further asunder, and fewer in number, than in the region of the ciliary body, where they were

* Fig. 8.—The vitreous and lens cut through their centres in the eye of a lamb which had been steeped for five hours in a solution of diacetate of lead, after the tunics had been removed from the hyaloid as far forward as the ora serrata. At *a a* the lines are very fine and close, and should be fifteen or twenty in number, and only visible with a lens. The ciliary body is not represented.

Fig. 9.—Eye of an ox. Tunics, removed so as to expose the hyaloid as far forwards as the ora serrata, then immersed in solution of diacetate of lead for forty-eight hours, and cut with a very sharp knife through the centre. *a a*, ciliary body in section; at *b*, the dense white lines are thick and wide apart; at *c*, are indications of irregular layers of precipitate; at *d*, is a white lamella passing from near the lens, and subdividing in the substance of the vitreous body. Very close and fine lines run from the hinder part of the ciliary body, or rather from the hyaloid, towards the coarse lines behind; others approach the lens behind the canal of Petit.

Fig. 10.—From the sheep, prepared as fig. 9, drawn on a magnified scale. The fine lines of precipitate in the vitreous opposite the ciliary body; *a a*, hyaloid in contact with the ciliary body; *b*, light and dark lines, each 1-600th of an inch wide; *c*, still finer lines, which in this specimen were not parallel to those at *b*.

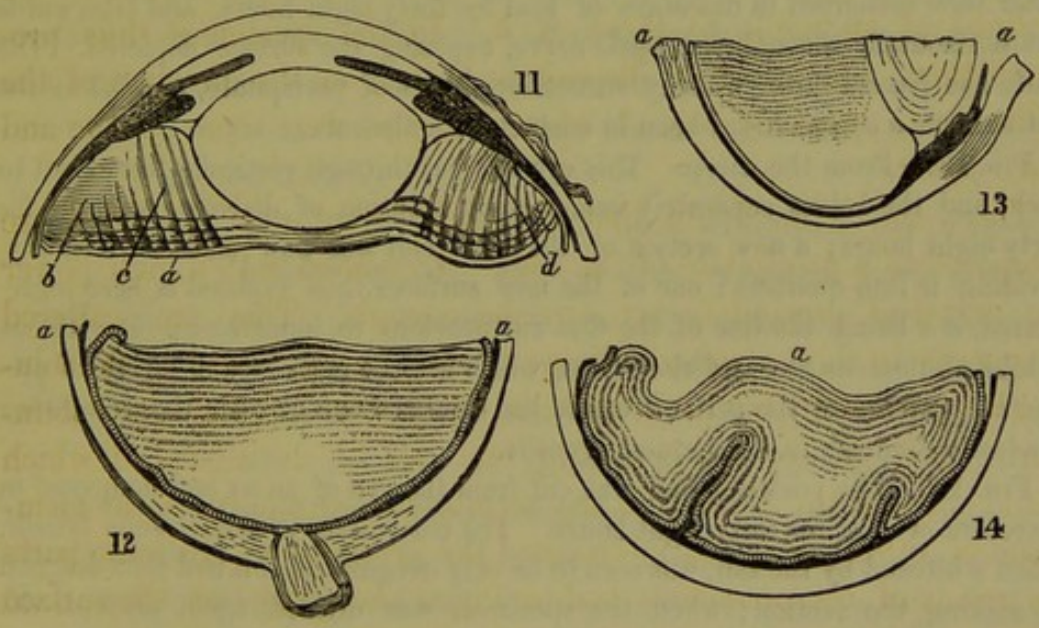
very fine, delicate, and closely arranged, so as hardly to be visible without the aid of a pocket-glass (see fig. 8). The difficulty of making a clean section at this part, even with a sharp knife, in consequence of the tendency of the structure to be drawn before the blade, caused some uncertainty with regard to the ultimate destination of these lines in the ciliary region. However, after examination of many specimens, I was enabled to feel assured that they passed up to the hyaloid at or in front of the ora serrata, and did not pass round at the back of the lens, in parallelism with the anterior surface of the vitreous body. This being the general arrangement, I noticed in some specimens, of which fig. 9 was the best marked, white layers of irregular character behind the lens at *c*, and others obviously dipping backwards from the side of the lens, behind the canal of Petit, into the central portion of the vitreous, and there breaking up into fine layers, *d*. Others, again, followed the posterior wall of the canal of Petit from the ciliary body to the lens. It will be observed that the layer marked *d* corresponds nearly in direction with those which diverge from the ciliary body, and run up to the lens in figs. 1 and 2 from the human eye. In one section through the close and fine lines near the ora serrata I found the appearance delineated in fig. 10, where the lines *c* are inclined at an angle to those at *b*. In the specimens thus prepared there was usually a disposition to tear in the direction of the white lines, especially behind, where the lines were more opaque and wider apart.

There can be no doubt that the white layers now described are composed of a precipitate of the lead. Examined with a high power the grains of precipitate are obvious enough. They are scattered irregularly in the transparent tissue of the vitreous wherever the solution has penetrated, but in the white layers they are infinitely more abundant. Still no sudden bounding line can be distinguished which would warrant the belief that any membrane like the basement membrane of other parts had intercepted the precipitate. In some parts the grains of the precipitate had arranged themselves on the surface of the more opaque layers in something of an areolar form.

It is easy to understand how an accumulation of a multitude of precipitated particles in a certain plane would, so far as their presence extended, serve to break up the continuity and strength of the vitreous substance in that direction; therefore the splitting or tearing of

the tissue along such lines adds nothing to the evidence afforded by the simple deposit of the precipitate for the existence of real lamellæ in the original tissue.

Feeling uncertain whether the layers of precipitate thus parallel to the surface exposed to the salt might not be due to some purely physical cause, I procured some perfectly fresh eyes of oxen and sheep, and, before immersing them in the solution of the diacetate of lead, divided them right across with a very sharp instrument, with the greatest care to avoid dragging, or disturbing the texture of the vitreous humor. Some were divided horizontally, and others into an anterior and posterior half. The halves were then placed in the diacetate for forty-eight hours, some with the vitreous upwards, others downwards. When examined at the end of that time, the cut surface of the vitreous, which had been in contact with the salt, was of a dense white, like that of the uncut surface in the former experiments, and on making an incision into it, white lines were found running parallel with it, just as they had been found running parallel with the uncut surface. To make this more apparent I have added some figures.*



* Fig. 11.—From the ox. This eye was cut vertically into an anterior and posterior half. The anterior half, having lain forty-eight hours in diacetate of lead solution, was divided so as to show the surface delineated. *a*, the line of section previous to the immersion in salt,—parallel to this are several lines of white precipitate, coarse and far apart; *b*, other lines of precipitate, also

The descriptions appended to these figures will explain the points they are intended to illustrate. The conclusion they lead to is this: that the very beautiful and very elegant layers produced in the vitreous substance by immersion in the salt of lead do not depend on any corresponding series of anatomical membranes, but are due to a physical cause, which will probably be explained more easily by the physico-chemical inquirer than by the anatomist. At first sight, indeed, they seem not to admit of explanation by any of the known laws of imbibition and transmission of fluids through porous substances; and some of my friends well versed in those laws were not able to offer even a probable explanation, when I shewed them the preparations. The difference in the closeness of the layers in the hinder region of the vitreous, and in front near the ciliary body, may depend on some real difference in regard to closeness, or compactness, or per-

parallel to the surface which has been exposed to the fluid, but finer and closer; *c*, dense lines of precipitate, taking a different direction, and crossing the others; *d*, similar lines, which seem to run up to the ciliary body, and to be attached there; all the lines indicate cut edges of lamellæ of precipitate.

Fig. 12.—The eye of an ox, cut into an anterior and posterior half, and the latter then immersed in diacetate of lead for forty-eight hours, and afterwards cut horizontally through the optic nerve, exposing the surface depicted. The knife has passed through many successive planes of precipitate, parallel to the cut surface, *a a*, which has been in contact with the salt.

Fig. 13.—From the sheep. This eye was cut through vertically from front to back, and the halves separately immersed in solution of diacetate of lead for forty-eight hours; a new section of the outer half was now made horizontally, dividing it into quarters; one of the new surfaces thus exposed is here represented, *a a* being the line of the first cut previous to immersion; the vitreous exhibits numerous fine and close lines, which are the cut edges of layers of precipitate, parallel to the surface which has been in contact with the salt; they gradually diminish in distinctness inwards.

Fig. 14.—The posterior half was cut from the eye of an ox and immersed in diacetate of lead for forty-eight hours. The cut surface of the vitreous humor, when whitened by the salt, was seen to be very irregular, as if it had been dragged in making the section; when the specimen was divided again through the centre, so as to expose the surface delineated, the retina was seen thrown into deep folds, obviously in making the former cut; the lines of precipitate were parallel to the retina thus folded, and also to the irregular surface *a*, which had been made by the original cut. By the loosening of the retina from the choroid in the specimen, the fluid had probably found its way nearly equally to the whole surface of the vitreous mass immersed in it.

meability, or chemical constitution of the vitreous substance in the two situations. Or it may possibly depend on the different access of the solution to the two parts. But however such variations may be explicable, they are proved, I think, by the last-cited experiments, not to depend on any difference in the number or thickness of actual membranes in the two situations. The fine, close lines in fig. 8 and 9, and the equally fine ones in the same region of fig. 11 *b*, traverse the vitreous substance in directions too dissimilar for us to imagine them to be the exponents of an anatomical lamination; but they are in both cases parallel to the surface previously exposed to the salt.

The frozen vitreous humor.—In his later paper, Brücke draws an argument for the existence of the concentric layers as a true structure from the condition of the vitreous when frozen; but in this I confess he appears to me to have been warped by the idea previously in his mind. He says that when the thawing of the frozen mass commences, thin flakes of ice may be picked off from the surface, as though the ice had taken the form of the concentric lamellæ while freezing. For my own part I have been unsuccessful in finding any indication of the concentric flakes in this way. The ice appears to shoot in the substance of the vitreous in a crystalline form, quite irrespective of any structure existing there, and as it melts, layers and angular fragments may be got off it in a variety of directions. I feel sure that the ice never takes the figure of the cup-shaped lamellæ supposed.

Vitreous humor of the bird.—I have examined the vitreous humor of the eye of the common fowl after a month's immersion in the solution of chromic acid. After this period of immersion, short as compared with that recommended by Hannover, the vitreous—as shown in the annexed wood-cut, fig. 15*—was found throughout rendered slightly opaque; no concentric lamellæ or layers, in any respect parallel to each other, were discovered; but a very evident arrangement of more opaque fibres

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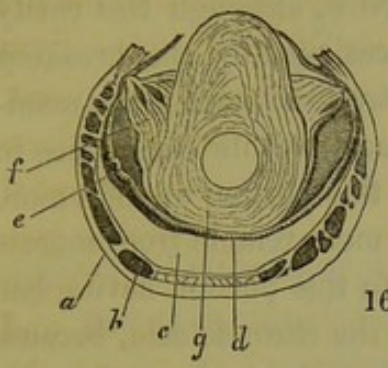
* Fig. 15.—Fresh eye of a common fowl, immersed during three weeks in dilute solution of chromic acid; section carried obliquely through, and parallel to, the plates of the pecten; striæ are seen proceeding from the summit of the pecten, chiefly towards the ciliary body, but also towards the lens; others appear to pass from the ciliary body towards the lens.

was seen extending chiefly from the summit of the pecten towards the ora serrata, and a few towards the lens, while others stretched from the ciliary body to the side of the lens. On attempting to break down the the vitreous substance it tore by preference along these fibres, so as to leave them dissected and isolated, and they manifested a certain elasticity. The sides of the pecten also appeared to give off a few fibres, but only in one or two situations. In the bird's eye I found that the vitreous had always undergone partial collapse, and so become separated from the retina during the immersion in the solution. It still, however, adhered to the surface of the pecten, and to the ciliary body and lens. A thin exterior layer of the lens was hard and opaque, while all within retained its perfectly fresh characters.

Vitreous humor in fishes. — I also placed several eyes of fishes in the same solution of chromic acid, some entire, others with the cornea carefully removed, in order to permit a freer and readier access of the acid to the vitreous substance. In the former I found, after a month, that the interior parts had not been reached by the acid, and that they were destroyed by decomposition. In the others, all the textures were preserved, and in making a section in the axis the following appearances were observed in the vitreous humor. It passed in layers from the region of the ora serrata to the side and back of the lens. The layers diverged to reach their several destinations, and here and there open spaces between them were cut through, which, though possibly the result of the mode of preparation, yet showed the tendency of the structure to split in the direction of the layers. The lamination of the structure was exceedingly evident. Some of the anterior layers, instead of proceeding from the junction of the choroid and iris, which in this eye corresponds with the anterior border of the retina, were derived at successive distances from the suspensory ligament of the lens, which bounds the vitreous in front, extending from the junction of the choroid and the iris to the side of the lens. The explanation of fig. 16, here represented, will further interpret the appearance.*

* Fig. 16.—Eye of a cod-fish. The cornea was removed, and the eye then immersed in dilute chromic acid for three weeks; a section was then made in the axis of the humors; *a*, sclerotica, within which is a cellular space; *b*, silvery layer; *c*, choroid gland; *d*, pigment and retina; *e*, space between retina and



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General conclusions. — The researches now described have not been numerous or varied enough to satisfy me with regard to many points which it is still desirable to clear up; but they will serve, I think, to place in its true light the remarkable phenomenon on which Brücke has founded his view of a very complex and artificial construction of the vitreous body. If I may venture to deduce a conclusion from the experiments I have detailed, I would say that the construction he has described is not in the least supported by the experiments with the salt of lead, which may be made to indicate a lamination in any direction at the pleasure of the anatomist; but, nevertheless, there remains good reason for supposing that there do exist certain layers in the vitreous substance, capable of being rendered visible by art. I think in the sections of the human eye (figs. 1 and 2), the uniformity of the arrangement of the layers disclosed in the neighbourhood of the lens could hardly have been produced, independently of a pre-existing structure, by simple immersion in the chromic acid. The same view is supported to some extent by the appearance of fig. 9, *d*, which could not have been due to a merely physical cause. Then, again, we have the manifest existence of sets of fibres stretching in determinate directions through the vitreous in the eye of the bird, and the still more decisive lamellated arrangement in the fish, which last affords the most striking and conclusive evidence for the artificial conformation of this exquisitely transparent part that we yet possess. The great solidity and weight of the lens of the fish may, perhaps, be the occasion of this.

It is certainly remarkable that in all specimens of the adult human vitreous humor preserved in chromic acid, a central cavity was dis-

vitreous body, occasioned by the collapse of the latter; *f*, the vitreous body descending in distinct layers from near the junction of the choroid and iris, and passing to the side and hinder part of the lens; the lens *g*, probably by its weight during the immersion, has pressed out all fluid from the hinder part of the vitreous body, and so, apparently, come into contact with the retina: the hard nucleus of the lens, seen in the centre, is not acted on by the acid; the anterior soft portion has advanced through the pupil.

covered on making a section of the eye. Now, although this cavity may be regarded as a false appearance, occasioned by the breaking down of the vitreous substance in the central part during the manipulations preceding the immersion in the acid, yet its occurrence in every specimen would seem to indicate that this portion was of a more fragile consistency than the rest, since it is more remote from sources of injury. The cavity could hardly be due to this portion having had time to decompose before being reached by the chromic acid, because the permeation of the whole mass would probably be sufficiently rapid to anticipate such a change.

I may observe, in conclusion, that in a case of phlebitic ophthalmitis, in which the vitreous substance was filled by inflammatory exudation corpuscles, the yellow colour derived from the deposit gave no indication of lamellæ, but made exceedingly evident a flattened cavity in the central part of the vitreous humor, capable of containing a pea (see Case M in the Appendix).

APPENDIX,

CONTAINING NOTICES OF A FEW MISCELLANEOUS CASES OF OPHTHALMIC DISEASES, CHIEFLY ILLUSTRATIVE OF POINTS REFERRED TO IN THE FOREGOING LECTURES.

CASE A.—*Small intractable ulcers of the sclerotica.*

(Partly from the notes of my friend Mr. WYATT.)

July 13, 1848.—John Kemster, æt. 38, a house-painter, of slender frame, looking sallow, and out of health, (but never having suffered from colica pictonum), had had slight opacities from his youth, with some dimness of sight in his left eye. Five weeks ago had a lacerated wound of the right brow, and while this was slowly healing, the eye became painful, and discharged much hot watery fluid. He, however, continued his work until last week, when the great pain obliged him to desist.

There is *now* a deep round ulcer, about the size of a mustard seed, all but through the sclerotica, over the ciliary muscle, close to the lower border of the cornea. It looks just as if a small piece had been punched out, the edges abrupt and yellowish, with considerable redness of the surrounding conjunctiva and sclerotica: but no chemosis. The iris and aqueous humor are healthy. On the other eye, there is a yellowish deposit in the conjunctiva and sclerotica, in the horizontal axis, close to the cornea, on the outer side, with a little vascularity around. This seems an early stage of what has become an ulcer in the right eye. Tongue clean; bowels confined; appetite very bad; pulse 80, cannot sleep at night. Lunar Caustic to the ulcer. Drops of the same (1 gr. to the ounce) every morning.—Pil. Purg. C. gr. v. every night. Quinine gr. j., three times a day.

17th.—The hole now filled to the level with yellow non-vascular lymph. Aching, shooting pain in brow.—Repeat.

20th.—The lymph gone, and the ulcer as on the 13th.

24th.—The ulcer deeper in the centre, where a dark point seems to indicate its complete peforation to the pigment. Aqueous chambers still natural. The surrounding vascularity less, and purplish. The yellow spot in the other eye is more distinct, contains no red vessels, is not raised, but, on the contrary, slightly depressed, as though the conjunctiva were superficially ulcerated over it. Has been living low for three weeks, being out of work, and is besides much depressed in spirits, having six children dependent upon him.—Repeat.

27th.—Has obtained more nourishment. There is some attempt at filling up the gap, which occupies a wider area. The ulcer on the other eye deeper, engaging the sclerotica.

After this he went into King's College Hospital for three weeks, and under a more generous diet and quinine, the ulcers appeared to be rapidly healing. On leaving the hospital, however, he became again reduced to a very poor diet, and six weeks afterwards (Oct. 5) was as follows:—The right eye without morbid vascularity; the original ulcer about half filled up: its base semi-transparent, unlike the surrounding sclerotica, and with pigment appearing through. The left sclerotica generally pink; the conjunctiva considerably injected. A yellowish non-vascular infiltration into the subconjunctival tissue at the seat of the former ulcer (in the horizontal axis, on the outer side, close to the cornea); and above this at the distance of one-eighth of an inch, also at the confines of the sclerotica and cornea, a new ulcer in both textures, circular and deep, like the former ones. Internal parts natural. Aching pain in this eyeball. Tongue clean; appetite good. Battley's Liq. Cinchonæ was freely given, and the Nitrate of Silver drops resumed.

Oct. 12th.—The ulcers remain the same, but there is much more inflammation of the sclerotica and conjunctiva, with pain, and mucous discharge.

On the 17th he was taken into St. Thomas's Hospital by my friend Mr. Dixon, and remained there till the 26th December, having been treated during that interval on a strictly tonic plan. Other ulcers had formed, one on the right cornea, but he was altogether in a very much improved state, when he left the hospital at his own desire.

On the 28th December I made the following note:—"There is now a transparent substance filling up the hole in the right sclerotica (the original ulcer), and the other ulcers on the left have healed with little mark. The right iris and lens are in contact with the cornea, and I suppose there must be a fistula corneæ, but I cannot detect its exact situation. This cornea is slightly and irregularly nebulous, and presents some unevenness of surface at the lower and inner part."

A month after, having been again living very poorly, a new ulcer had formed on the right sclerotica, with intolerance of light. The aqueous was regenerated, but the cornea continued a little cloudy. Treatment according to the same principles was repeated.

Cases B.—*Sloughing of the corneæ in the collapse of scarlet fever.*

Five boys of one family had scarlet fever during the autumn of last year, when it was so generally fatal. Two lost their sight by sloughing of the corneæ, within a week of their seizure. Of these, one died; the other was brought to me some time afterwards, with the globe sunk, and without the least perception of light. Of the three others, in whom the eyes were not affected, one died, the other two recovered.

There was no previous debility discoverable in these cases to account for this unusual destruction of the corneæ.

CASE C.—*Central ulcer of the cornea—healing slowly, without the development of vessels.*

A boy, æt. 7, of rather feeble health, had slight ophthalmia, with a small speck, for which the ordinary treatment was adopted, but without good result, and after four months, a small central ulcer was found on the cornea, attended with much lacrymation and intolerance of light. It was carefully treated with nitrate of silver, alteratives, sedatives, and tonics, but at the end of a month remained without action, deep, clear, and without vessels. Bark and steel were freely administered and agreed well, and under their use an almost imperceptibly slow improvement took place, until, in about three months, the health was completely restored and the ulcer healed, leaving a dense opacity accurately limited to the affected spot. The healing process had been unaccompanied with the formation of any vessels in the cornea, or even with any nebulosity between the ulcer and the margin. Perhaps this would not have happened if the ulcer had been much nearer to one side than the other, so as to attract the materials of repair from some definite portion of the neighbouring blood-vessels.

CASE D.—*Sloughing of the whole cornea, from acute inflammation—retention of the lens by its suspensory ligament—subsequent progress of the reparative action.*

October 2nd.—Sarah Stenning, æt. 52, a charwoman, subject to chronic ophthalmia for 5 years (after erysipelas of the face), 18 days ago had a "violent cold in the right eye:" the lids were swollen and closed, and she suffered great pain. She was immediately treated by a surgeon, but when she came under my care, 5 days ago, the cornea was nearly all detached in a sloughing state, and she was very weak and low. I treated her with bark, Dover's powder at night, and soothing applications.

To-day she is in rather better health. The eye presents the following remarkable condition: considerable chemosis, the entire cornea is gone by slough, and the iris and lens are exposed, forming the front of the globe. The iris is covered with a thin film of yellow exudation in the outer 2-3rds of its breadth; the inner third, round the pupil, retaining its natural dark brown aspect. The pupil (○) is occupied by the front of the lens, which has *its natural transparency*. The iris is conical, the pupillary border being projected by the lens, which pushes forwards from behind. It is singular that the lens has not escaped. Notwithstanding the transparency of the lens, she has no perception of light with that eye. She has no pain in the ball, only in the brow. Delicate pressure on the globe moves the iris gently on the lens, and shows that the two structures are but loosely adherent, or simply in contact.

She was admitted on the 6th: the lens did not appear to have escaped. The same system was pursued. The iris became gradually covered with a thicker, and at length vascular, layer of soft lymph, obscuring the true texture. At first the pupillary border was simply fringed with yellow lymph; this lymph became red with vessels, and then threw out more on its border, and so on till the pupil

(or rather the capsule of the lens behind it) was covered over with organized membrane, only differing from the rest in not having the dark iris behind it. By the 23rd October the whole front of the globe had become flatter, and she suffered hardly any pain.

Nov. 2nd.—The new front to the iris is contracting in circumference. The pupil is marked by a dark spot, into which sinks a small vein, formed from vessels of the new tissue, which are supplied by one of the anterior ciliary arteries. No pain.

9th.—The new covering of the iris is rapidly contracting. The front is flat, and the softened globe is beginning to get squared by the passage of the recti muscles.

Dec. 11th.—The new front is now about half the size of the original cornea, and not further contracting. No pain, and hardly any irritation.

Jan. 25th.—No further change: no irritation. Dismissed.

CASE E.—*Chronic ulcer of the cornea, presenting the appearance of concentric rings—perforation—escape of the aqueous humor—cure without adhesion of the iris.*

28th Feb. 1848.—Isabella Ashdown, æt. 5, has a perfectly circular conical ulcer on the right cornea, in which there is an appearance of concentric rings, alternately opaque and transparent. It is a little below and outside the centre of the cornea. The iris acts freely. She was healthy till two months ago, when her father states that she caught cold in her eye. Tongue clean; appetite good; bowels open; pulse weak; no thirst; skin cool. Sod. c. Cinch. gr. v. b. d.; Gutt. Arg. Nitr. b. d.

March 2nd.—The deepest and most central point of the ulcer has given way, and the aqueous has escaped, the iris coming into contact with the cornea and a point near to its pupillary margin falling against the ulcer, without prolapse. General symptoms the same. Very little vascularity around the cornea, none *in* it. On the application of atropine to the conjunctiva, the pupil dilated, and the iris was drawn away from the orifice in the ulcer. Rep. Gutt. o. n.; Extr. Belladon. supercil. o. n.; Sod. et Cinch. gr. viii. b. d.

March 6th.—The aqueous humor restored: pupil dilated. The ulcer healing, opaque, without concentric rings.—Rep.

13th.—Edges of the ulcer smoothed off; surface opaque.

20th.—Ulcer healed, except in the centre: the healed margin and the unhealed centre both opaque.—Rep.

In another fortnight the cicatrization was complete.

CASE F.—*Intractable ulcer of the cornea, perforating at one point, and afterwards slowly destroying its whole anterior surface.*

George Noble, æt 52, a married man, of rather sallow complexion, who had

rheumatic fever when 13 years old, and has since been subject to rheumatic pains, but otherwise of good constitution; had iritis of the *right* side in 1845, but rapidly got well under cupping, blisters, and mercury. About May, 1847, he had another attack in the *left* eye, from which he recovered by similar treatment, no less promptly, under the care of the same able surgeon, Mr. Holthouse. In February, 1848, he was again seized with severe inflammation in the same eye (the left), which appears to have involved the iris, but was at the same time attended, either at first or at an early date, with a curved ulcer at the inner margin of the cornea, which at length penetrated to the aqueous humor, and led to prolapse of the iris, and displacement of the pupil inwards. All the remedies which are usual in such a case were judiciously employed, and the perforation closed, but still the ulcer remained, and even enlarged in area, spreading upwards and downwards within the margin of the cornea, till, in May or June, when I first saw the patient with Mr. Holthouse, it was in shape like a quarter moon, its pointed extremities reaching over beyond the median line, and threatening to encircle the whole cornea. As caustics and astringents had been employed, and bark freely administered, and as on a careful examination of all his secretions nothing wrong could be detected, it was hard to discover the reason of so obstinate a form of ulceration, or to devise a rational treatment. There was no syphilitic or other specific taint. As he was suffering much pain, opium was given freely, with sarsaparilla, and the iodide of potass internally, and mild solution of nitrate of silver to the ulcer itself.

No relief being felt from this plan, he came under my care at the Ophthalmic Hospital in July. I then left off all local applications, and gave him Ext. Conii et Pil. Hydr. Chl. C. aa. gr. v. o. n. with a bitter Decoction. At first a favourable change appeared to be taking place; the ulcer had a cleaner surface, and was smaller; the irritation was less; there was still a dull, muddy vascularity of the neighbouring conjunctiva and sclerotica.

Aug. 3d.—The ulcer is about the same in aspect; the edge, towards the centre of the cornea, very sharply defined; less constant pain,—but a sudden sharp pain now and then seizes him, as if something was in the eye, probably from friction. A new ulceration is appearing on the outer and lower border. The congestion in the vicinity of the old ulcer has a venous character; and one large vein courses over the base of the ulcer. Gums very slightly sore; tongue clean; appetite very good; pulse quiet and regular. He has a worn countenance; has been out of work seven months, and rather badly off for food.—Liq. Cinchon. gtt. xv. t. d.; Ext. Conii, gr. v. o. n.; Gutt. A. N. O. M. Good diet; Beer. The eye to be covered with a light wadding to prevent friction of the lids.

10th.—Decided relief from closure of the lids; but the ulceration is slowly extending. The two ulcers have coalesced, and all but encircle the cornea.—Rep. Liq. Cinch. gtt. xx. ter die.

Sept. 7th.—More irritation. The ulcer encroaches slowly on the central part of the cornea, but is not so deep; and at the inner border is healing up to the level, and contains large veins.—Castor Oil to be dropped in frequently to diminish friction. An issue in the temple. Continue the Bark and Hemlock.

14th.—The eye has been "very easy." The ulceration is not deep, and vessels shoot into it. The central portion of the cornea, which has been hazy, is clearer.—Rep.

21st.—Steady improvement. The ulceration does not spread, but is filled up nearly to the level of the central part, which is clear. The ulcerated part is defined by an abrupt line from the healthy cornea, and is opalescent. On the inner side, in the seat of the original ulcer, it admits of our seeing the iris through it.

28th.—More irritability of the eye, and pain in the cheek. The ulcerated parts, though not so deep, are more extended, and occupy all but a central portion of a quarter of an inch wide.—Rep. Pulv. Ipecac. C. gr. viii. o. n.

Oct. 23d.—Little alteration. The eye has been, on the whole, quieter; but every now and then becomes more irritable for a few days. Still has the issue.—Rep.

30th.—More aching pain in the globe. The ulceration is no where deep, only slightly below the level of the remaining cornea, and looks like a very old vascular leucoma,—having vessels of considerable size running into it from the conjunctiva and sclerotica. The remaining non-ulcerated portion is more opaque. There is nothing new in his general state, and no new injection of the eye.

Nov. 8th.—The remaining portion diminishes by encroachment of the ulcer, which still exhibits no tendency to advance into the deepest layers. A vessel from the outside shoots into the central part, which is quite dull.

27th.—He suffers much less irritation; has had no sharp or severe pain for some time; sleeps very well; feels very well; no bulge of that portion over which the ulceration has extended; the ulceration still slowly spreads.

Jan. 25th, 1849.—There is now but a small point of the cornea of its original level; very little irritation.

Feb. 1st.—The whole original front of the cornea now gone. The new surface is opaque, smooth, on a level with the conjunctiva scleroticæ, and traversed with a few large purple veins. An ulcer occupies the spot where the last remnant of the original surface was situated, and threatens to perforate.

March 1st.—This ulcer continued stationary for a few weeks, but is now nearly healed. The cornea has its natural curvature, though formed only by the posterior layers, fortified by leucomatous deposit and vessels. Though it is very opaque, he can distinguish large objects. The eye gives him no distress. The irritation appears to be permanently subsiding.

Case G.—*Chronic vesication of the cornea, in an eye the seat of slow disorganising action.*

(Under the care of Mr. Dixon.)

Feb. 7th, 1848.—Lucy Dudgeon, æt. 48, a phlegmatic, pale-looking, nervous woman, older in look than in years, has had glaucoma, with cataract and staphyloma scleroticæ of the *left* eye, for three years. The *right* eye has for a year been gradually becoming impaired. The deep-seated vessels are large,

and easily fill on irritation; the pupil is large,—irregular; sight very dim; has had scintillations, &c.

The cornea is perfectly clear; but the epithelium over one-fourth of the area, near the centre, is loosened from the cornea, with a very little fluid beneath it, as in a vesicle. When the lower lid is pushed upwards, against and over the cornea, the loose epithelium is wrinkled, and bulges with the fluid behind it. When the front of the cornea is untouched, the epithelium lies smooth, so small is the quantity of the enclosed fluid. This affection seems a consequence of general impairment of nutrition in the organ, and not of any inflammation in the cornea, which is quite transparent. I have seen the same state in several other instances.

CASE H.—*Acute glaucoma; subsequent slow disorganization of the corneæ; and (in one eye) escape of the humors and retina. Examination of these structures.*

June 26, 1848.—Mary Kilby, æt. 54, was led to the Ophthalmic Hospital, having been totally blind for nine months. She had suffered from bad health for some time, with occasional slight dimness of sight, when she was taken ill in the street, with some head affection, of which she does not give any distinct account, but it was unattended with paralysis or loss of consciousness. Being taken home, she found herself totally without sight next morning, and she has not had the least glimmer since. The attack was attended with great pain in the temples, which has been, and still is, her principal grievance. She kept her bed for seven months.

Present state of the eyes.—The corneæ dewy, as though breathed upon; scleroticæ contain large congested vessels; irides brown and slate-coloured; pupils dilated, irregularly oval, and fixed; lenses greenish and semi-opaque. She has constant pain in the brows, or, if not there, in the occiput, aggravated at intervals.

Appetite very good; bowels regular; tongue clean; usually sleeps well. Tartar emetic ointment to the temples; Haust. Pot. Iodid. bis die.

Oct. 2.—Less pain in the brows; irritation of the right globe from vesication of the conjunctival epithelium of the cornea, a portion of which is detached. The rest is dim.—Guttæ Zinci Sulph. o. m.

30th.—The right cornea opaque: its surface dim, especially near the centre, with more inflammation.

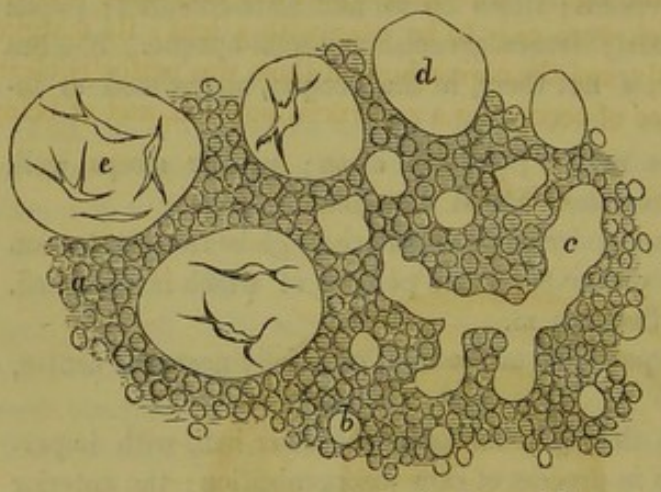
Dec. 2nd.—The right cornea thickly nebulous in the inner half, with imperfect *pannus*. The left cornea is in process of slow disorganization; the anterior layers are loose and flaccid, as though in a state of slough, and yet they do not separate. On the outer side there is a semi-circle of opaque yellow deposit in the lamellæ, a little way from the margin; there is also much chronic vascularity of conjunctiva, and tendency to chemosis. Much pain in the left eye, and some in the right. That in the left eye and brow is sudden and darting, night and day, and often so severe as to cause her almost to start from her chair; yet her appetite is good, and she says she is "pretty well in health."—Emp. Lyttæ pone aur. sinist.; Ung. Hyd. c. Opio supercilio.

11th.—She reports that on the 9th, as she sneezed, the left eye burst and bled, with severe pain. I find the cornea has given way at the point previously sloughing. The whole cornea, except a narrow rim, has separated, leaving the iris exposed, with the lens pressing forward, but not apparently inclined to escape. In this state of things, as she was suffering very much, I thought it might relieve her much to remove the lens, which I accordingly did, leaving the capsule *in situ*. The capsule was of quite horny consistence, and when incised the soft substance of the lens escaped, looking nearly of its proper transparency. The nucleus, I think, remained in the eye, for as a little vitreous humor was beginning to escape, I desisted from any further attempt to extract it.

14th.—The eye has been much easier since the operation. It continues to discharge, but no blood. Still much headache. She was now received into King's College Hospital.

During her stay here she was still a great sufferer from aching and throbbing pain in the brows, chiefly the right; and in the course of about a fortnight (Dec. 29th), the right cornea gave way as the left had done, but in this instance the separation of the slough was attended with forcible protrusion of the lens, the whole vitreous humor, and the retina. Considerable hæmorrhage attended this grave accident, but it was readily arrested by slight compression of the lids. By the prompt zeal of Mr. S. J. A. Salter, the house-surgeon, who was at once called up by the nurse, and found the protruded parts on the patient's cheek, I was enabled to examine them when perfectly fresh, and as such opportunities are very rare, I shall relate the exact condition in which we found them.

FIG. 33.



External view of a portion of the retina (case of Glaucoma). *a*, ends of the rods. *b*, bulb of Jacob's membrane. *c*, light space apparently formed by the coalescence of several bulbs. *d*, large circular light space. *e*, another with included caudate bodies. Magnified 350 diam.

The *lens* could not be found. The *vitreous humor* was perfectly pellucid—neither yellow nor green—and of its natural consistence. The *hyaloid membrane* was also natural in appearance. In the substance of the vitreous near the hyaloid were seen a few irregular granules.

The *retina* had to the naked eye very much its ordinary appearance. Under a high magnifying power, its outer surface presented in some places the usual series of the rods (*a*), and bulbs (*b*), of Jacob's membrane in their natural arrangement and proportions, but in others, certain departures from the healthy condition were noticed, which are imperfectly represented in the woodcut, fig. 33.

There were numerous transparent spaces among the rods, some seeming to

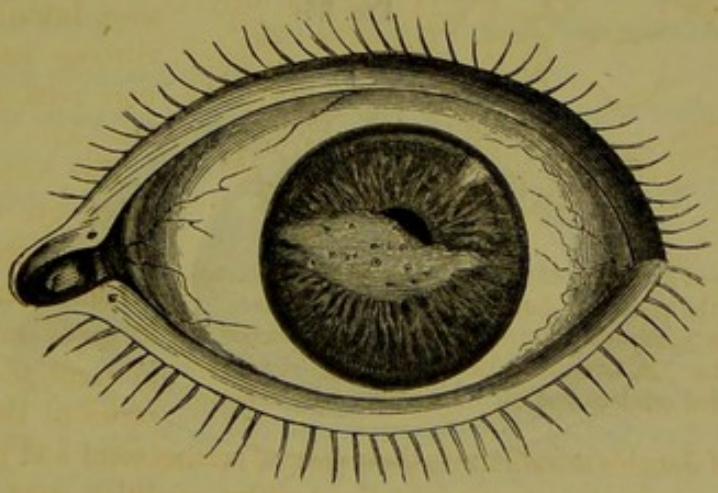
be formed by the running together of adjacent bulbs (*c*), others by the great enlargement of the bulbs, or of the beds in which these had rested (*d*). These latter large transparent spaces seemed to occupy nearly the whole thickness of the retina, where they were close together: the retina looked cribriform. They were occupied by transparent fluid, in which lay a few small and very delicate caudate bodies, like small caudate nerve-vesicles, but without nuclei (*e*).

In the middle of January she left the hospital, still suffering a good deal of pain in the region of the brow.

CASE I.—*Symmetrical opacity of both corneæ, extending horizontally over the central region, and obstructing vision; consisting of an earthy deposit limited to the anterior elastic lamina, and successfully removed by operation.*

James Kemp, æt. 55, for forty years a house-painter, a man of healthy constitution, but of late reduced by deficiency of food, arising from want of power to follow his occupation, came under my care in January, 1849. On each cornea was a horizontal band, of brownish opacity, extending from side to side, and so much broader opposite the pupil as completely to hide it from view, unless the pupil was dilated, or was examined either from above or below, through the still transparent cornea. Both the iris and the pupil could then be seen to be perfectly natural and active. When the pupils were considerably dilated, he obtained some useful vision, especially with the left eye, where the opacity was not quite so extensive as on the right. The opaque part was very finely mottled with dark dots, some of which were only to be seen with a lens: its margins were shaded off rather abruptly, and the cornea beyond them was perfectly clear. The opacity had the appearance of occupying a superficial position, and of being

FIG. 34.



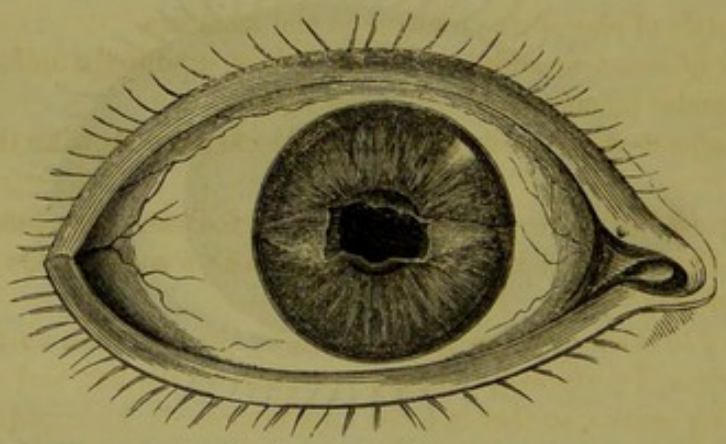
Left eye of Kemp, showing the appearance of the opacity, when the pupil was rather more than usually dilated. He could then see his way about, the light entering above the opacity. Magnified 2 diameters. Drawn by Dr. Westmacott.

very slightly raised, but the surface reflected the light as brilliantly as other parts. The shape of the opaque tract was peculiar in being slightly inclined downwards from the inner side, so that its lower edge in each eye corresponded exactly with the margin of the lower lid, when the eyes were directed to a near object. The inner end of the opacity in the left eye was traversed by a narrow line in which the cornea was as transparent as ever.

The singularity of these opacities led me to inquire particularly into the man's history. He had had an ophthalmia ten years before, lasting only a fortnight, and leaving no blemish. After a period of about three years, his wife noticed that he had a speck on each eye, but as his sight was perfect, he doubted it. After two or three years more the specks were more evident to others, and he began to find that in a strong light his sight was clouded, so that he applied for relief at the Ophthalmic Hospital, and remained a patient there for about two years, during which he was treated with drops and lotions, but rather got worse than better: in fact, the opacity seemed confirmed and incurable, and was steadily encroaching over the front of the pupil. Within the last year he has been quite thrown out of work, able to see only in an obscure light, and then only objects on one side.

Like those who had previously seen him, I regarded these opacities as indelible, but as he came from time to time, it occurred to me to make an attempt to shave off a portion of one of them, in order to examine its nature more completely. I accordingly made the patient come from the hospital to my house, where I could at once place any particle I might be able to detach under the microscope. The first scratch with the point of the lancet on the right eye (January 20th) detached the epithelium, which seemed healthy, and brought me down upon the opacity, which felt hard to the instrument, and had a smooth surface. In scraping and trying to slice off a thin film of it, a thin flake cracked off and separated, leaving what seemed a hole through the cornea; but the aqueous did not escape, and I then saw that the pupil was visible through the

FIG. 35.



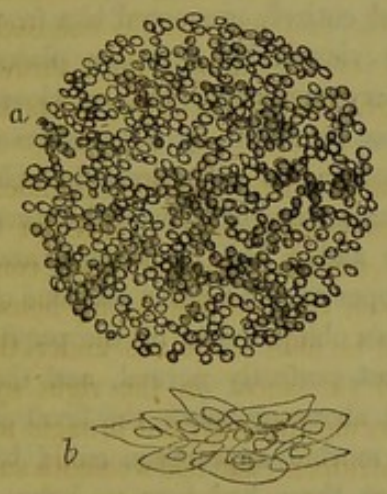
Right eye of Kemp, after the removal of the opacity from over the pupil, which is here shown dilated more than ordinary. Magnified 2 diameters. From a Drawing by Dr. Westmacott.

perfectly transparent lamellated texture, behind the opacity. It was now easy to chip off the opaque film over a space corresponding to the pupil, and when this was done he could see large letters plainly, for the exposed surface was nearly smooth.

The pain attending this little operation was great, and the poor fellow fainted; but the subsequent inflammation was slight, and in a few days the epithelium was restored, without any return of opacity, and he could see very much better.

The fragments which had been removed became of an opaque white when dry, and when examined under a sufficient magnifying power presented the appearance of an aggregation of rounded, highly refracting grains, disposed in a sort of net-work. They all lay nearly in one plane, and the epithelium which had covered them was perfectly healthy.

Fig. 36.



a, Earthy deposit on the front of the cornea—Magnified about 150 diam.
b, Epithelium covering it in a healthy state.
(Case of Kemp.)

Having a vague notion, derived from the shape of the opacities, that the deposit might possibly consist of some material exhaled from the paint he had so long used, I requested my friend, Professor Miller, to examine it with chemical tests under the microscope; and, though the result did not bear out my conjecture, I shall give it in Dr. Miller's own words.

"*Chemical examination of a superficial deposit upon the cornea.*

"Jan. 22, 1849.—Placed in *acetic acid*, the granular matter very slowly dissolved out of the tissue containing it.

"*Hydrochloric acid* attacked it briskly, attended with effervescence, and completely dissolved it.

"*Ammonia*, added to the hydrochloric solution, caused an amorphous coherent precipitate, mixed with a few of the well-known serrated stellate crystals of phosphate of magnesia and ammonia.

"*Oxalate of ammonia*, added to the preceding, produced a uniformly diffused, coarsely granular precipitate of oxalate of lime.

"*Hydrosulphate of ammonia* produced no blackening, showing the absence of lead.

"The deposit, therefore, appears to consist of the same ingredients as ordinary bone—viz. Phosphates of lime and magnesia, with a considerable proportion of carbonate of lime."

On the 22d February, the area exposed by the operation on the right eye remaining clear, I performed the same operation on the left, and with precisely corresponding results, so that in a few days afterwards he could see almost as well as eight years before. With this eye he could, in fact, with some care read the type called "Pearl type"—viz. (London.)

The above case is one of those referred to in the Lecture (p. 38), as of a

brown tint, chronic course, non-inflammatory origin, and liable to affect both corneæ at the same time; and I think it is evidently seated in the anterior elastic lamina, as there surmised. I had seen four or five examples of it, but had till now deemed it irremediable. The issue of Kemp's case I am anxious should be known, because there are probably many similar ones scattered over the country given up as incurable, and yet within reach of this method of relief.

CASE J.—*Symmetrical opacities, very similar to the last: removed by operation.*

(This case was treated by Mr. DIXON, to whom I am indebted for the following notes.)

J. T., a cabinet-maker, æt. 58, applied at the London Ophthalmic Hospital, October 16, 1848, complaining of dimness of sight, which had been gradually getting worse for the last six months, until it had entirely prevented him from following his trade. His eyes, when cursorily viewed by a person placed directly in front of him, seemed to have no pupillary apertures; but on closer inspection it was found that this appearance was produced by a transverse, opaque band, passing along the equator of each cornea, so as entirely to hide the corresponding portion of the iris. These bands were of a brownish tint, closely resembling that of the irides, about a line and a half in breadth, and gradually shaded off at their edges, leaving the upper and the lower portions of the corneæ perfectly transparent, through which an oblique view of the pupils could be obtained. These were rather small, but perfectly normal, and the patient could readily distinguish an object placed above or below the level of the eye. Except the opacities of the corneæ, no morbid appearance could be detected in either eye; and the patient stated that there had been no inflammatory symptoms during the time the dimness had been coming on.

Counter-irritation, by means of issues in the temples, stimulant applications, and mercurial frictions around the orbits, having been employed in succession without any result, I tried to remove the opacities by operation. On February 19th I carefully scraped off the epithelium from the centre of the right cornea, and found a very thin layer of hard matter beneath it. This was closely united to the proper substance of the cornea, and could be raised from it only in small flakes, and with considerable difficulty. When this opaque deposit had been entirely scraped off, the cornea beneath it was found to be perfectly transparent. The patient complained of extreme pain both during and after the operation, and I applied to the denuded surface a drop of castor oil, which I have always found to be the most soothing application in those very painful cases in which the epithelium has been scratched or roughly stripped off from the surface of the cornea.

By the 1st of March the irritability of the eye had subsided, and the spot where the opacity had been removed was covered with new and perfectly transparent epithelium.

[In the following week Mr. Dixon repeated the same procedure on the left eye, the result of which was a very great improvement of vision, and a

restoration of the cornea in front of the pupil to its almost perfect transparency. The fragments removed became opaque when dry, like those in Kemp's case, and, on being chemically tested by Professor Taylor, were found to consist principally of lime, either in the state of phosphate or sulphate.

CASE K.—*Penetrating wound of globe, followed by destructive inflammation in that eye, and considerable damage to the other: illustrating one variety of corneal opacity.*

(From the notes of my friend Dr. GRIEVE.)

Aug. 3d, 1846.—F. G., æt. 42, a poor woman, reduced in health and spirits by repeated ill usage on the part of her husband, received a blow on the *left* eye from a teacup, which he threw at her in a state of drunkenness. The wound bled profusely, and was very painful. No treatment was pursued for ten days, when she applied at the London Ophthalmic Hospital. There was a penetrating wound, half an inch long, through the sclerotica and choroid on the outer side, and a clot of blood behind the lens, which remained transparent. The iris was adherent to the lens on the side of the wound, and she was totally without sight in that eye.—Active treatment being out of the question, Mr. Bowman applied a blister and fomentations.

13th.—The wound is healed, with only a slight collapse of the globe. The lens is transparent, and there is a slight glimmer of light. She is suffering from poor diet, and anxiety about her children.—She now took quinine and better fare, and improved considerably in health, but the eye got no better.

Sept. 24th.—Lens opaque towards the outer side, where the iris adheres; iris turbid; vision almost entirely gone: she can just distinguish where the window is, and a hand passing across. Much pain in the eye.—Hirud.; Mist. Ferri C. ʒj. bis die.

Oct. 8th.—The lens now opaque.

15th.—The anterior chamber appears to be encroached upon by the iris, which is pushed forwards, probably by the deposit of lymph on the ciliary processes. The *right* eye has been getting dim for a fortnight. Its cornea is now covered in the central region with minute circular specks. The pupil is bordered with a black rim of *uvea*, and the contiguous part of the capsule seems muddy. Under the influence of atropine the pupil dilates, leaving, however, on the front of the lens a circular line of dirty-looking lymph, corresponding to its former position. Vision is improved by the atropine, as the cornea is clear except in the centre. She is very feeble and depressed.—Rep. Mist. Ferri C.; Ext. Belladonnæ supercilio dextro.

22d.—Right lens now perfectly clear; specks on the right cornea as before. The left cornea presents large spots of opacity, like mould-spots.—Lot. Aceti.

Nov. 12th.—The left cornea is now almost completely obscured by opaque deposit of the same kind as before, but in larger flakes. The sight of the right eye is much impaired: though this lens is clear, the cornea is still studded with a dense cluster of very minute but distinct round spots as before.—Rep. Capt. Ammon. Carb. gr. v. bis die ex Infus. Gent. C.

Dec. 3d.—The opaque deposit has disappeared from the left cornea. The pupil is full of lymph, and the lens bulges forwards, with great pain.—S. Quin. Disulph. gr. ij. bis die. Hyd. c. Cret. gr. ij.; Pulv. Doveri, ℈ss. o. n.

Jan. 21st.—There is less pain, but she still suffers much in the night.—℞ Potass. Iodid. gr. iij.; Decoct. Sarzæ, ℥ij. bis die.

Feb. 18th.—The *left* eye is now in a quiet state, and without pain. The overcharged vessels are all diminished in size. The pupil is still occupied by a *yellow* mass, which seems to be the lens covered with a layer of lymph, which is indisposed either to be absorbed or to become vascular. The margin of the pupil, however, adheres to it, and seems to send a few minute vessels a very little way into it. Vision is, of course, entirely lost in this eye.

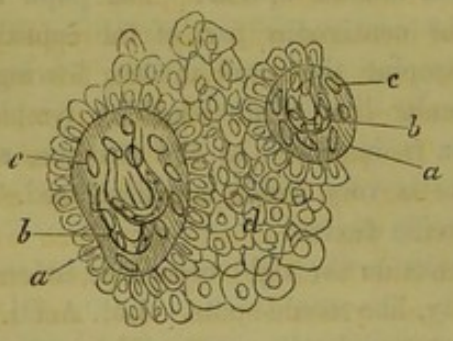
The morbid changes in the *right* eye seem to be at an end. The cornea is still dotted with dark brown and very small circular specks, not very obvious without a glass, and the deeper textures are probably impaired, for she cannot see small type, or to thread a needle. General health much improved.

She continued in attendance for several months after this, but no further change occurred in either eye. It was impossible to ascertain with certainty in what part of the corneal textures the minute specks above described were situated.

Case L.—*Warty opacity of the cornea, relieved by operation.*

July 13th, 1848.—Mrs. Goldsmith, æt. 38: has an old-standing prominent opacity of the right cornea, lying in a transverse position just below the centre, and extending completely across, corresponding to the interval between the lids. The iris is adherent to it. It followed a severe ophthalmia four years ago. The lids seem to have moulded the opacity, for it ceases abruptly above, at the line which the margin of the upper lid forms when partially closed, and this lid in passing down over the cornea seems to be stopped by coming against the prominent edge of the opacity. Its surface is rough, like that of a soft corn. Its prominence seems to fret the lids, and keep up chronic inflammation. She has been in attendance for a year or more, and finding no benefit from various stringent applications, I about six months ago shaved off a very thin layer from the surface, expecting to find papillæ developed, as in the case of a similar looking opacity in the eye of an animal which I had examined, but I could see nothing but thickened epithelium.

Fig. 37.



Horizontal section of a warty opacity of the cornea. *a a*, basement membrane. *b b*, capillary loop. *c c*, nuclei within papillæ. *d*, conjunctival epithelium. Magnified 150 diameters.

To-day she presents herself with the opacity as above described. She thinks the removal of the former portion has diminished the prominence, and I think so too. I have therefore now sliced off

the opacity down to the level of the healthy cornea. The cut surface bled at numerous points (blood oozed from the whole cut surface); and when I examined the slices under the microscope, I found them to contain a great abundance of papillæ, which had, of course, been cut across: many of these had still blood in their vessels. The epithelium was very thick about them and over them, and they had not been reached in the previous operation. The interior of the papillæ consisted of blood-vessels and an obscure tissue, with many nuclei (see fig. 37). The operation gave her very little pain. No nerves were seen by the microscope.

Oct. 5th.—The part is much flatter, and her sight is improved.

CASE M.—*Phlebitic ophthalmitis after amputation: with an account of the post-mortem examination of the textures of the eye; and remarks.*

(This case appeared in the London Medical Gazette of October 30, 1846.)

Early in August 1846, in consequence of Mr. Simon's absence from town, I assumed the care of a young man, whose leg he had amputated about ten days previously, on account of disease of the ankle and tarsus.

The case was going on unfavourably: there had been a shivering fit on the fifth day from the amputation, followed by decisive symptoms of inflammation of the veins of the stump, advancing even above the groin. He was already in a state of high irritative fever, with a sallow and exhausted countenance; and on the 5th he was attacked with diarrhœa, which required starch and opiate enemata, with small doses of gray powder and Dover's powder. This symptom soon ceased, but bed-sores were appearing, and he had repeated rigors, with parched tongue, very rapid pulse, a hot skin, and an anxious and sunken look, which indicated serious internal disease. The stump itself was meanwhile assuming a more healthy action, and the ligatures had separated; yet there was some projection of the bone, in spite of our efforts to prevent it.

On the morning of the 6th he complained of his left eye smarting and aching, and it appeared to be affected with slight catarrhal ophthalmia. There was superficial redness, with mucous discharge. Alum lotion was applied.

On the following day the inflammation had increased with frightful rapidity: there was excessive florid chemosis, partly concealing the cornea; the lids were turgid, and the eye wanted none of the characters of a severe attack of purulent ophthalmia, except the purulent discharge. The pain in the globe was of an aching darting kind. The cornea remained clear, but the aqueous humor and iris were muddy, and sight was totally lost. The chemosed membrane was scarified, and four leeches were applied, which had the effect of speedily reducing the scarlet colour of the conjunctiva to a pale yellowish-pink tint, and the chemosis became of that sort which is known as "serous." This speedy change was accelerated by his weakened state, and showed that active depletion was inadmissible. Fomentations were then applied. The general treatment was continued, with an opiate at bed-time.

On the 8th, dull pain in the eye continued, and the chemosis had increased

and projected between the lids, but was pale and serous. The cornea had become cloudy, the chambers were yellowish, the iris obscured by lymph, the pupil occupied by a yellow mass of lymph, which looked like an opaque lens. The lids had become less œdematous, so that the condition of the interior of the organ could be more exactly noted. Meanwhile the local symptoms of phlebitis in the stump were on the decline, and the stump assumed a more healthy aspect, the bones still protruding slightly. But the rigors now recurred daily, with considerable regularity, attended with much exhaustion; and about the 15th he was seized with pleurisy of the right side, for which he was blistered, and took a grain of calomel with opium every four hours for two days. At the end of this period the pain in the side had nearly subsided, and (what is interesting) the lymph was absorbed from the iris and the pupil, which resumed very nearly their natural appearance, the latter only remaining rather turbid. He had lost almost all pain in the organ, and the morbid action within it seemed entirely checked. Some pale chemosis remained, but the cornea was clear, and the globe wore no appearance of internal suppuration. All pain in the organ had likewise ceased.

On the 20th he died, after an aggravation of the symptoms betokening internal phlebitic abscessses.

I examined the eye before twenty-four hours had elapsed, and had appointed an hour for the inspection of the rest of the body; but this was unfortunately prevented by the interference of the friends.

The following is the result of a careful and deliberate examination of the eye itself.

The *iris*, seen through the transparent cornea, was clear green, without lymph on its surface, but firmly adherent by its entire posterior surface to the capsule of the lens, which presented only a partial opacity near its centre. This posterior synechia and opacity of the capsule appeared of old standing (and the patient had stated that this eye had been a poor one, and vision imperfect with it for many years).

The *lens* itself was *perfectly transparent.*

Under one of the recti, immediately behind its insertion, the sclerotic (and also the choroid) was much bulged, and so distended as to be almost giving way, evidently by pressure from within. It formed what would have been termed, from its shape and circumscribed figure, a staphyloma scleroticæ. In order to ascertain its nature, I carefully cut all round it through the sclerotica only, and in detaching this coat I found that it was extremely thin, and its fibres as it were unravelled at the apex, where also the choroid was adherent to it by a film of recent lymph, and, like the sclerotica, distended from within. The outer surface of the choroid was perfectly natural, except at the apex of the swelling. On now cutting through the choroid, a whey-like fluid, with particles of lymph floating in it, escaped in abundance; and I found that this effused fluid was filled with nucleated and other irregular granules, hanging together in little masses, and resembling lymph rather than pus. In this turbid fluid there lay loosely a great number of smooth, round, or oval beads of soft yellow lymph, of every size up to that of a rape-seed, and these consisted of an agglomeration

of nucleated lymph-particles, with many shapeless granules in the connecting material. Scarcely any fibres could be discovered. I emptied the cavity between the choroid and retina, in which this effusion had collected, by syringing it under water, and the inner surface of the choroid then exhibited a coating of yellow lymph, which appeared to be deposited not merely on the surface, but also in the interstices of the capillary network which lies under the epithelium forming that surface; almost all trace of this epithelium (the "membrane of the black pigment" of Mr. Wharton Jones) being lost. The vitreous humor, in its enveloping hyaloid membrane, together with the broken remains of the retina, had been thrown by the effusion to the central part of the globe, where they occupied only about half their natural space. The retina was not at all coated with lymph, and its capillary network was perfect, but the nervous substance was in a great measure destroyed, as though macerated; yet what remained exhibited the characteristic elements of the nervous substance of that part. In particular, I discovered several well-marked examples of the *caudate nerve-vesicles*, which I had never before unequivocally seen in that membrane, although strongly suspecting their existence. Jacob's membrane was nowhere visible.

The hyaloid capsule (that homogeneous glassy membrane which forms the outer covering of the vitreous humor, and in the adult eye shuts it off, as the capsule does the lens, from the capillary blood-vessels of surrounding parts, and constitutes it a non-vascular texture)—the hyaloid texture, was everywhere entire, but thrown into innumerable minute folds, in consequence of its collapsed form. A good many lymph-globules were accumulated on its exterior in certain parts, and the nuclei naturally present on its inner surface were very distinctly visible. But what I wish specially to notice was the state of the vitreous humor itself. This highly delicate structure, from its transparency and exquisite texture, displayed with remarkable clearness themorbid changes that had been taking place within it. In a state of health the vitreous body presents no corpuscles, but here every part of it was turbid and cloudy, from a finely granular and amorphous deposit in its substance. This deposit might be supposed to be a simple coagulation of albuminous matter; no trace of organization could be detected in it. But, in addition to this, there were disseminated through the vitreous humor innumerable nucleated cells, like those of the lymph already described. These nucleated particles were much more numerous immediately within the hyaloid capsule, in the superficial portions of the vitreous humor, than towards its centre, where they very gradually ceased. They were all distinct from one another, placed apart in the vitreous tissue, and had everywhere the same appearance and size. Mingled with them, however, were several smaller, more granular, and irregular particles, which might be in process of development. I could perceive no appearance indicating a multiplication of the particles by splitting or division. In the central part of the vitreous humor there were none of the nucleated particles, but in the neighbourhood of the optic foramen and yellow spot, and particularly near the ciliary processes at the border of the lens, and near its posterior surface, they were so abundant as

to render the vitreous humor perfectly opaque and yellow: yet even here they only differed in number from those found elsewhere.

Remarks.—In this case the death was consequent on phlebitis and secondary inflammation, and probably suppuration of the viscera. The course of the symptoms, and especially the attack on the eye, render this as certain as can be, in the absence of an examination of the internal organs. By a reference to the recorded cases of destructive inflammation of the eye in such circumstances, their course will be found very variable, both in duration and severity. In some the eye has gone rapidly into general suppuration and discharge of the contents of the globe; in others, the organ has retained its figure, and the inflammation has been checked, after it has destroyed the integrity of the most important tissues.

The place at which the globe gives way under a distending force from within is well illustrated here. By exact examination it will be found that the sclerotica is thinner immediately behind and under cover of the insertion of the tendons of the recti than at any other points, these tendons grooving the fibrous coat slightly before their actual insertion into it. The bulge of this tunic was precisely at one of these weak points in the present case; and I believe it will be generally found that suppuration of the globe (not a consequence of conjunctival or corneal inflammation) will discharge itself in a similar situation. I have heard of the sclerotica being opened at this point by incautious use of the scissors in the operation for strabismus.

The principal seat of the effusion of lymph in this case is very interesting to notice, if we bear in mind that the choroid membrane, from which it seems to have proceeded, has its capillaries on its inner surface; its arteries, and especially its ample veins, on its outer surface. The effusion was on the inner surface, and clearly from the capillaries: the arteries and veins forming the outer surface were quite healthy; there was not a particle of lymph about them, except where the tunics were giving way.

The deposit was of lymph—of lymph consisting of little else than nucleated cells, which formed masses of rounded shape, floating in a turbid serum. It may be supposed that those which had been effused from the surface of the iris under the mercurial action were of a similar kind.

The capillaries of the retina, and the nervous tissue of the retina, though to some extent macerated and disorganized by the contact and pressure of the effusion within the choroid, yet did not appear to have any lymph adhering to them, or to have themselves exuded any.

The presence of the nucleated lymph-particles in the tissue of the vitreous humor within the homogeneous hyaloid membrane which separates the vitreous humor from the contiguous capillaries, seems to me a fact of great importance to the question of the source and mode of formation of such effusions. The opinion that pus is absorbed from suppurating surfaces and carried by the blood-vessels to distant organs, and there deposited anew, is one which, however it may seem, at a cursory glance, to explain the phenomena of "secondary

depositions," yet will hardly bear a rigorous scrutiny. How can pus or lymph-globules be absorbed by vessels which certainly have no open mouths? And how, admitting such globules to be in circulation in these cases, could they get out of the capillaries, and find their road, as here, through a homogeneous membrane such as the hyaloid, into the interior of the vitreous humor? The anatomical conditions here present seem demonstrative that these nucleated cells, lymph-corpuscles, or exudation particles, were formed at the spots at which they were found, from effusion, strictly fluid, through the capillary wall, the hyaloid membrane, and the vitreous tissue. It is interesting to observe that their relative numbers were far greater in those parts of the vitreous humor where it may be presumed that the ordinary processes of nutrition are carried on the most actively, and especially between the ciliary processes and the lens.

We see, in this instance of the morbid products of inflammation occurring in a non-vascular part, decisive proof of the possibility of real inflammation arising in that class of structures without their having vessels, and without their becoming vascular; and we find proof, also, of the subordinate or ministerial part which the blood-vessels play in inflammation—of their being, in reality, the channels only of the supply of that fluid, a certain change in the constitution of which forms the essential condition of the process. But of course where large masses of vascular tissues are inflamed, the blood-vessels must share largely in the production of the resultant phenomena.

CASE N.—*Ophthalmitis, similar to that of the last case, but not so clearly of phlebitic origin, accompanying extensive inflammation of the heart and brain.*

A. B., a medical student, who had been the subject of severe rheumatic fever when a boy, and continued to have a diastolic bellows-sound over the cardiac region subsequently, though otherwise in apparently good health, began to feel indisposed in the commencement of August, 1847. There was nothing, however, to alarm him, or to induce him to abandon his ordinary pursuits, and he even undertook to dress some patients for a friend on the 26th of the month, when he was seized on the 27th with sickness and diarrhœa, with much depression. The diarrhœa continued for four days, and then ceased. It was attended with great exhaustion, and a dry, furred tongue, and it was feared he might be suffering from the typhoid fever then prevalent. Saline medicines, opiate enemata, fomentations, and, on the 30th, ammonia, were employed.

On the 28th he discovered that the sight of the left eye was impaired, and on the following day he could not distinguish light from darkness. All this was without any scintillations, or other symptoms of retinitis, as ordinarily described. He had, however, some dull, deep-seated pain in the globe, but not extending to the brow or head.

On the 29th twelve leeches were applied round the eye. They relieved the pain for a short time, but the blindness was complete; and on the 30th a blister was applied to the temple.

On the 31st I was requested to see him, in consultation with Dr. Todd and Mr. Bloxham, with regard to the state of the eye. I found him totally amaurotic in this eye, in which he still complained of a dull, deep-seated, beating pain. The pupil was half dilated, almost immoveable. The humors quite clear. No morbid appearance in the tissue of the iris, which was of a dark brown. Slight conjunctival and sclerotic injection. The pulse was above 100, and had rallied under the ammonia. Tongue dry and brown. Some tenderness of abdomen over the region of the colon. A *bruit de soufflet* was heard over the heart, probably such as was known to have previously existed. Considering his prostration, which was such that he was unable to walk, and also the state of the bowels, it was a question whether to give mercury, though the state of the eye seemed so imperatively to demand it. It was agreed to rub in mercury, and to apply four leeches to the eye, with fomentations, and to continue the ammonia, with beef-tea, &c.

Sept. 1st.—The pain continues in the eye, though mitigated: more injection of the conjunctiva, and disposition to chemosis. The margin of the pupil slightly irregular, otherwise the eye appears the same; the general symptoms are the same.—Ext. Bellad. ad frontem. Rep.

2nd.—A more sunken countenance; the eyelids somewhat swollen; decided serous chemosis, overlapping the cornea a little. Humors clear. Iris apparently natural, except that the pupil is puckered. The pain in the eye as before, deep-seated and aching, not acute or intolerable, or preventing sleep. He complains of soreness and pain in the right shoulder, and on examining this and other joints, we found effusion in the left knee (query, rheumatism, or purulent infection?) It was deemed well to continue the inunction, as no mercurial action had yet manifested itself. Two glasses of sherry, beef-tea, arrow-root, a blister to the knee, and behind the ear.

3rd.—To-day more prostration. Tongue coated, moist; pulse 120; weaker. Has wandered, and slept little. More serous chemosis, projecting a little between the lids, which are swollen, but allow us just to see the cornea. This is clear, and so is the aqueous humor. The lens has a pale, milky tinge, especially at the border of the pupil, which is irregular. Front of the iris natural. Pain in the eye not severe. Total blindness continues in this eye. The mercury has produced very slight soreness of the gums. He complains of some pain about the base of the chest, and catches at the breath. A friction sound over the heart. The lungs everywhere pervious. The effusion in the knee has disappeared. Is so low that he must omit the mercury.—Capt. Quin. gr. ii. 4tis horis, c. Tr. Opii, ♏ v.; Morph. Acet. gr. ½, horâ somni; Empl. Lyttæ lateri; port wine ʒx.; beef-tea.

4th.—Pulse stronger, 120. Has had no sleep; tongue brown and dry; less pain in the chest. A limited rubbing sound over the pericardium; still complains of the shoulder. The chemosis has disappeared; the sclerotica being still dull with vessels. Pupil fixed; lens more milky; mouth not sore.—Rep. omnia; Pil. Hydrarg. gr. v. h. s.; Bellad.

5th.—I did not see him, but no particular change occurred. The opium and

quinine were discontinued, and ammonia with more wine given. There had been delirium.

6th.—In the morning about nine o'clock he became quite incapable of recognizing any one, but lay in a low muttering delirium. Pulse from 130 to 160, very feeble, and unequal. Constant profuse perspiration. Bowels since yesterday have been repeatedly moved unconsciously. A rubbing sound is still heard over the heart. The pupil is occupied by opaque milky effusion. The chemosis is gone, and there is much less redness.

He is now having wine and beef-tea every half hour, and takes it pretty well.

After this he continued delirious till his death, which took place at about ten o'clock next morning, being the 12th day of his acute disease.

Examination twenty-seven hours after death.

Chest.—Lungs natural, except slight recent adhesion of the right where overlapping the pericardium. Pericardium distended with several ounces of turbid, flaky serum. The entire surface of the pericardium and heart covered with mossy fibrine, in most parts drawn into threads half an inch long, but over the pulmonary sinus of the right ventricle, and at the base of the left ventricle behind, it was thicker, and formed a closer pile. The heart was hypertrophied. One of the aortic valves was perforated by a large hole, with smooth, though irregular and tuberculated edges. This seemed to be in part at least an old diseased condition, and was, perhaps, (together with the hypertrophy) assignable to the old attack, of which mention has been made. But, besides this, there was on the semi-lunar valve, corresponding to the mitral valve, a large mass of ragged tuberculated fibrine; and, in continuation of this, down upon the flap of the mitral valve, another still larger, which almost concealed this flap. The central part of this was so ragged that the valve seemed to be destroyed, and on looking at the opposite or auricular surface, a corresponding, but smaller spot, covered with fibrine, was seen. The valve was, in fact, perforated here, and the aperture occupied with loose, soft fibrine. The lining membrane of the heart, except at these points, was natural.

Abdomen.—Natural.

Head.—The arachnoid natural on its free surfaces. Underneath, on the surface of both hemispheres, in the tissue of the pia mater, chiefly in the sulci, an abundance of recent pale yellow lymph. Much, also, at the base; and, in the fourth ventricle, half a drachm of creamy pus. No ulcer or abscess. Sinuses healthy. Substance of the brain healthy.

Left eye.—All chemosis and outward redness had subsided, and the globe looked very much as the other, except that the pupil was rendered opaque by an effusion of lymph, adherent to its border, and to the capsule of the lens. The front of the iris had hardly lost any of its brilliance: the aqueous humor was clear, and the cornea transparent. On dissecting the outer surface of the eyeball, the areolar tissue contiguous to the sclerotica was found in some parts thickened, and rendered semi-transparent by the effusion which had attended the external inflammation.

The *optic nerve* was itself natural, but its sheath, for half an inch nearest to the globe, was distended with clear serum, in which floated a few nucleated cells. This effusion gave the nerve a bulbous and semi-transparent appearance. It could be made to gravitate from side to side, because it did not tightly distend the space it occupied around the nerve. It lay in the large meshes of the peculiar tissue intervening between the external layer of the sheath and the nerve.

On carefully opening the sclerotica, the *choroid* was found everywhere in contact with it, and apparently healthy. The vessels and nerves on its outer surface seemed as usual. The ciliary muscle also natural. But the moment a puncture was made in the choroid, a turbid yellow serum, with small flakes and granules, escaped. This effusion lay between the choroid and retina, which latter was thrown somewhat inwards upon the vitreous humor, and lay in folds. The quantity of fluid altogether may have been about 20 minims. It coagulated by heat. On examination under the microscope, it was seen to contain—(1), small masses of granules, very like the agglomerated granules of the retina; (2), many exudation-corpuscles merging into pus-corpuscles; and (3), much amorphous, finely-granular matter. Nothing like the particles of Jacob's membrane, or fragments of them, could be found in it. The cavity in which this effusion lay extended in a forward direction only as far as the *ora serrata*, in front of which the ciliary processes of the choroid adhered naturally to the vitreous body. Backwards, it did not reach the point of entrance of the optic nerve, being limited by a quantity of yellow lymph (with pus in its centre), disposed in a layer 1-12th of an inch thick, uniting the choroid and retina, but most intimately adherent to the latter. The inner surface of the choroid, in contact with the effused fluid, was everywhere coated with lymph, which gave it a mottled aspect, and varied in quantity at different parts. None of the pigment seemed to be detached, and the lymph appeared to lie on the retinal surface of the choroidal epithelium. The choroidal was somewhat thickened, and tore more readily than natural. It also contained more blood than usual.

The state of the *retina* was very remarkable. When exposed to view, by the removal of the effused turbid serum already described, it appeared everywhere entire, and of its natural texture, except near the optic nerve, where, as above mentioned, a considerable mass of lymph adhered to it. The retina, however, exhibited throughout its whole extent either isolated or confluent specks of ecchymosis, which were so abundant around the optic nerve as to give to that part of it a nearly uniform crimson tint, but none existed over the extremity of the nerve, where it is seen within the globe. These ecchymoses all lay in the substance of the internal or vascular layers of the retina: seen from within, they were very vivid: seen from the outside, they were fainter and bluish, being covered by the non-vascular layers or portions of them. When the retina was afterwards dried on a sheet of glass, they continued to be strikingly obvious.

I carefully examined the structure of the retina when fresh, with the view of ascertaining the changes which the inflammation might have occasioned in its elementary tissues. I could discover no trace of the elements composing Jacob's membrane, which had apparently been all dissolved or destroyed by the contact

of the effused fluid. But the granular layer, the gray nervous layer with the delicate filaments contained in it, and, above all, the caudate nucleated globules, were all visible, and nearly in their natural state, though falling asunder too easily. The caudate corpuscles had all the characteristic appearances of these structures elsewhere: they were small and numerous, and much more readily seen than in the fresh and healthy retina. In fact, they strewed the field of the microscope, among the rest of the debris of the membrane. Numerous exudation corpuscles were likewise intermingled.

The retina was adherent to the hyaloid as usual: no effusion separated them. On removing the retina, some little of the extravasated blood rested in points upon the surface of the hyaloid.

The *vitreous humor* was diminished in size, of rather firmer consistence than natural, and of a green straw colour. Though mostly semi-transparent, it was in some parts (viz. at the bottom of the eye, and on one side, near the lens), of an opaque yellow colour, from a denser effusion of lymph into its substance. Under the microscope it was seen to contain multitudes of minute amorphous granules, with very numerous nucleated particles, like those in the fluid effused between the choroid and retina, and evidently of inflammatory origin. These were most numerous where the opacity was densest, and on their presence the opacity manifestly depended. The hyaloid membrane was entire, and no trace of capillary vessel or red blood-corpuscle could be found in the vitreous body.

Finally, the *lens and its capsule* preserved their transparency, if we except that portion of the capsule which occupied the pupil. This part of it was rendered opaque by a film of lymph which covered it, and adhered to the margin of the pupil; and it was not a little remarkable that this lymph did not fill the posterior chamber, so as to glue the uvea to the lens, but that aqueous fluid intervened as usual between these parts, and their surfaces were free and healthy. The lymph on the capsule was limited to the area of the pupil, and by its adhesion to the border of the pupil, shut off the posterior chamber from the anterior.

CASE O.—*Cataract of 5 years' standing, relieved by spontaneous depression of the lens, vision remaining.*

May 24th.—Wm. Rogers, æt. 65, a hale man, has had cataract in the *right* eye for 5 years. The lens is tremulous, and so is the iris. The cataract is apparently hard, and in the substance of the lens only. More recently the left lens also has become opaque; but he can still see his way about, with the aid of Belladonna. Both irides are active, and there is no obvious cause to account for the cataracts. Gutt. Belladonnæ, bis die.

June 28th.—In exactly the same state. Rep. Gutt.

July 19th.—He states that his sight is greatly improved in the *right* eye, so that he can see large objects. On examination, the right lens, which was previously in the axis of the eye, is found to have disappeared from the pupil, but when the pupil is dilated, the upper border of the lens can be just discerned be-

hind its lower edge. In fact, the cataractous lens, before partially loosened, has now dropped down, as if it had been couched. He suffers no pain or uneasiness: there is no inflammation, and with a cataract glass he can see to read a printed page.

I saw him again in August and September, when the condition remained precisely the same, and nothing was attempted on the other eye.

CASE P.—*Spontaneous depression of a cataractous lens, from loosening of the suspensory ligament and softening of the vitreous humor.*

22d November, 1848.—Mr. T. M., æt. 78, a very intelligent old gentleman, now in reduced circumstances, of active and regular habits, was told by Dr. ——, at 20, that he would die of consumption, and he has been ailing all his life, and has now some chronic cough.

He was near-sighted from the age of 15: wore spectacles, and his near-sight diminished. About 40, he began to have little black specks (intensely black) flying before his right eye when he looked at any light object. These continued very gradually getting worse, but did not much annoy him. They were spots and filaments flying about, but he could still "make shift" to read with this eye, till nine years ago, when, on getting up one morning, he thought the right side of his nose was black, till, on going to the glass, he was undeceived. As the day advanced, the obscurity increased: spots and a network, much more than previously, appeared, and at night he was *quite* blind, and has so continued since, with that eye (the right). This attack was not attended with any pain or appearance of inflammation. The eye looked as well as ever it did. He was attended by an eminent oculist in London.

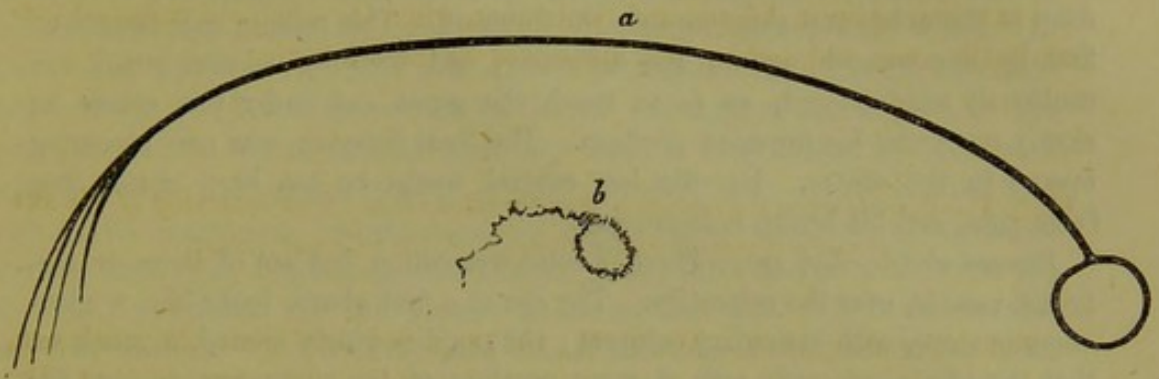
About a twelvemonth afterwards, the lens turned of a pearl colour rather suddenly, *i. e.* in the course of a few weeks, and when this opacity had become fully established for a week or two, having taken a blue pill over night (this is his description), the next morning he was surprised, on going to shave, to find the cataract totally gone, though of course he continued blind.

This right eye has now very much the natural appearance, except that the pupil is fixed at about one-sixth of an inch diameter. On looking, however, carefully through the pupil from above, *the upper edge of the vanished lens is perceptible behind the iris*, having sunk down in nearly the same position as was mentioned in the last case.

Such is the state of the right eye, but he comes for advice regarding the *left*. He says that eight years ago, or shortly after the total blindness of the other, a film and spots appeared in the left. The film, as it then appeared, he represents as an arched line with a circle at one end, and a small brush at the other, appearing suddenly, and extending horizontally across a surface of about two feet in width. (Fig. 38, *a*). It gradually diminished, and in a few days had contracted itself into a fainter and smaller line, having the same general shape, and still

terminated by a circle. Thus it still remains. (Fig. 38, *b*). He has no pain, and only fears it may get worse.

Fig. 38.



Appearance of fixed muscæ. (Case P). *a*, First appearance; *b*, The same after eight years.

Present state of left eye.—With the pupil (which is active) contracted, no morbid appearance. With the pupil dilated I see a faint yellow film moving or glancing behind the lens according to the motions of the eye. The film is very small (the size of a large pin's head), with a string attached. It seems to shoot up from the lower and inner side, on any sudden turn of the eye, as far as opposite the middle of the lens, and immediately falls again when the eye is tranquil. The vitreous is of course so far fluid as to allow of this; but the tension of the globe is natural. The lens is slightly greenish, without striæ. The three images are seen, but the inverted one is not quite so distinct as it ought to be.

He sees to read very fairly with this eye.

Case Q.—*Spontaneous dislocation of the lens into the anterior chamber, probably from previous loosening of the suspensory ligament.*

A gentleman of middle age, tall, and of good constitution, was brought to me by a surgeon, and I gathered the following particulars of his previous history:—

Eighteen months ago, one eye was noticed by his friends to have something odd about it, different from the other; at the same time he could not see in shooting so well as before,—was "bothered," and could not tell the distance. There was no inflammation or pain, and he took no particular heed of it. He appears, however, to have had some unusual irritability of the eyes, and subsequently some trivial ophthalmia at times, till about five months ago, when after a few weeks' indisposition in the eyes, for which he took no advice, he was seized one morning on waking with severe pain in the left eye. The pain was intense, and deep seated in the globe, not in the orbit or brow. No scintillations. The pupil was widely dilated and fixed, and it was irregular, being more dilated on one side. He was actively treated for the inflammation, with leeches, blisters, and mercury, and found the eye somewhat better in the course of some weeks, but he was much reduced by the treatment. The sight, however, was nearly

gone. He could see large objects, if in motion, or the window. He now came under the care of an eminent oculist, who put him on a tonic plan by which he was regaining strength, when he was overwhelmed by a sudden and severe recurrence of the inflammation in all its violence. The pain was most excruciating, deep in the orbit, and shooting into the forehead. This relapse was treated at first by dry warmth, opium and antimony, and then by calomel, which was cautiously administered, so as to touch the gums, and under this course he slowly recovered his previous position. The lens, however, was now becoming opaque in the centre. For the last several weeks he has been almost free from pain, and his health is improving.

Present state.—Left eye.—There is some congestion, but not of large or tortuous vessels, over the sclerotica. The eye at a first glance looks like a glaucomatous eye, with secondary cataract: the pupil is widely dilated, so much so, that the iris is not easily seen at some portions of the circumference, and the central part of the lens is of a whitish, semi-opaque colour. On nearer examination, however, aided by a glass, throwing a strong light upon the organ, the lens is seen not merely advanced, but in actual contact with the cornea, and its margin very decidedly *in front of the iris.* The circumference of the lens preserves very nearly its natural transparency, and its extreme margin, in favourable lights, appears as a glistening, yellow, golden line, leaving no doubt as to its position, for both on the inner and outer sides the iris can be seen behind this bright edge. The cornea is quite clear. The eye is somewhat irritable, and readily waters. Sight almost gone. He can, however, see the fire and the window sideways, especially if they lie towards the outer side of the field. He can also see the passing of a large object between the eye and the light.

Right eye.—Sight excellent, even for the smallest objects. Every visible part of the organ, carefully examined, appears perfectly healthy.

Though much reduced by treatment, and sallow, he thinks himself sound and substantially in good health, and of good constitution. He is not a gouty or rheumatic subject. His friends fear that the state of the eye may depend on some cerebral disease (of which, however, there is no sort of indication), and that the other eye is in jeopardy.

[Since the above was in type, the professional friend with whom I had first seen this gentleman, was so obliging as to procure from him a statement of his symptoms from the commencement of his illness, so far as he could himself relate them; and as the account is a graphic one, I append it. The italics are mine:—

"In the fall of the year 1847, while resident in London, I had a severe attack of influenza, which was attended with a *bad cough.* Shortly after this the sight first became slightly imperfect, and *a rim was observed round the pupil of the eye* by a gentleman sometimes in my company. About this time I went on the Continent (Feb. 1848); the sight apparently strengthened by the cold weather which had intervened. As soon as the warm season set in it became weaker every way, which, as *I was still free from pain,* I considered to arise from the constant view of the sands on the coast, the yellow-washed

houses, the glare of the sea, and the additional glare of the sun. *By degrees it became difficult for me to identify a friend across the street*, or even the joint of meat which was necessary to be carved. No measure was taken by me to remedy the evil; being unaccustomed to illness generally for 55 years, I trusted to my constitution and the next winter, to bring matters right again. In October of that year (1848) a cold seemed to strike the left eye more particularly; the pupil felt tender to a fearful degree, and a great deal of redness was manifested in the corner farthest from the nostril. I shut the eye and read with the other, not yet resorting to advice. In about ten days the pupil lost part of its brightness, *looked irregularly shaped*, and, upon trying the vision, for the first time, I found it was almost gone; *there was a mist before me*, though I could just see the ground under my feet with it. I then became seriously alarmed. The next morning *intense pain* commenced, not in the head, but in the back of the eye, which lasted about twenty-four hours. Leeches having been applied, and all other remedies which the medical attendant deemed best, at the end of a month or so, the inflammation, and the congestion which followed, appeared greatly overcome. I was allowed to go out for a walk: the sight, however, *continued defective;* it was in my power to see across a room, and to discover a picture hanging on the wall at the other side, but not to distinguish the design. I could see also the surface of a table, but no small object upon it. I then paid a visit to England to obtain first-rate advice; and under the care of the oculist, and from the change of air, my strength improved very fast indeed; but there was no move for the better in the eye, nor any for the worse: *the feeling to myself was constantly that of something sticking in it.* Having incautiously exposed myself to the wet while walking, a *second inflammation* came on, which was pronounced to be rheumatism—dreadful pain for forty-eight hours; the eye-ball, however, did not become so very tender in this case; the evil seemed to dwell more in the socket, extending at times (and for the first time) up the nerves of the forehead. While under treatment for this new enemy, the *sight of the eye failed altogether*, a cataract having been formed at the end of a fortnight from the commencement of this second attack. It is right, perhaps, to mention that I could distinctly perceive the fire out of one corner of the eye for some time after its formation. ..... 16th March, 1849."]

CASE R.—*Loosening of the suspensory ligament of the lens in both eyes. Dislocation of one of the lenses into the anterior chamber. Singular mobility of the other, by which it falls out of the axis of vision in certain positions of the head, but yet retains its transparency.*

The following very remarkable, and, in some respects, I believe, unique case, is still to be seen at the hospital, and has excited the interest of many medical men:—

19th June, 1848.—John Bennett, æt. 26, of slight make, pale complexion, light hair, and blue irides, comes to-day with the left eye much inflamed, and gives the following account of himself :—Having had excellent sight with both eyes, (though habitually short-sighted), he was walking quietly along the street a fortnight ago, when he found the *left eye* beginning to shoot and throb, and water very much, and his sight became affected, so that he could no longer see anything distinctly with that eye. The organ then became inflamed, and very painful, so that sleep was impossible; but as circumstances compelled him to continue his employment (of picking coffee), he did not apply for advice for a week, hoping it would get better. The pain, however, got worse, extending to the brow and forehead, and becoming quite excruciating. He then saw a surgeon, who blistered him, and surrounded the eye with ointment (probably mercurial).

Appearances.—The *left globe* is tense to the touch, and the anterior portion of the sclerotica is stretched forwards, so as to give the eyeball a conical form. All this part of the sclerotica is of a dull red colour, loaded with congested vessels, and about the eighth of an inch from the cornea the dark hue of the choroid dimly shows through. The cornea is quite bright and clear, but seems too prominent. The pupil is so widely dilated, that the iris is nowhere so much as one-twentieth of an inch in breadth, and the lens projects into and occupies the pupil, advancing through it, so as to fill the anterior chamber, and to be in contact with the cornea. The lens has a slight amber tint, and a narrow resplendent golden ring, apparently formed by its margin, runs round within the pupillary border of the iris. This brilliant ring is not seen all at once, but as the organ changes its position, different parts of it come into view, and the same occurs if pressure be made on one side, so as to tilt the lens a little. This sparkling, glancing appearance of the margin of the lens, makes the eye look for a moment as if it contained a particle of polished metal. It seems singular that the lens does not come quite through the pupil, so as to allow the iris to contract behind it. Instead of this, the edge of the lens seems to be engaged in the pupil, or, at least, to lie with a part of its circumference immediately behind the margin of the pupil.

There being no morbid effusion in the transparent media, I was anxious to discover what amount of sight he retained in the left eye. He can distinguish the German from the Roman text on the hospital ticket, though not the individual letters, except the small capitals at the head of the paper; and these he reads better with the help of the concave glass, No. 8. He sees best at about six inches distance.

With the *right eye* he is able to read very small type, but has to place it within six inches of the eye. This eye he considers quite perfect, but, on examination, the iris is very tremulous and flat, though it acts promptly and fully under the stimulus of light. From the flatness of this iris, one would fancy the lens must be gone, if he did not see so well.

Atropine was now applied to both eyes. It caused no change in the left, but widely dilated the right pupil. With the help of a taper in a dark corner, it was now easy to perceive the exact position of the lens in the right eye—viz.

that it is attached only at the upper and inner part of its circumference, and swings about according to the inclination of the head, so that when he leans towards the right it comes opposite the pupil, but when towards the left it falls altogether out of the axis of the eye, and disappears on the nasal side of even the dilated pupil. In this movement its anterior surface continues to be turned nearly forward. The lens preserves its transparency.

On trying the power of the eye under these different positions of the lens, what might have been expected, occurs. It is only when the lens is behind the pupil (*i. e.* when the head is upright, or bent to the right) that he can see to read small type: the moment the head begins to incline over to the left, his sight grows confused, and he is unable to read even large letters. He describes the change to be "like the flowing of water." When, however, a magnifying glass is placed before the eye, he can distinguish even small objects once more.

On the following day, it was determined in consultation with Mr. Dalrymple and Mr. Dixon, to extract the lens from the left eye, as it was obviously still causing great irritation by its displacement. The man was laid on his back, and I sat behind at his head, and with Beer's knife in the left hand made a downward section through nearly one-half of the cornea. The knife, of course, pierced the lens on its way across the anterior chamber, and a good deal of soft lenticular substance, quite transparent, escaped by the side of the knife before the section was completed. The remainder was then immediately expelled, and with it about half a drachm of aqueous non-viscid fluid, probably altered vitreous humor. This continued to trickle for half a minute, and perhaps amounted altogether to a quarter of the whole contents of the globe. The pupil was then found to have contracted to about half its previous size, and to be perfectly clear. The iris had not come at all in the way of the knife, as I had feared it might have been disposed to do. The eye was then bandaged as after ordinary extraction.

On examination, the lenticular substance was found perfectly natural, except a very slight opacity on one side, where it had been pressed upon by the pupillary border. The capsule had escaped with it.

He now went on as favourably as possible. The pain was immediately relieved by the operation. By the 6th of July the corneal section was firmly united, and he could see to count two fingers with that eye, notwithstanding a little haze of the cornea near the section.

17th July.—The eye is better; less vascularity; no pain. Is taking quinine.

31st.—Has had pain in the eye and head. The cornea is more disposed to bulge. The front of the sclerotica is more stretched, so as to disclose the colour of the pigment of the choroid. There is also a circumscribed bulge of the sclerotica at the upper and inner part between the tendons of the recti. The cornea is clear. He can still discern the fingers.

21st Sept.—The bulging of the anterior part of the sclerotica is increased, particularly at the upper and inner side. The pigment of the choroid is visible all round the cornea, making the opaque white ciliary ligament very visible.

19th Oct.—The iris appears to have lost its contractility on the left side. The bulges of the sclerotica increase. Health better.

2nd Nov.—He still sees a finger, or piece of paper, if waved before the left eye. No irritation: no pain. The aqueous humor is clear, not serous: the left globe rather hard.

March 12th, 1849.—No change has now occurred for several months. The left eye is in a quiet state: the sclerotica is irregularly distended, but not now painful, or inclined to bulge more. There is no redness or irritation of any kind. He can see the light, and large passing objects, but nothing more.

The state of the *right* eye remains also precisely as it was when I first saw the patient, nine months ago. The lens swings about according to the position of the head: it continues transparent, and he can see very small type when the head is properly inclined.

I have now to mention one other feature in this case, which appears to be of some interest, as indicating the hereditary or constitutional origin of the detachment of the lens.

This young man mentioned to me, some time after I had extracted the lens, that one of his paternal uncles, now dead, had had "the appearance of a gold ring" in his eye, which he could make to come and go. I have a written statement from another uncle relative to this appearance, which, though imperfect, makes it not unlikely that it was a looseness of the crystalline lens, which enabled the person to throw it backwards and forwards through the pupil. I have myself seen an instance in which the patient could pass the lens through the pupil at will, without its occasioning any irritation. The lens, however, in this case was opaque.

The most singular circumstances in the history of the case I have now related, certainly seem to be—first, the perfect manner in which the right lens retains its transparency, even though detached so very much from its connections; and secondly, the unimpaired condition of the deeper-seated textures of the same eye, particularly the retina.

CASES S.—*Minute central specks on the lens and cornea, corresponding with each other.*

1. James Pratt, æt. 8 months, appears to have had purulent ophthalmia after birth. At present there is an opacity (a mere point, but dense white) in the centre of the anterior surface of the capsule of the lens, in both eyes, together with a central nebulous opacity of the left cornea, and a similar one, but not quite central, of the right cornea. The opacity of the right cornea does not exactly correspond with that of the capsule, but that of the left does. The explanation of the condition in the right eye is probably this: that the lens has come into contact with the cornea, and become opaque at the point of contact, although the cornea has been chiefly inflamed at a neighbouring point. This case would seem to explain those cases of minute central capsular opacity, where the nebulous state of the cornea is no longer visible, or has not even existed.

2. Cornelius Judge, æt. 28, comes for slight ophthalmia, and is observed to have a minute opaque dot on the anterior part of the capsule of the right lens just below the centre, and a corresponding, but much fainter speck on the cornea exactly opposite. All else quite healthy. He knows nothing of the specks, as his sight is unaffected by them, and they have not been seen before. They have probably existed from infancy, and been due to the same cause as in the last case.

Case T.—*Examination of an eye after the operation of solution.*

The following is an account of the examination of an eye taken from an elderly man, who died in the Middlesex Hospital, in 1846, after a contused and lacerated wound of the scalp, which had caused so much swelling of the lids, that the globe had been invisible during life, but it was understood to have been long a "bad one." The eye was obligingly sent me by my friend Mr. Alexander Shaw.

Globe of natural shape and texture externally. No mark of cicatrix on the external tunics. Iris natural. In the lower part of the pupil was seen an opacity apparently of the capsule, irregular, and somewhat moveable; also a more deep-seated, more flocculent, and more moveable opacity, which did not appear through the pupil, except in certain lights. On opening the eye, I found the lens nearly gone. In its place was a cavity continuous with the posterior chamber, the margin of the cavity being formed by the anterior part of the capsule, which had been largely opened, and had rolled up on all sides, retaining in some situations its transparency and other usual characters; while in other parts, especially below, it was obscured by a dense white earthy deposit. This deposit had in connexion with it a remnant of the fibrous tissue of the lens, and even traces of the superficial cells of the lens. Some of the fibres were nearly natural; others were more or less granular and broken. The posterior portion of the capsule remained, forming the bottom of the cavity, and when torn by the knife seemed perfectly natural in transparency and texture. It was also interesting to notice that the suspensory ligament of the lens was still there, and in a healthy state, holding the circumference of the capsule as usual. The ciliary muscle, also, was quite as large as usual. The vitreous humor was somewhat less firm in front than usual, and it contained in the midst of its clear, transparent substance, a number of minute chalky-looking streaks or dots, the streaks being mostly directed from behind forwards, towards the back, and particularly the border, of the capsule of the lens. On examination, these consisted of minute granular particles, of an earthy nature, varying in size from mere points to 1-1500th of an inch.

CASE U.—*Dropsy of posterior aqueous chamber, with synechia posterior—bulging of the sclerotica over the ciliary processes.*

(For a part of the notes of this case, I am indebted to my friend and former pupil, Mr. GEO. SHEPPARD.)

12th Oct. 1848.—Hannah Jones, æt. 28, a single woman, always enjoyed good health till two years ago, when her eyes became severely inflamed from a cold, caught, as she believes, in moving into a cold and damp house. Leeches and other remedies were employed, but did not relieve the pain (which was very acute), or palliate the symptoms. The sight from the beginning of the attack was very imperfect, and in three months was gone from the right eye, and much impaired in the left. Her mouth was made sore, probably by mercury. At present she feels well, and her appetite is good.

Condition of the eyes.—Jerking oscillations of both towards the left side. *Left.* Posterior synechia. Capsule and cornea cloudy. Can just distinguish the window bars. *Right.* The same condition, but *also* distension of the anterior part of the sclerotica, which, for one-eighth of an inch from the cornea, is slate-coloured, full of dull red vessels, and presents both above and below three or four small dark spots, where staphylomatous bulging of the sclerotica appears to be commencing. The dark points are about as large as pins' heads, and seem to be caused by a distension of the posterior chamber with fluid, bulging between the ciliary processes.

The remedies employed had reference to some external inflammation for which she had applied to the hospital, and which was speedily subdued. The condition of the eyes remained. She suffered from frequent dull pain, and there seemed a disposition for the distension of the right eye to increase. There were some blotches of doubtful character on the face and forehead.—Ung. Ant. P. Tart. temp.; Pil. Hyd. Chl. C. gr. v. o. n.

Nov. 9th.—*Right eye.* I found by atropine that the border of the pupil was in all probability adherent everywhere to the capsule of the lens, for it showed no inclination to recede. As there was a persistence of the pain, and some tendency to further distension, I made a careful puncture with a grooved needle through one of the small projecting points of the sclerotica above, and drew off several drops of very nearly clear, watery fluid, which became very slightly turbid by heat (it was nearly natural aqueous humor.) The operation gave no pain, and though it occasioned an immediate diminution of tension and fulness of the globe, yet it produced no change whatever in the anterior chamber, showing that there was no communication between the chambers through the pupil. No bad symptom followed this puncture, and she felt rather relieved, the pain being lessened, and even vision improved in a trifling degree on January 4th.

Feb. 1st.—Still rather improved; no pain; appearances similar. I repeated the puncture, with the same results. There occurs now, on the entrance of the

needle (what occurred before, but it was not mentioned), an instantaneous injection of the vessels of the sclerotica and conjunctiva with blood, so that they look much congested, or actively inflamed, and two or three large vessels (before invisible) disclose themselves in the cornea.

This woman is still in attendance, and continues to improve a little.

CASE V. – *Clot of blood in serum occupying the aqueous chambers, undergoing very slow absorption during twelve months.*

23rd Dec. 1847.—Wm. Byron, æt. 48, lost his left eye nineteen years ago, by a wound, for which he was treated at this hospital by the late Mr. Scott. The eye has been left with a transparent cornea, serum in the aqueous chambers, ossific, or earthy matter on the capsule of the lens, and enlargement of the choroidal vessels. There is also an inward squint. A fortnight ago, an effusion of blood took place into the aqueous chambers, with pain, followed by injection of the conjunctiva, and a faint zonular redness of the sclerotica. The blood has trickled from the upper part, and forms a red clot, occupying nearly one half the anterior chamber.—Emp. Lyttæ; Magn. Sulph. ℥ss. mane; Lot. Saturn.

6th Jan.—Rather more blood; pain in the eye and orbit, as well as in the head; bowels open.—Rep. Emp. Lyttæ; Sodæ c. Cinch. gr. x. t. d.

17th.—Better; sharp pain gone except at night.—Rep.

31st.—Better; very little pain. The blood remains unaltered. The coagulum presents a film descending from above, showing the point from which it has trickled, precisely as five weeks ago.

24th Feb.—Free from all bad symptoms. The blood remains precisely as before.

23rd March.—Clot slightly less. Some pain on pressure of the globe, with slight zone.—Emp. Lyttæ.

27th April.—Clot a little smaller, and paler, though still red; eye quiet.

22nd May.—Clot reddish, and semi-transparent in the upper part; pale in the lower part.

26th June.—Clot still faintly coloured at the upper part.

4th Dec. 1848.—There is still a semi-transparent mesh of fibrine at the lower part. The globe has been collapsing, and is now four-grooved by the traction of the recti muscles. The cornea is reduced in size, but still clear. The lens and iris unchanged. No pain or inconvenience.

Out Patients treated at the ROYAL LONDON OPHTHALMIC HOSPITAL, MOORFIELDS, *during the last Ten Years.*

(Extracted from the Annual Reports.)

DISEASE.	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	TOTAL Of each Class of Disease.
Inflammation of the Conjunctiva, Acute and Chronic	1451	1686	1454	1625	1825	2226	3189	2128	2396	2468	19848
Ditto, Catarrhal and Pustular	498	507	572	644	441	810		1052	1104	1364	7592
Ditto, Purulent (Adults)	146	6	190	172	205	24	15	6	36	20	187
Ditto, Ditto (Infants)		136				164	152	166	144	195	1590
Ditto, Strumous	396	465	485	708	1109	595	696	535	394	593	5976
Inflammation of Sclerotica	79	—	103	102	—	178	158	120	139	177	1056
Inflammation, ulcers, and opacities of the cornea	564	546	461	297	360	581	495	542	576	663	5085
Conical cornea	2	10	5	7	—	12	4	9	5	6	60
Iritis, of various forms	75	147	126	95	103	113	94	75	166	149	1143
Cataract, of various forms	158	165	153	184	117	151	123	133	141	206	1531
Amaurosis, in various degrees	465	481	469	562	598	385	466	413	459	567	4865
Inflammation of internal tunics and glaucoma	113	90	229	41	162	203	282	242	195	190	1747
Neuralgia, Palsy of 3d, 6th, and 7th nerves, and Strabismus	50	39	55	160	49	53	94	84	145	124	853
Inflammation of lids	105	63	120	120	83	48	102	90	150	148	1029
Tumours of lids	74	74	108	91	123	88	79	85	81	95	898
Tinea, Lippitudo, Trichiasis	370	571	490	630	752	564	497	610	653	638	5775
Inversion and Eversion of lids	10	12	22	22	11	21	—	21	9	16	144
Diseases of the Lacrymal apparatus	86	74	71	115	125	145	96	99	158	131	1100
Wounds of the Eye, &c.	135	171	187	197	209	213	162	300	401	327	2302
Fungus of the globe or its appendages	7	7	1	4	—	—	1	—	2	2	24
Tumours of the orbit	1	—	—	3	—	—	—	—	10	2	16
Miscellaneous	6	5	7	5	—	—	—	—	8	1	32
Escaped registration	100	100	200	300	300	300	300	300	300	300	2500
Total of each year	4891	5355	5528	6085	6572	6874	7005	7010	7672	8382	65,353

Numerical View of the principal Operations performed at the ROYAL LONDON OPHTHALMIC HOSPITAL *during the last Ten Years.*

(Extracted from the Annual Reports.)

	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	TOTAL of each OPERATION.	
CATARACT { Extraction	50	53	46	71	46	57	37	23	35	33	451	Total Operations for Cataract, 983
CATARACT { Depression	—	2	8	—	—	4	2	2	2	6	26	
CATARACT { Solution	17	30	21	34	38	24	55	48	62	67	396	
CATARACT { Congenital	4	9	6	4	10	17	13	10	20	17	110	
Dislocated Lens	—	—	—	—	—	—	—	—	1	5	6	
Artificial Pupil	7	19	9	14	16	6	9	7	14	22	123	
Tumours	—	—	—	2	3	1	1	—	2	4	13	
Pterygium	—	—	—	—	—	—	1	—	—	—	1	
Staphyloma	—	1	—	2	—	3	2	2	1	7	18	
Strabismus	—	24	9	25	27	14	8	9	33	39	188	
Miscellaneous	—	—	—	—	—	—	—	—	2	—	2	
Entropion	3	6	3	2	3	—	—	3	10	19	49	
Do. cilia dissected out	—	—	—	—	—	—	—	—	—	7	7	
Globe extirpated	1	—	—	—	2	1	—	—	—	—	4	
Lacrymal gland removed*	1	—	—	—	—	—	—	—	—	1	1	
New Lower Eyelid	—	2	—	—	1	—	—	—	—	—	4	
Fist. Lacrymalis	—	—	—	—	—	—	—	—	5	15	20	
Total of each Year	83	146	102	154	146	127	128	104	187	242	1419	

* The palpebral aperture was afterwards enlarged, and an artificial pupil made in the same eye of this patient, by Mr. Dixon—an admirable example of what enlightened surgery can accomplish, in apparently a most hopeless case of blindness after an explosion of gunpowder.

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