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ON

THE VISION OF OBJECTS ON AND IN THE EYE.

BY

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(*From the Edin. Med. and Surg. Journal, No.* 164.)

EDINBURGH:
PRINTED BY STARK AND COMPANY.
MDCCCXLV.

ON THE VISION OF OBJECTS ON AND IN THE EYE

Introduction.

§ 1. *Distinction of objective and subjective vision.*

A scholastic distinction, which, at first view, seems clear and well defined, has been drawn between *objective* and *subjective* vision. Under the former, it is meant to include those impressions of sight, which arise from objects external to the organ of vision; and under the latter, those sensations, or apparent sensations, which are independent of external objects. Light, emitted or reflected from any external body, passing through the pupil and humours of the eye, and striking the retina, will produce objective vision. Familiar examples of subjective vision occur as the result of pressure on the retina, either from without or from within the eye; of making the eye part of a galvanic circle; and of certain disordered states, either of the retina or of those portions of the nervous system with which the retina is continuous, and on which visual perception ultimately depends. Admitting, then, that there are grounds for the distinction of objective and subjective vision, under which head are we to place those phenomena, which appear when an observer looks at his own eye, (I do not mean in a mirror, but as if it were an external object placed before him,) inspects the surface of his own cornea, examines the state of his own vitreous humour, or contemplates the arrangement of the blood-vessels, which ramify on his own retina? For-

tunate it is for us, that the objects on and in the eye are not generally seen in the exercise of normal vision, but either require some particular optical contrivance to bring them into view, become visible when the eye has lost its natural powers of adjustment, or impress the nerve of sight only in consequence of disease; for so very numerous are those objects, that, were they seen under ordinary circumstances, they would necessarily render vision exceedingly perplexed and obscure. Akin to some of the observations now referred to are certain imitations of visual sensation, which result from actual insensibility of some portion of the nervous apparatus of vision. The fact is, that objective vision merges into subjective, by degrees so insensible that it is scarcely possible to say where the one ends and the other begins.

§ 2. *Explanation of terms :—Muscæ volitantes, Spectra, Scotoma, Myodesopia.*

The vision of objects situated on the surface, or in the interior of the eye, has attracted attention, chiefly in relation to a symptom, to which the name of *muscæ volitantes** has been given. Any *spectrum*, or visual appearance, which is apt to impose on the patient, and lead him to think that flies are moving before him in the air, is called a *musca volitans ;* and that whether it results from an impression on the retina, produced by an object on or in the eye, or from a loss of sensibility in that membrane. Sir David Brewster† limits the term *musca* to the darkest portion of a certain variety of spectrum, but this is not the sense in which it is generally received. A dark spectrum is sometimes called a *scotoma*,‡ although not very correctly, as this term signifies properly the darkness which occasionally attends the feeling of vertigo. The seeing of muscæ volitantes has received from pathologists the name of *myodesopia*,§ a disease which has sometimes been defined‖ to be the seeing of objects not really present. The definition would be much more applicable to the generality of cases, were the word "not" omitted; for myodesopia, although in certain instances the result of a mere want of sensibility in the retina, arises oftener from the actual perception of

* French—*Mouches volantes, Imaginations perpétuelles.* German—*Die Flecken vor den Augen.* Called by Galen sometimes *idola*, i. e. images or spectres; sometimes *phantasmata*, i. e. phantoms or apparitions. By later writers *imagines*, i. e. imitations.

† Transactions of the Royal Society of Edinburgh, Vol. xv. p. 380. Edinburgh, 1843.

‡ Σκότωμα, *vertigo*, from σκότος, *darkness.*

§ *Myodesopia, myodesopsia*, or *myiodesopsia*, from μυῖα, *a fly*, εἶδος *form*, and ὤψ *appearance* or *sight.* Latin—*Visus muscarum ; Visio phantasmatum.* German—*Das Flockensehen ; Das Mückensehen.*

‖ Even one of the most accurate and perspicuous of surgical writers has fallen into this absurdity. "Personen, die diesen Augenfehler (Myodesopsia, Crupsia, Photopsia) haben, sehen Gegenstände, die nicht wirklich da sind." Richter's Anfangsgründe der Wundarzneykunst, Vol. iii. p. 501. Göttingen, 1804.

objects on or in the eye. These two facts mark out the grand distinction of *myodesopia sensitiva* and *insensitiva.*

§ 3. *Ancient notions regarding the cause of muscæ volitantes.*

The most ancient notions respecting the cause of muscæ volitantes were, that they arose from a turbid state of the humours of the eye, or from the presence of opaque corpuscles swimming in the aqueous humour. Hippocrates adopts the former of these suppositions, and compares the appearances in question to the figures of birds or of black lentils moving in the air;* while Galen, who adheres to the latter and more definite view, says, they seem as if so many gnats were flying about before the eyes.†

§ 4. *Pitcairn attempts to determine the cause of muscæ volitantes on mathematical principles.*

The positive manner in which Pitcairn, both in his inaugural Oration at Leyden, and in his tract, entitled *Theoria Morborum Oculi*,‡ asserted that no substance floating in the aqueous humour, or corpuscle inclosed within the eye, could form an image on the retina, and that therefore the common notions respecting muscæ volitantes, such as those above referred to, must be false, appear to have had considerable weight with succeeding authors.§

"Whoever," says he in his Oration, "will take into account the diameters of the humours of the eye, and the laws of refraction, will readily perceive that the images of objects in the eye would be projected behind the retina, and can therefore by no means affect vision.

"To make it evident, that corpuscles, in the aqueous or the vitreous humour, by intercepting the rays emitted by objects, can never produce the appearances of muscæ volitantes, we have only to refer to the optical principle, that there is no point of a visible object from which rays of light do not reach to every point of the cornea, and therefore, that although many points of the cornea may be covered, still all the parts of the object are seen by the eye.

"But if that point of the retina on which the rays emitted by some visible object ought to meet, be from any cause so covered or compressed as not to receive the image, then no sense of the object is excited; and if this happens to many points of the retina, the appearances called muscæ volitantes will be produced."

* Hippocrates de Locis in Homine, § 7.

† Galenus de Symptomatum Causis, Lib. i. Cap. 2.

‡ Pitcairnii Opera, pp. 203, 206. Lugduni Batavorum, 1737.

§ The same opinion as that held by Pitcairn is ascribed by Morgagni to Des Chales, whose works I have not had an opportunity of consulting.

Pursuing the same subject in his *Theoria Morborum Oculi*, he thus expresses himself,—

"To those who understand the mathematical principles of vision, it is known, that, of parallel rays emerging from the aqueous humour into a glass sphere, the focus, after refraction at the convex surface of the sphere, is nine semidiameters of the sphere from the vertex of incidence; and of those same rays, on emergence from the sphere, that the focus is three semidiameters and a half from the sphere. Wherefore, parallel rays in the aqueous humour would, after refraction by an entire glass sphere, inclosed in the aqueous humour, converge to a point three semidiameters and a half of the sphere from the opposite side of the sphere; or, which is the same thing, the rays proceeding from a radiating point, placed three semidiameters and a half from a glass sphere, inclosed in the aqueous humour, would emerge parallel from the sphere, so that the image of this point being infinitely distant, could not be painted on the retina, and no vision of it therefore be produced.

"Optical observations being admitted, by which it is shown that the crystalline humour enjoys the same refractive power as glass, it is evident that no image can be pictured of any radiating body placed three semidiameters and a half from the crystalline. But the cornea of no eye is distant three semidiameters and a half of the crystalline from the crystalline. Therefore, there can be no vision of any body situated in the cornea, or in the aqueous humour, whether such body be fixed or free."

From these reasonings he draws the four following conclusions:—

1. That in cataract no figures of corpuscles can be observed by the patient, such as medical writers enumerate among the symptoms of that disease. But if along with an obscuration of sight, such spectra are perceived, amaurosis and cataract must be present together.

2. That if muscæ volitantes be perceived, no external ophthalmia being present, there must be amaurosis.

3. That, if along with external ophthalmia, muscæ volitantes are present, there must also be inflammation extending to the retina itself.

4. That in all cases such spectra arise from disease of the retina, parts of it being congested, compressed, or covered, so as to be incapable of receiving images.

Such being the views promulgated by Pitcairn, and implicitly received by Boerhaave, Plenck, Wardrop, and others, it may be satisfactory to see how far they are borne out by experiment.

§ 5. *Small bodies close to the eye rendered visible by excluding the lateral pencils of light.*

Exp. 1. Having closed one eye, and placed any small object,

as a pin, at such a distance before the other eye as to see it most distinctly, if we gradually bring the object towards the eye, it becomes less and less distinct, and at last, when so close as to touch the eye-lashes, it disappears, the whole effect of its presence being to throw a shadow over the entire retina, and thus cause a mistiness in our perception of surrounding objects, so slight, however, as not even to prevent our reading a printed book held at the ordinary distance.

Exp. 2. If we now take a card, perforated with a pinhole, and bring it between the eye and the pin, we find that through the pinhole we see the pin distinctly.

Let A*b*, A*c*, A*d*, fig. 1, be rays proceeding from the point A, of the object, placed, as in these experiments, nearer the eye than the distance for distinct vision. The refractive powers of the eye would suffice to make those rays converge no nearer than to *y*, a point behind the eye, in tending to which point they would occupy on the retina a considerable circular space, and could therefore produce no distinct image of the point A. In like manner, the rays, B*b*, B*c*, B*d*, proceeding from B, would converge towards *x*, occupy on the retina a circular space partially overlapping that occupied by the rays proceeding from A, and produce no distinct image of the point B. This is the state of matters in the first experiment, in which the pin being brought closer and closer to the eye, at length disappears, in consequence of what is termed *distantial aberration*, the refractive powers of the cornea and humours being insufficient to bring the rays proceeding from an object placed so near to the eye, to focal points upon the retina.

By the intervention of the perforated card, in the second experiment, we interrupt the rays A*b*, A*d*, proceeding from the first point, and the rays B*b*, B*d*, proceeding from the second, reduce thus the circles of dissipation on the retina, so that they do not coincide, and allow a distinct image to be formed by means of the central rays, A*c*, B*c*, of each pencil.

The conclusion from the experiments is, that it is not the nearness of the object, but the large size of the pupil, or, in other words, the breadth of the luminous pencils, which, in ordinary circumstances, prevents small objects from forming an image on the retina, when brought close to the eye. The same cause, it is evident, will operate, to a certain extent, in preventing corpuscles, in or on the eye, from being seen, unless we limit the breadth of the luminous pencil which is admitted into the eye, by looking through a fine aperture. If we do so, it seems probable that any corpuscle on the surface or in the interior of the eye will be seen, exactly as the small body out of the eye is made perceptible by the same contrivance. We shall presently explain that this is really the case.

It is well known that a speck of the cornea, such as results from a deposition of lymph, and is called an *albugo*, or arises from the cicatrization of an ulcer, and is styled a *leucoma*, as it is incapable of causing a well-defined image on the retina, is never perceived, under ordinary circumstances, by the patient, but merely occasions, like the pin brought close to the eye in the first of the above experiments, a dimness over the whole retina, and consequently an indistinctness in the perception of all objects, proportionate to its breadth and density. The same holds true with respect to opacities immediately behind the pupil, such as central cataract, or a shred of opaque capsule remaining after an operation for cataract. Ann Thomson, aged 13, is at present under my care at the Glasgow Eye Infirmary, (No. 14133,) on account of *muscæ volitantes* which she sees with her right eye, in consequence of postfebrile ophthalmitis. The humours of this eye appear perfectly clear. On her left cornea she has a thin leucoma, and in the centre of the anterior capsule a small dense opacity, both of old standing; but with this eye she sees distinctly, and has no muscæ before it. Mr Ware mentions a case, "in which, after the removal of a cataract, a white opaque particle, about the size of the head of a small pin, moved continually upwards and downwards, near the centre of the pupil; but though very perceptible to observers, it was wholly unperceived by the patient, and neither interfered with vision, nor occasioned the smallest appearance of a *musca volitans*."* But, though opacities of the cornea and crystalline throw merely a shadow over the whole retina under ordinary circumstances, we only require to make the patient look through a pinhole, in order that he may see the figure of the spot. On doing so, he generally compares it to the wing of a fly, or to some similar object.

If we are to give assent to the doctrine of Pitcairn, it can only be with certain important limitations. We may admit it to be true, that the eye being of normal form, the pupil of a medium size, and no artificial means employed to limit the breadth of the luminous pencils admitted into the eye, no corpuscle, situated on or in the eye, and in front of its focal centre, can be seen by means of any image of it, formed by the refractive powers of the media of the eye alone, and thrown upon the retina.

Neither the mathematical principles of vision, referred to by Pitcairn, nor the experiments above noticed, determine the question, how far the retina will receive impressions from the shadow of bodies, placed behind the focal centre of the eye. "Corpora opaca postremas vitrei humoris cellulas inquinantia ab ægris non animadverti non posse," is the opinion of Morgagni,† an author than whom none who preceded him, and few who have followed

* Medico-Chirurgical Transactions, Vol. v. p. 265. London, 1814.

† Adversaria Anatomica Sexta, Animadversio 75, p. 95. Lugduni Batavorum, 1723.

him, have written so sagaciously on our present subject. Besides, it seems reasonable to believe, that both opaque and transparent bodies, situated on or in the eye, may sometimes be rendered objects of visual perception, by other means than simply by the rays of light, emitted or reflected by them, passing through the transparent media of the organ, and being thereby brought to foci upon the retina. It can scarcely admit of doubt, that the refractive powers of the bodies themselves may, in some instances, serve so to change the direction of the rays of light which pass through them, as to ensure the formation of images of those bodies on the retina, while, in other cases, the influence of those causes which give rise to that apparent property which the edges of bodies were once supposed to possess, and to which the name of *diffraction* or *inflection* of light was applied, may lead to the perception of minute filaments and corpuscles, situated in the interior of the eye, by means of the magnified and peculiarly constituted shadows which those causes produce.

§ 6. *Enumeration of the different kinds of spectra which give rise to myodesopia.*

I now proceed to consider the different kinds of spectra of which the eye is susceptible, and which, when they become exaggerated, give rise to the sensation of *muscæ volitantes*. This I shall do in the following order :—

I. Muco-lacrymal spectrum.

II. Spectra depending on corpuscles between the cornea and the vitreous body.

III. Spectra depending on corpuscles in or behind the vitreous body. Floating muscæ.

IV. Circulatory spectrum.

V. Vascular spectrum. Accidental colours. Retinal and choroidal muscæ. Fixed muscæ.

The first class includes an ectommatic spectrum ; the other four classes are entommatic.*

I. Muco-lacrymal spectrum.

§ 7. *Vision of the layer of mucus and tears on the surface of the cornea.*

In a number of the experiments, to which I shall have occasion hereafter to refer, it is necessary to ascertain whether the lenses, with which they are to be performed, be perfectly clean. This is ascertained by looking at the flame of a candle through the lens, and at the same time turning it on its axis. On doing so, any particles of dust adhering to the lens will revolve with

* *Entommatic*, from ἐντος, *within*, and ὄμμα, *the eye*, is a convenient term invented by Nordmann. To get rid of two cumbrous circumlocutions, I have ventured to coin on the same model, *ectommatic* and *entohyaloid*.

it, and must be removed. If the lens is marked with scratches, this will be discovered in the same manner, and such a lens must be laid aside. This direction being understood once for all, it will be unnecessary to repeat it.

Exp. 3. If a normal or a presbyopic eye be directed through a pretty deep concave lens, as one of $2\frac{1}{2}$ inches' radius, or what is called No. 12, towards the flame of a candle, placed at the distance of about twenty feet, a circular luminous figure appears, dotted all over with minute round spots. These spots are images of the candle, multiplied by the layer of fluid lying on the surface of the cornea, and which consists of globules. The spots are seen to change their position with every act of nictitation. They are also seen to run together occasionally, so as to form larger spots, and then to separate, as we wink, into smaller ones. The fluid which gives rise to this appearance, is, of course, a mixture of tears with the mucous secretion of the conjunctiva. It lies upon the surface of the cornea in the form of minute drops, and no doubt exercises the function of preserving that surface in a moist and transparent state, fit for the easy transmission of the rays of light. Invisible in general to the naked eye, it is, in this simple experiment, rendered visible, by directing through it a small pencil of divergent light, each globule acting on the light which falls upon it, so as to converge it sufficiently, along with the refraction of the transparent media of the eye, to bring it to a focus on the retina.

Exp. 4. The fluid which bedews the cornea may be seen still more distinctly, by viewing a candle at twenty feet distance, or a street lamp at sixty feet distance, through a double-convex lens of $1\frac{1}{2}$ inch focus, placed close before the eye. Every act of nictitation is seen to push the fluid down to the lower lid, and instantly as the eye is opened a number of the globules of which it consists spring up again towards the upper lid. They seem large, opaque, and their edges iridescent.

Exp. 5. In the last experiment, the upper eyelid and the globules on the cornea are seen in their natural place. To see them inverted, we require only to carry the lens forward from the eye, so that the cornea is no longer within the focal distance of the lens. On closing the eye, the upper eyelid is now seen as if rising from the lower part of the field of view, and the globules, after each act of nictitation, appear as if they floated downwards over the cornea. The same objects are also inverted in Exp. 3.

§ 8. *Muco-lacrymal spectrum seen in the field of the microscope and telescope.*

In hanging the head over the microscope, especially if one is affected at the time with catarrh, the globules seen in the last three experiments, by gravitating to the centre of the cornea, not

unfrequently appear to the observer, so as to impede his view of the object, till by another act of nictitation he clears them away.

In telescopic observations, also, the muco-lacrymal spectrum is apt to prove a source of annoyance. Thus, in looking at the sun through a tinted glass, the observer may be unable to distinguish the spots on that body, being perplexed by what seems the reflexion of some part of his own eye, interposed between it and the sun. This is caused by the layer of mucus and tears on the surface of the cornea.

§ 9. *Muco-lacrymal muscæ volitantes.*

I have been consulted by a very short-sighted person, who is occasionally troubled with the appearance of numerous opaque round spots before one of his eyes, each spot being surrounded by a halo. Sometimes several of them appear to run together into dots, which again divide and disappear. He notices that they ascend after every act of nictitation. From his description, and the figure which he sent me, of this peculiar variety of *muscæ volitantes*, I had no doubt that what he saw was merely the globules of the muco-lacrymal fluid on the surface of the cornea. It is perhaps to this sort of *muscæ volitantes* that Morgagni refers, when he says, "At spectra illa non modo oculis immotis, moventur, sed assiduè (ad palpebrarum præsertim motum, lacrymalem illum impurum laticem dimoventium) variantur, evanescunt, redeunt." At the same time, *muscæ volitantes* depending on the muco-lacrymal fluid are very rarely the subject of complaint.

II. Spectra depending on corpuscles between the cornea and the vitreous humour.

§ 10. *Want of accurate observations of such spectra.*

I shall by and bye consider the opinions of Donné and Prevost, who place the cause of the most common kind of *muscæ volitantes*, the former in the aqueous humour, and the latter in the humour of Morgagni. I am not prepared to deny the possibility of spectra being discovered by optical contrivances, depending on the presence of corpuscles between the cornea and the vitreous humour, although my present conviction is, that no accurate observations have been made of any such spectra. Corpuscles in the aqueous or the crystalline humour will not be visible, under ordinary circumstances, to the person in whose eye they exist, and will have little, if any, effect on the distinctness of vision. They may perhaps be visible to an eye exceedingly myopic, and, to the scientific observer, may sometimes prove a still more serious evil than the globules on the cornea, as their shadow, perceptible on looking through a microscope or telescope of high power, cannot be got quit of, like the muco-lacrymal spectrum, by mere nictitation.

§ 11. *Methods of detecting and distinguishing such spectra.*

The methods of detecting the presence of corpuscles in the aqueous or the crystalline humour will resemble those already indicated in *Exps.* 3, 4, and 5, or those which I shall presently describe for the discovery of spectra depending on causes residing behind the crystalline. They will be distinguished from the globules which rest on the cornea, by their occupying a posterior plane in the field of view; by the double images, formed of them on exposing the eye to two divergent beams of light, being less separated from one another than the double images of the muco-lacrymal spectrum, and by their not suffering the same changes from the act of nictitation. From corpuscles residing in the vitreous humour, they will be distinguished by their occupying an anterior plane in the field of view, by their double images being more widely separated, and by the possibility of readily inverting their spectrum, by the same means by which we invert that of the globules on the cornea, as in *Exp.* 5.

This last circumstance has been fixed on by Captain Kater,* as affording a ready means of discriminating between spectra depending on causes residing in the cornea, aqueous humour, or crystalline, and those depending on causes residing in the vitreous humour. The rules, however, which he gives for the use of this test, although perfectly correct, are delivered in a style rather enigmatical, and therefore apt to puzzle those not perfectly acquainted with the subject. The simplest view of the matter seems to be this:—If, as in *Exps.* 4 and 5, by shifting the focus of the rays which impinge on the retina, we find that the corpuscles, the situation of which is the object of investigation, are at one time, as in *Exp.* 4, anterior, and at another time, as in *Exp.* 5, posterior to that focus, and their spectrum thereby inverted, this proves that they are situated in the anterior part of the eye, whereas if we cannot thus invert the spectrum, the cause must reside in the vitreous humour.†

III. Spectra depending on corpuscles in or behind the vitreous body. Floating muscæ.

§ 12. *Four different spectra of this class. Methods of viewing them. Relative positions of the corpuscles which produce them. Their limited mobility.*

Exp. 6. Through the eye-glass of a compound microscope, look at the flame of a candle, two or three feet distant. On steadily regarding the luminous field presented to view, four sets of spectra will be seen, independent of the muco-lacrymal spec-

* Remarks on certain Spots discoverable in the Human Eye, at the end of Guthrie on Extraction of a Cataract. London, 1834.

† It would be desirable that the above rule were more definite. On theoretical principles, it seems possible to invert the image of any corpuscle, however deep in the eye it may be situated; but I have never succeeded except with the muco-lacrymal spectrum.

trum. The most remarkable appears nearest to the eye, and consists of twisted strings of minute pearly globules hung across the field of view. The second in point of remarkableness, and the farthest from the eye, consists of watery-like threads, destitute of any globular appearance, and depending chiefly from the upper part of the field. I shall call the former the *pearly spectrum*, and the latter the *watery*. In two distinct planes, between those occupied by these two spectra, are placed two sets of globules, not aggregated into threads, but insulated. These constitute what I shall call the *insulo-globular spectra*. The set farther from the eye is hazy and ill defined, and may be compared to small grains of sago. The set nearer to the eye are clear in the centre, exterior to which they present a sharp black ring, and still more exteriorly a lucid circumference. These four sets of spectra never mingle with one another, so as to change the order in which they stand before the eye; but the pearly spectrum always appears the nearest, then the sharply defined insulo-globular, then the obscurely defined globules, and farthest away the watery threads. Fig. 2.

Donné* has described the pearly and the two insulo-globular spectra, as seen through a pinhole in a card. The watery spectrum had escaped his observation.

That the corpuscles which produce these four sets of spectra are situated in or behind the vitreous humour, and not, as Donné supposed with regard to those of them which he saw, in the aqueous, is manifest from the fact, that none of these spectra can be inverted, by viewing them through a concave lens, or by first viewing them through a convex lens held close to the eye, and then carrying the lens forwards from the eye, so that the eye is without the focal distance of the lens, experiments which at once invert the muco-lacrymal spectrum, and would, it is presumed, do the same to any spectrum depending on the state of the aqueous humour or the crystalline.

That the spectra stand in the order which I have assigned to them, will appear distinctly, perhaps not at the very first glance, but certainly on conducting the examination with a little pains, either through the eye-glass of the compound microscope, or through a hole made in a card with a fine needle, the eye being directed towards the sky, or towards a lighted candle.†

Various other methods of viewing the spectra in question might be mentioned. The following is the readiest of all.

Exp. 7. If, bringing the eyelids towards each other, we look at a lighted candle, the spectra now described appear very distinctly over the flame, and in the two vertical beams of light which are produced by the action of the edges of the eyelids upon the

* Archives Générales de Médecine, Tom. xxiii. p. 115. Paris, 1830.

† These methods of examining spectra appear to have been first pointed out in the Histoire de l'Académie Royale des Sciences pour 1760, p. 57. Paris, 1766.

light of the candle.* If we bend the head to one side, the beams assume a horizontal direction, and, at the same time, the linear spectra which appeared, in the former position of the head, in a vertical direction, will now be seen in a horizontal one, and *vice versa*, showing that their cause is not loose within any of the fluids of the eye, nor swimming on its surface, in either of which cases they would, on the position of the head being changed, immediately assume the same direction as that in which they were at first seen.

§ 13. *Method of procuring double images of corpuscles situated in front of the retina.*

The following beautiful experiment, by which we procure double images of every object on the eye, or within it and in front of the retina, we owe to Sir David Brewster, who has by its means thrown more light on the subject of *muscæ volitantes* than all preceding writers.

Exp. 8. Place two candles before the eye, at the distance of a few inches from each other. Look at them through a pin-hole or through a double-convex lens, so as to make the two luminous fields to overlap. In the middle space, formed by the overlapping of the two fields, double images will be seen of all the perceptible objects on the eye, or within it and in front of the retina, and amongst these, double images of the muco-lacrymal globules, the watery spectrum, the insulo-globular spectra, and the pearly spectrum. If the candles are placed about ten feet from the eye, and viewed through a lens of one and a half inch focus, the double images of the muco-lacrymal globules will be seen to be widely apart from one another, the double images of the threads of the watery spectrum less widely, less widely still those of the obscure insulo-globular spectrum and of the sharply defined one, while the double images of the pearly spectrum are quite close to one another, showing the relative position of the causes of these spectra in the eye; viz. the muco-lacrymal substance on the surface of the cornea, and the corpuscles causing the pearly spectrum close to the retina, while the causes of the watery and insulo-globular spectra occupy the middle space.

§ 14. *Appearances of the watery spectrum.*

The depending threads of which the watery spectrum consists have somewhat of a rounded appearance, differing in this respect from the pearly *muscæ volitantes*, the threads of which seem flat. Each of the watery threads is bounded by two dark lines, within

* The production of these beams of light by the edges of the eyelids has been referred to refraction by some authors, and by others to inflection. The upper beam is the effect of the lower lid, and *vice versa*.—See Harris's Treatise of Optics, p. 137. London, 1775.

which there is a broad space, which is clear, and entirely destitute of anything like globules. These watery threads measure fully twice the diameter of the threads of the pearly spectrum. Their number is generally about six or eight. They are not all situated in one plane. Their general course is vertical, and gently flexuous. They often divide at their lower extremity into two or more branches, which seem to melt away insensibly. They have so much the appearance which we might suppose streams of tears to have, as they descend from the lacrymal ducts and flow over the cornea, that I at one time thought that this was their real nature, till I discovered that they exist in a plane or planes posterior to the muco-lacrymal spectrum. At first view, they seem to slide down slowly from the upper to the middle part of the field of view, but they possess neither the extent nor the quickness of motion of the pearly spectrum. They are rarely seen at the lower part of the field of view. Any bending or extending which they undergo in the movements of the eye are slight, and their seeming to be displaced and broken into fragments by nictitation is a deception.

I have called this spectrum the *watery*, merely from its appearance, for I have ascertained neither its exact seat nor its nature. It seems probable, that the cause upon which it depends is not far behind the crystalline, and that this cause may be connected with the obliterated capsular vessels, is a natural enough conjecture, although, perhaps, not to be much depended upon.

§ 15. *Sensation of muscæ volitantes produced by the watery spectrum.*

The watery spectrum becomes, in some cases, so much exaggerated, as to give rise to the sensation of *muscæ volitantes*. It is most apt to be perceived by the naked eye, on first going out in the morning. It is compared, by some patients, to the appearance of threads of spun glass, laid across each other, or to that of a fine lock of wool. It appears a little above the centre of the field of vision, and, of course, seems greatly magnified by the distance of the surface against which it is viewed. Although it still retains the form of numerous watery threads, and these never appearing to contain globules, the threads are more irregularly heaped together, and often assume a zigzag figure. They are also either readily dispersed by one or two forcible acts of nictitation, (differing in this respect from the spectrum, as viewed through a pinhole or the eye-glass of a compound microscope,) or by such acts the eye falls into a state in which they are no longer perceptible. The circumstances now noticed are very apt to mislead the patient as to the seat of what he sees, which he probably refers to the surface, and not to the interior of his eye, where the cause actually resides.

§ 16. *Muscæ volitantes produced by the insulo-globular spectra.*

The ill-defined globules, which lie immediately behind the watery spectrum, rarely give rise to the sensation of *muscæ volitantes;* but the globules which occupy the next plane, and whose edges are sharp and dark, frequently appear to the naked eye, either as simple black points, or as black rings. Viewed carelessly, or without the aid of any optical contrivance, they generally seem to be connected to the outside of the threads constituting the pearly *muscæ volitantes.*

§ 17. *Appearances of the pearly spectrum.*

Almost every eye, even the most healthy, and which has never attracted the possessor's attention by *muscæ volitantes*, exhibits the pearly spectrum, on being directed, as in *Exp.* 6, towards a luminous field, through a fine pinhole, the eye-glass of a compound microscope, or a convex or concave lens of short focus. I give it the name of the *pearly spectrum,* from its resemblance to a string of pearls. Prevost* has already called it *apparence perlée*, or simply *perles.*

The lines of the pearly spectrum are hung across the field of vision as often transversely as vertically. On first directing the eye towards the luminous field, in one or other of the methods just mentioned, perhaps only a very few small pearly globules are perceived; but after steadily regarding it for some time, numerous strings of them are discovered, generally twisted in different forms, often placed side by side with one another, and presenting a variety of knots, loops, and agglomerations. Sometimes they are so numerous as to form an extensive shower or cloud. The pearly threads are of different lengths, some of them very short, others stretching across the whole field. Not unfrequently some of them end abruptly in a sort of bulb. The globules or pearls, forming the threads or rosaries, seem joined together merely by apposition, without being contained in any tube. Sometimes, however, the globules are rather indistinct, and then the threads approach to a tubular appearance. The globules or pearls are always in single rows. They appear to be destitute of any nucleus. They are not all of one diameter, but are all smaller than the globules of the insulo-globular spectra. I have not satisfied myself that they all occupy the same plane, although it is very evident that they are behind the insulo-globular spectra.

§ 18. *Apparent and real motions of the pearly spectrum.*

That portion of the pearly spectrum, which appears in the centre of the field of view, has but little real motion; less perhaps

* Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, Tom. v. p. 24. Genève, 1832.

than the watery spectrum, which is seen beyond it. Both partake, of course, in the motion of the eye-ball, and this gives to both a wide apparent motion. But if the field be examined towards its circumference, or if the eye be suddenly rotated upwards, other pearly spectra appear, which it is difficult or impossible for the observer to bring directly before him, and which, when he succeeds in some measure in doing so, quickly subside again out of view, partly by a real motion of their own, partly by a wide apparent motion, owing to their obliquity in respect to the axis of vision. It is these last spectra chiefly, which produce the pearly *muscæ volitantes.*

§ 19. *Appearances of the pearly muscæ volitantes.*

Those who begin to be troubled with by far the most common kind of *muscæ volitantes*, find their attention attracted by the appearance of one or more blackish particles dancing before them in the air, and leading them to suppose that perhaps a bit of soot is sticking to their eyelashes, or a minute spider suspending itself from the brim of the hat. On trying to brush away the supposed object, they find out the mistake, and that the spectrum which they see depends on something more immediately affecting the organ of vision than they at first imagined.

In other cases the earliest appearance is that of a thin cloud, somewhat like the wing of a fly, or that of semi-opaque threads, like spider's web.

On directing the eyes from side to side, the spectrum moves also, and with such seeming swiftness as often to lead the patient to suppose that a gnat or small fly is crossing the field of vision. Hence the name *muscæ volitantes.*

In this state the patient often continues for months or years, without taking the trouble of examining the appearances with any considerable degree of attention. Sometimes, indeed, the annular figure of the darkest portions of the muscæ is too striking to escape notice, and patients often designate such by the name of *black stars.* If the patient takes the trouble of turning his eyes steadily to the clear sky for a minute or two, he often finds what had hitherto appeared like a thin cloud, bit of cobweb, or the wing of an insect, to resolve itself into a great number of globules, or minute rings, moving as the eye moves, and connected together as if by some invisible film, so that, although they may change in some measure their relative positions, they never separate entirely from one another.

A still more careful examination of his muscæ volitantes against the clear expanse of the sky, or against the ground covered with snow, probably discloses to the patient a twisted tubular appearance, the tube being bounded by two opaque lines, while the central space is occupied by a chain of obscure spots or globules, not

sufficiently large in general to fill the diameter of the tube, so that the patient, while he compares the whole spectrum to a twisted snake, tells us perhaps that the inside of it resembles the withered substance within the stalk of a quill. The globules, however, are not all of one size, for here and there one larger and more distinctly nucleated than the rest appears, and fills the tube's diameter, while not unfrequently one or two of the rings of the insulo-globular spectrum is seen as if attached to the outside of the tube, as is represented in Fig. 3. The observer also remarks, in some cases, that the tubes seem to end in dark bulbous extremities, as if formed by agglomerations of globules. The dark spots, or black stars, which he first saw when he began to be troubled with such sensations, he finds to be caused either by such agglomerations, or by an appearance at certain points as if the tubes were coiled up or doubled upon themselves. Such dark spots are often so dense, that in a good light they are visible even through the closed eye-lids.

If the patient views his muscæ volitantes, in the manner pointed out in *Exp.* 6, the appearance of a tube, containing globules, is by no means so striking as when he views them with the naked eye against the sky, so that he sees merely rosaries and showers of globules, and these destitute of nuclei. The appearance of a tube is produced in fact by those portions of the rings or globules which touch each other becoming obscure, while the portions by which they do no not touch continue more or less distinct. Hence the edges of the tubes are not straight lines, but undulated.

Pearly muscæ appear chiefly when the patient looks at the clear sky, a thin light cloud, the ground covered with snow, a white wall, and the like. By candle light he seldom notices them, nor do they appear when he regards a dark object, or is in a place where there is but little light. He seldom remarks them when he looks at near objects, or when he keeps his eyes still.

§ 20. *Position of the pearly muscæ volitantes. Their apparent motions.*

The pearly muscæ volitantes are rarely in the axis of vision, but generally a considerable number of degrees from it, outwards or inwards, upwards or downwards. The consequence is, that the patient finds it difficult, in proportion to the obliquity of their position, to examine their configuration and apparent structure; for whenever he tries to bring them directly before him, they flit away, so that he sees them only by a side glance. They partake also in the motions of the eye, darting upwards or downwards, or from side to side, as the eye is moved, and justifying by their apparent movements the comparison indicated by the name of *muscæ volitantes*.

§ 21. *Real motions of the pearly muscæ volitantes.*

If a musca volitans is in or near the axis of vision, it is easy for the patient to keep it fixed for a length of time, over any particular spot in the prospect before him, or in the centre of the luminous field presented by a candle, viewed through a convex or concave lens. The pearly muscæ volitantes, however, have a motion of their own, excited no doubt by the motions of the eye-ball, but still more extensive than their apparent motions, and partly exhibited after the eye-ball is at rest. Thus, if, from looking before him in a horizontal direction, the patient suddenly raises his eyes towards a point about 30° above the horizon, and fixes them on some object at that height, he observes that the muscæ fly upwards considerably beyond that degree of elevation, and even beyond the field of view, and then come sailing down before him till they disappear below, evidently showing that whatever be the nature and seat of the corpuscles by which such spectra are produced, they are not fixed, but enjoy a certain degree of freedom.

Muscæ volitantes are described by some authors* as suddenly darting upwards, and then as suddenly sinking; but they never do this, unless first set in motion by the movement of the eye-ball; and although the motion which they perform in consequence of the impetus given them by the movement of the eye-ball is rapid, that by which they return to their former place is comparatively slow.

Were the corpuscles, which produce the pearly muscæ volitantes, situated anterior to the focal centre of the eye, then their real motion would correspond with the apparent motion of the spectrum or muscæ; that is to say, they would descend within the eye, when the muscæ appeared to descend; but if the corpuscles be situated behind the focal centre, the apparent descent of the muscæ must depend on an actual ascent of the corpuscles. Wherever a corpuscle is situated, whether at *a* or at *a'*, (Fig. 4,) its spectrum will appear as if projected out of the eye in the continued course of a straight line, passing through the corpuscle, and falling nearly perpendicularly on the retina at A. A corpuscle at *b*, anterior to the focal centre of the eye, or at *b'*, posterior to that centre, will form its image at B, and produce the sensation of a spectrum out of the eye, in the direction of the line B*b'b*. If the corpuscle is situated at *a*, and sinks in the eye to *b*, then its image will move over the retina from A to B, and its spectrum will appear to the patient to descend from A′ to B′. But if the corpuscle is situated at *a'*, it will only be by floating upwards from *a'* to *b'* in the vitreous humour that its image will move over the retina from A to B, and its spectrum appear to the patient to descend from A′ to B′.

* Beer, Lehre von den Augenkrankheiten, vol. ii. p. 424. Wien, 1817.

If the cause, then, of the pearly muscæ, which always appear to descend when the eye is fixed on any elevated object, resided in the aqueous humour, this apparent descent of the muscæ would depend on a real descent of the corpuscles by which they are produced; but if the cause resides in the vitreous humour, the apparent descent of the muscæ must depend on a real ascent of the corpuscles.

Besides the motions of ascent and descent, the pearly muscæ present lateral movements, although less marked, as well as changes in the relative positions of their several parts. If three or four *black stars*, as they are termed, exist in the mesh-like texture which floats before the eye, they will perhaps be observed to lie sometimes in a straight line, and at other times to form an angle with one another, being thrown into different positions in the various movements of the eye. The upper part of the tube-like spectrum will sometimes seem to bend in one direction, and the lower part in the opposite. The tubes will appear to uncoil themselves, and then twist themselves into their former shape. A vacillating motion is sometimes observed, as if the web waved backward and forward. All these movements are excited by the motion of the eye-ball; but it is easily observed that their extent is greater than that of the motion of the eye-ball, and that the latter serves merely to set the motions of the muscæ agoing.

§ 22. *Seat of the efficient cause of the pearly muscæ volitantes.*

Many conjectures have been offered regarding the seat of the corpuscles or filaments, which give rise to the pearly *muscæ volitantes*. The surface of the cornea, the aqueous humour, the humour of Morgagni, the vitreous humour, the space between the hyaloid membrane and the retina, the retina, and the choroid, have each been supposed to be occupied by the efficient cause of this symptom. That the pearly muscæ do not arise from corpuscles, situated on the cornea, in the aqueous humour, or in the humour of Morgagni, is evident, from their existing in a plane far behind the corpuscles which produce the muco-lacrymal and watery spectra, from their never mingling with these spectra, from their not being inverted in the experiment which inverts the muco-lacrymal spectrum, and from the closeness of their double images to one another when viewed by means of two divergent beams of light. The fact that double images of the pearly spectrum are always produced in this mode of examining them, shows that their cause does not reside in the nervous substance of the retina, or in the choroid. So decisive are the proofs afforded by the simple facts now referred to, that I might almost be excused from entering on a critical review of opinions so palpably false, as some of those I shall now shortly notice.

1. *Cornea.*—Ribes,* Vest,† Wigan,‡ and Stark,§ have maintained, at considerable length, that *muscæ volitantes*, (and it is evident that under this term they include the pearly,) depend on the tears resting on the cornea, and moving over its surface.

Ribes evidently confounds the muco-lacrymal with the pearly spectrum. He says, indeed, that he saw several layers of globules, sliding apparently over one another; but he has overlooked the important fact, that the most remote of these layers is displaced by the act of nictitation, while the nearest remains totally unaffected, and erroneously attributes the whole to the tears.

Vest examines the entohyaloid muscæ as in Exp. 7; but omitting to observe, that they exist in several planes, posterior to that of the muco-lacrymal spectrum, he refers them to the fluids resting on the surface of the cornea.

Mr Wigan seems to have observed only the pearly muscæ, but to have deceived himself, as to their being dispersed into fresh forms by nictitation.

Dr Stark saw both muco-lacrymal and pearly spectra; but the fact that they are in different planes escaped him, and he states that the globules never rolled over each other.

He thinks the particles of the pearly muscæ are only accidentally agglutinated, as moving the eye seemed to him to have the effect of destroying completely their old arrangement, and of throwing them into new, but still linear forms. If the particles were only accidentally agglutinated, how could it happen that for a long series of years they should chance day after day to reassume the same identical order, so as to produce spectra, the form, size, and extent of which remain unaltered? True it is, a toss of the head will throw them for a little while into somewhat of a different figure, will perhaps make the knots, or darker spots, of the lines or rosaries, the *real muscæ* of Sir David Brewster, the *black stars* of the vulgar, to approach each other, or the lines to twist or to uncoil themselves; but these changes are merely transient, as generally in a few minutes the knots and lines reassume their former disposition, and appear exactly as they have done day after day for many successive years. This is totally irreconcilable to the supposition that the lines consist of particles accidentally connected together, either on the surface of the cornea or any where else.

Neither is there any breaking off of any of the particles of the pearly muscæ. This only *seems* to be the case, from some part of the tube or filament becoming, for a time, less distinctly, or not at all, visible. In a few minutes the rings or globules again appear in continuity, and the rosary is seen exactly as it was before,

* Archives Générales de Médecine, Tome xxii. p. 445. Paris, 1830.

† Abhandlung über das Mückensehen, von J. B. Ritter v. Felsach, p. 10. Wien, 1833.

‡ London Medical Gazette, Vol. xxvii. p. 719. London, 1841.

§ Edinburgh Medical and Surgical Journal, Vol. lx. p. 399. Edinburgh, 1843.

and as it has been seen perhaps for twenty years. Although the muscæ appear to separate and break, some invisible connection still holds them together, and serves to bring them again before the eye in their old shape.

"Sometimes," says Dr Stark, describing his observations, "two lines would unite where they came into contact, form a thicker line, and, if the situation of the line were somewhat vertical, form a kind of ball or globe at its lower point, evidently at the expense of the line above, would drop off, and more rapidly fall beyond the field of vision."* Now, pearly muscæ never unite in this way. Their filaments have often a bulb at their extremities; but it is a permanent thing; the observer never sees it form.

The greater part of Dr Stark's account of the rate of motion of the muscæ, probably applies to the tears or mucous globules, but there can be no doubt, I think, that in his description he has confounded these with the pearly muscæ. What he says about "the muscæ never crossing each other's edges, so as to be visible in all their circumference during the whole time," cannot apply to the spectra depending on corpuscles in the vitreous humour. Every one may see different layers of these spectra, independent altogether of anything on the surface of the cornea. The pearly, the insulo-globular, and the watery spectra are seen, the one set behind the other; while still farther from the eye appears the muco-lacrymal spectrum. All these cross each other, as the eye is moved from side to side, the one set eclipsing for the time those who are more remote from the retina. Dr Stark's statement shows, that though he saw pearly muscæ as well as muco-lacrymal ones, he did not observe them with accuracy.

If Dr Stark's description could be received as correct, and not defective in any material point, we should admit his conclusion, "that the only place of the eye which could permit of the occurrence of phenomena such as those described must be on the conjunctival surface of the transparent cornea." But the fact, that the bodies causing the sensation of *muscæ volitantes* are seen in at least five different planes, sets aside this conclusion entirely.

Dr Stark tells us, that "the eye looking through a fine aperture in a plate of metal, or through a minute lens, was directed to the bright wall or a clear portion of the sky. It was then kept fixed steadily in one position, till the greater part of the muscæ had descended below the middle of the axis of vision. The ball of the eye being still kept steadily fixed, the upper eyelid was brought slowly down till the obscuration by a dark body fringed with eye-lashes, and making its descent, arrived over the uppermost of the descending muscæ. The moment this was done, the body was arrested in its downward progress, and when the eyelid was al-

* Ib. p. 404.

lowed to elevate itself, those muscæ which it had covered were raised with it, and immediately thereafter began to redescend slowly as before."*

In this observation Dr Stark has completely deceived himself; for if we look through a pinhole or minute lens, as he describes, and bring the upper eyelid down over the eye, the obscuration appears below, agreeably to the first of the laws of light, viz. that from every luminous point light radiates in straight lines. The experiment which shows this to be true is exceedingly simple.

Exp. 9. Let a pinhole in a card be brought in front of the eye directed towards a luminous field, and let any opaque body, such as a paper-folder, be brought in slowly between the eye and the hole in the card. When this is done, it will be observed, that the opposite side of the field to that on which the opaque body is brought in becomes eclipsed; the left side, for instance, if the paper-folder is brought in from the right, and *vice versa*. If the upper eyelid be the opaque body, it will be observed that as it descends, the lower part of the field becomes darkened, the shadow of the eyelid appearing to rise from below.

To excite inquiry in those commencing to study optics, the experiment is often made in the following manner.

Exp. 10. The eye being directed through a pinhole towards any luminous field, such as that furnished by a lighted candle, a common pin, with its head uppermost, is brought up from below, between the eye and the pinhole. When this is done, the pin appears as if it were on the other side of the card, dark and inverted. In this experiment, the shadow of the pin on the eye is projected on the retina, and so far as the flame of the candle is concerned, the pin intercepts the light proceeding from above, through the pinhole, exactly as if it were placed beyond the pinhole, with its head downwards. Hence the inverted appearance of the pin.

Let AB, Fig. 5, be the candle, and AC, AD, the cone of rays, which, proceeding from A, can pass through the pinhole, H, and BE, BF, the cone proceeding from B. As the one cone must cross the other, if the pin, P, be brought with its head uppermost, between the eye and the pinhole, it will prevent the cone of light proceeding from A, from reaching the eye, exactly as if it were introduced with its head down at P′, beyond the pinhole. The shadow of the pin at P is projected on the retina, and produces the same impression as if it were in an inverted position at P′.

So also will the edge of the upper eyelid appear inverted in the experiment described by Dr Stark, and no such thing as a *dark body making its descent, till it arrives at the uppermost of the muscæ, will be seen.*

* Ib. p. 406.

When Prevost, in the Society of Natural Philosophy and Natural History of Geneva, urged the permanency of the forms of the pearly rosaries, which he had seen for a long series of years, as incompatible with a cause so changeable as the tears, one of the members proposed to explain the constancy, by certain tracks or furrows, which he presumed might exist on the surface of the cornea. This notion will appear quite untenable to any one who has in his own eye watched the ascent and descent of the pearly muscæ, when the eye is suddenly turned upwards, and then fixed upon some elevated object. These motions depend upon a real change of place in the corpuscles which produce the pearly muscæ, but one of a very different character from the confined movement of a fluid in a track or furrow.

2. *Aqueous humour.*—The aqueous humour has been regarded as the seat of the efficient cause of *muscæ volitantes*, some supposing the cause to be opaque and others transparent, some supposing it to be free and others partially attached.

The motions of the pearly muscæ, on suddenly raising the eye and fixing it on some elevated object, are totally irreconcilable to the idea of the cause being free to move in every direction in a fluid; for although by no means so confined as they would be, were their cause a fluid moving in a furrow, they are still limited, both in extent and in direction. Neither do the corpuscles which produce the pearly spectrum move as if they settled from their gravity at the bottom of the cavity wherein they are contained, or swam to the top of it from lightness, as they might do, if in the aqueous humour. These objections apply as well to transparent as to opaque corpuscles.

Donné* has detected microscopic corpuscles in the aqueous humour in large quantity. They are one half less than those of the blood, and are perfectly transparent. He supposes them to be the cause of the pearly and insulo-globular spectra. The rosaries, however, of globules, which constitute the pearly spectrum, are too constant in their figure to be the result of any accidental accumulation of particles, floating freely through a fluid. Even the insulo-globular spectra are evidently owing to globules which are adherent to some moveable film.

The notion of De la Hire† is perhaps somewhat less improbable than that of Donné, namely, that *muscæ volitantes* are owing to the existence of certain *filaments*, as well as *grains*, which, by possessing refractive powers different from the refractive power of the aqueous humour in which they float, cast their images on the retina.

* Op. cit. p. 113.

† Dissertation sur les differens Accidens de la Vue, in his Mémoires de Mathematique et de Physique, p. 262, Paris, 1694; and in Mémoires de l'Académie Royale des Sciences, Tome ix. p. 574, Paris, 1730.

Porterfield* adopts De la Hire's notion with scarcely any alteration. Neither of them speaks of the supposed grains or diaphanous particles as constituting the filaments, or as situated in their interior; but even were either of these conditions admitted, the limited motion of the muscæ, so often referred to, is inconsistent with the idea of the cause being free and unattached, as De la Hire and Porterfield appear to suppose.

Exp. 10. Let the glass-blower blow a globule of an inch in diameter, and fill it with common water. Look through it at a candle some feet distant, and the motions of the corpuscles contained in the water, will be seen at once to be of a very different character from those of the pearly spectrum, and indeed of any of the spectra we discover by experimental examination of the eye. On the slightest agitation of the glass-globule, the corpuscles in the water are flung about, so as to cross each other in every direction, and with much greater rapidity, than is ever exhibited in the motions of the pearly spectrum. The latter float as if connected to a film or membrane; the former dance about uncontrolled by any sort of adhesion.

Plater's hypothesis, though a very unlikely one in other respects, is in one particular conformable to the appearances; for a filament floating in the aqueous humour, but attached, as I presume Plater supposed it to be, by one of its extremities to some of the neighbouring parts, if it could produce a spectrum at all, would be likely, we should presume, to produce one similar in its movements to those of the pearly muscæ. He tells us, he became suddenly affected one day with the sensation of a black round spot, about the size of a lentil, flying before his left eye, but not impeding vision. He supposes it to have arisen from some ligament of a ciliary process having become loosened from its connections, and to be swimming in the aqueous humour, so that it came before the pupil, and thus produced the sensation in question.†

Certainly the aqueous humour seems, on a superficial examination of the subject, to be a likely seat of the efficient cause of the pearly muscæ. It is somewhat surprising, that no author has thought of attributing the appearances to the remains of the vessels of the pupillary membrane. The direct experiments already detailed, (Exps. 6, 7,) however, demonstrate that the cause of the pearly muscæ must reside close to the retina.

3. *Humour of Morgagni.*—Prevost‡ places the cause of the pearly muscæ in the humour, supposed to exist between the crystalline lens and its anterior capsule. He conceives rightly, that the permanency of the appearances precludes any such inconstant

* Treatise on the Eye, Vol. ii. p. 78. Edinburgh, 1759.

† Quoted from Plater's Observationes, Lib. i. by Plempius, in his Ophthalmographia, p. 138. Lovanii, 1648.

‡ Op. cit. p. 250.

cause as small bodies floating in the aqueous humour. Such a cause, he urges, would produce irregular and variable appearances, but could not apply to such spectra as he himself had found to be unchanged for a track of years. He admits, but certainly without any proof, that the apparent descent of the muscæ depends on an actual descent of their cause, from its gravity, within a fluid less dense than itself, in the interior of the eye. Were this granted, the question, no doubt, would be very much narrowed. For if the cause sinks in the eye, and the spectrum seems to the observer to sink, then the cause must be situated before the focal centre of the eye. (§ 21.) Were it situated nearer to the retina than the focal centre, then, the cause descending, the spectra would appear to rise. The reverse of this, I think, is most likely to be actually the case, the corpuscles or filaments which produce the appearance of the pearly muscæ being probably extremely fine, and of less specific gravity than the vitreous fluid.

Limited by his arguments to the parts situated between the aqueous humour and the focal centre of the eye, Prevost fixes on the humour of Morgagni, which, he says, lubricates the capsule of the lens at its anterior part. "We can conceive," says he, "in that humour, situated between the crystalline and its capsule, a concretion of very small size, capable of intercepting the rays, and several such concretions may adhere together, or be connected by a filament. The movement of fixing the eye upon an elevated object may, by a slight pressure, make these opacities rise; whilst, again become free during the rest of the eye, steadily fixed, their specific gravity, a little greater than that of the humour, brings them slowly to their former situation."

The following considerations will set at rest, I think, the view of the subject adopted by Prevost.

1*st*, There is no such fluid as the humour of Morgagni in the healthy state of the crystalline body. On the contrary, the capsule adheres closely to the lens.

2*d*, Even the capsule itself, when torn to shreds, as it is in the operation of division of the cataract, unless greatly thickened by disease, is of less specific gravity than the aqueous humour, so that after the lens is absorbed, we sometimes observe portions of the capsule, fixed below but free above, floating up into the pupil. I cannot conceive the filaments upon which pearly muscæ depend, to be nearly so dense as the capsule.

3*d*, Pearly muscæ often remain visible after the operation for cataract, the capsule having been divided, and the lens removed by extraction or absorption, so that the seat assigned to their cause by Prevost is no longer in existence.

While we reject entirely, then, this part of Prevost's doctrine, we must not omit noticing his statement, that semitransparent bo-

dies within the eye might affect the retina, some of them by the *refraction* of the rays of light, and all of them by its *diffraction*, the coloration resulting from the latter cause being little observable at so small a distance.* That the pearly muscæ are shadows, magnified by diffraction, seems extremely probable; and although their edges do not appear coloured to the generality of observers, we shall find that this is not always the case.

4. *Vitreous humour.*—It is the opinion of Aepinus, Young, Wardrop, Weller, Andreæ and Brewster, that the cause of *muscæ volitantes* resides in the vitreous humour.

Aepinus† thinks that any obstacle placed before the pupil, or close behind it, in the crystalline or elsewhere, conformably to the laws of dioptrics, might prejudice the clearness of the image painted at the bottom of the eye, but could not project a picture of itself on the retina. This leads him to regard the vitreous humour, close to the retina, as the seat of the cause of *muscæ volitantes*. The argument, however, is not perfectly conclusive, for transparent globules, or even opaque filaments, placed in the aqueous humour, admitting that they could not form images on the retina simply by the light reflected from them, might still be capable of doing so by the light refracted by them, or diffracted by their edges, exactly as the mucus and tears occasionally do, which lie on the cornea, and form the muco-lacrymal spectrum already described. (§ 7, 8, 9.)

Aepinus disproves the notion, that muscæ, or, at least, that all muscæ, depend on a paralytic affection of the retina, by an optical observation, which he acknowledges to be difficult of execution, on account of the muscæ not being situated in the optic axis, and which must therefore be made by attending to a particular spot while not directing the eye towards it. He tells us, that the spots or muscæ, which he observed, appeared to be of two kinds; the one resembling knotty threads interwoven in various ways, and transparent, like lymphatic vessels; the other, round and semi-opaque, like smoke or a thin cloud.

"In the latter kind of spots," he says, "I observed a peculiar phenomenon, which seems to show distinctly what is the nature of these spots. If, for instance, the line FG (Fig. 6,) separates some certain opaque body HFGI from a transparent one FGKL, which is vividly illuminated by light passing through it, and the eye is so placed that some certain spot falls by its one-half ADC upon the opaque body, and by its other half ABC upon the transparent body, the part ABC will appear as if covered with a cloud, but the part ADC, which ought to appear opaque, appears also

* Op. cit. p. 254.

† Novi Commentarii Academiæ Scientiarum Imperialis Petropolitanæ, Tom. x. p. 291. Petropoli, 1766.

sensibly illuminated, so that the opaque space does not appear to be separated from the transparent by the straight line FG, but as if it were bounded by the line FADCG, composed of two straight lines and a semicircle.

"This phenomenon seems scarcely compatible with the opinion which regards this disease as a paralytic affection; for were it such, the space ADC could in nowise appear illuminated, but rather its appearance ought to be as if the opaque body were terminated by the line FABCG, not, as it always is, by the line FADCG. It is to be concluded, then, conformably to the laws of dioptrics, that there is some obstacle present in my eye, situated behind the aperture of the pupil, and near the retina, which impedes some rays in their passage, and irregularly disperses the rest."

The appearance here described by Aepinus is what we should expect to be produced by a semitransparent body, situated at some distance anterior to the retina, and viewed by bringing an opaque screen so far across it, that the edge of the screen should apparently coincide with the centre of the spot. It is to be observed that Aepinus does not say that ABC was quite dark, and ADC quite light. On the contrary, we would infer that the whole circle appeared dark, compared with the illuminated portion FKLGCBA, and decidedly less dark than the adjacent opaque space GIHFADC. But, in the circumstances supposed, ABC would appear darker than ADC, because the contrast with the adjacent illuminated space would be stronger. The inference drawn by Aepinus seems quite legitimate. If the dark spot, ABCD, in the field of vision, depended on a corresponding spot in the retina having lost its sensibility, or having its sensibility impaired, it is very difficult to conceive that the portion of *it* covered by the shadow of HFGI should appear *less* dark than the other portions of healthy retina, also covered by the shadow.

"As the whole eye, near the retina," says Aepinus, "is filled with the humour called vitreous, we may be certain the seat of the disease is to be sought for nowhere else than in this body. But as the substance of the vitreous humour contains, without doubt, very fine vessels, carrying a very clear lymph, it seems indubitable that the spots, of which I have been speaking, arise from an extreme dilatation of those vessels, by which it happens that there enter into them certain thicker parts, which are opaque, and refract the light differently from the lymph which they carry in the natural state; in short, I hold those spots to be as it were a varix of the lymphatic vessels."

Young* remarks, that *muscæ volitantes* "are sometimes, if not always, occasioned by an opacity of some of the vessels of the

* Introduction to Medical Literature, p. 167. London, 1813.

vitreous humour, near the retina. They are seen," says he, "in a full light, and cannot, therefore, as Sauvages has justly remarked, be caused by anything in the anterior part of the eye, and they may often be observed to change their form with the motions of the eye, which they could not do if they did not depend on some floating substance."

In that portion of his *Icones Ophthalmologicæ** which has been published, Weller, although he introduces his distinction of three genera of myodesopia, namely, the *local*, the *inflammatory*, and the *nervous*, describing the appearances of the first genus, and illustrating it by accurate representations, yet says nothing of the seat of *muscæ volitantes*. In the fourth edition, however, of his Treatise on the Diseases of the Eye,† (and it may be in the third, or in the second edition, neither of which I have seen,) he briefly states it as his opinion, that only the blood globules and the walls of the capillary vessels of the vitreous humour can produce the appearances of *muscæ volitantes*.

Those who believe that no lymphatics have been detected in the interior of the eye, will of course regard the opinion of Young and Weller as more probable than that of Aepinus. Mascagni alone has asserted the existence of lymphatics in the hyaloid membrane.‡

Mr Wardrop tells us, that muscæ "arise from different causes, and depend either on a morbid condition of the retina, or an opacity of some of the parts of the eye which are naturally transparent. In the latter case," says he, "the opacity must be in the posterior part of the vitreous humour, because experiments and the principles of optics prove that no opacity of the aqueous, crystalline, or anterior part of the vitreous humour can throw a partial shadow on the retina."§ Now, the muscæ which depend on a morbid condition of the retina are carefully to be distinguished from the pearly muscæ, which arise from corpuscles situated anterior to the retina. The former are fixed, the latter floating. As for the optical part of Mr Wardrop's statement, it is too loosely expressed, and has thereby attracted the critical observation of Prevost, who remarks that "an opacity, although very small, if sufficient to interfere with some of the rays of light, will inevitably affect the image." To settle the question, he took an artificial eye, and placed on the anterior surface of the lens which represents the crystalline, a fragment of a black wafer, sometimes in, sometimes out of the axis; and in both cases there was projected on the retina a black shadow or image, which he had no

* Fasciculus, i. Lipsiæ, 1824.

† Die Krankheiten des menschlichen Auges, p. 368. Wien, 1831.

‡ Descrizione delle Tavole citate nel Prodromo della Grande Anatomia, Tav. ix. Fig. 18, p. 52. Milano, 1821.

§ Essays on the Morbid Anatomy of the Human Eye, Vol. ii. p. 223. London, 1818.

difficulty in detecting. There is a difference, however, between such a fixed shadow as would be thrown on the retina by an opaque spot in the surface of the crystalline, the form of which would be altogether irrecognisable by the eye, and the diffracted mobile shadow which produces the definite sensation of *muscæ volitantes*.

Andreæ, the author of an elaborate communication* on our present subject, in which he carefully distinguishes the fixed from the floating muscæ, concludes from the peculiar motions of the latter, that they must have their seat not in any fixed part of the eye, nor in one partaking merely in the movements of the eyeball, but in a part which is moveable in itself and more or less fluid. He thinks the crystalline, confined within its capsule, to be too little moveable to explain the phenomena; while the two other media must be affected with an undulatory motion when the eyeball moves. The undulations of the aqueous humour he regards as too free, to correspond with the limited motions of the muscæ, the equable rising and falling of which he thinks can take place only in the vitreous humour. He holds the pearly muscæ, then, to be the shadows of opaque bodies floating in the vitreous humour and thrown upon the retina. In answer to the question, what those bodies are, he says they might be supposed to be blood-vessels, were it not that they do not ramify as blood-vessels do, but are merely single filaments twisted. He conjectures, that they may be depositions in the hyaloid membrane, affecting its transparency, as capsular cataract affects that of the crystalline capsule.

Our knowledge with respect to *muscæ volitantes* has been materially advanced, in several particulars, by the observations of Sir David Brewster, who includes under that general appellation the spectra which I have described (§ 12, 13, 14, 15, 16, 17, 18, 19, 20,) as the watery, the insulo-globular, and the pearly. Referring, doubtless, to these different spectra, without particularly discriminating them, he states that the cause why *muscæ volitantes* appear not only in different planes, but of four or five different sizes, arises from the filaments and spherical particles, whose diffracted shadows form the muscæ, being placed at four or five different distances from the retina, those which give the sharp, black, and minute shadows being placed near the retina, and those which are large and ill-defined at a greater distance from it. This being granted, it necessarily follows, that the vitreous humour is the seat of the cause of the muscæ, as no other part of the eye could afford space for the filaments and particles being so disposed in a series of planes. We could conceive the filaments and particles, no doubt, to be of different sizes, as well as situated at different

* Gräfe und Walther's Journal der Chirurgie und Augen-Heilkunde, Vol. viii. p. 16. Berlin, 1825.

distances from the retina, but this supposition would afford no explanation of the muscæ appearing the one set behind the other.

The limited motions of the muscæ are explained by Sir David to arise from the filaments and particles which give rise to them, being contained in the cells of the vitreous humour. "These various bodies," says he, "though they change their place, still preserve their general distance from the retina, thus clearly indicating that the vitreous humour is composed of cells within which the filaments and *muscæ* are lodged." He regards his experiments as demonstrative of there being at least four or five cells between the retina and the posterior surface of the crystalline lens. "The limited motion of the muscæ indicates," he says, "that the cell in which they float is of very limited extent." The motion, however, is perhaps not so limited as Sir David seems to suppose. On turning the eyes suddenly upwards, the filaments must sink through an extent of considerably more than 30°, and on fixing the eyes at that elevation above the horizon, they rise again so much, that their spectrum sinks entirely out of view. (§ 21.)

5. *Between the hyaloid and the retina.*—Hellwag and Steifensand place the cause of *muscæ volitantes* between the hyaloid and the sentient part of the retina.

Hellwag* was affected with both floating and fixed muscæ, and has described his case with great clearness. To account for the floating muscæ, he supposed a peculiar moveable fluid between the vitreous humour and the retina, without being able, as Andreae remarks, either to refer expressly to any such fluid, or to make it probable that such a fluid existed.

Steifensand† supposes, that in the motions of the eye there is an undulation or separation of the hyaloid from the retina, which, however slight, will be sufficient to cause a movement of the corpuscles situated in or between those membranes, and thus produce the appearance of floating muscæ. He seems to think that the corpuscles are seated in what he styles the *serous* lamina of the retina, that is to say, on its concave surface.

6. *Retina.*—St Yves,‡ having adopted the notion of Mariotte, that the choroid and lenticular ganglion form the sentient organ of vision, and that the retina serves merely as an epidermis, to moderate the impressions of light on the choroid, supposes the cause of *muscæ volitantes* to be a partial separation of the retina from the choroid, in consequence of a dilated state of the blood-vessels of the former. This causes, he says, an elevation or fold of the retina, which hinders the light in its passage to the choroid, and pro-

* Referred to by Andreae, op. cit. p. 21.

† Ammon's Monatsschrift für Medicin, Augenheilkunde und Chirurgie, Vol. i. p. 208. Leipzig, 1838.

‡ Nouveau Traité des Maladies des Yeux, p. 331. Paris, 1722.

duces a shadow which the patient sees in the air. This detachment he supposes to take place in several parts, and hence the multiplication of the muscæ.

Boerhaave* and Plenck† follow implicitly the dictate of Pitcairn, (§ 4,) that nothing floating in the eye can form an image on the retina, and that therefore the cause of muscæ must be insensibility of certain portions of the retina itself.

Rosas‡ admits, that *muscæ volitantes* may arise from partial opacities of the vitreous humour or the crystalline, effusions of lymph in the posterior chamber, a turbid state of the aqueous humour, and small central leucomata of the cornea, but evidently regards the retina as the texture which is generally affected. He represents myodesopia as originating in a congestion of blood, and pressure on the nervous substance within the eye, followed by varicose dilatations of the blood-vessels, and by thickening, induration, and other morbid changes of the retina.

Langenbeck, in his lectures on ophthalmology, makes a distinction, we are told,§ between that variety of myodesopia in which spots are seen flying before the eyes, and that in which certain immoveable appearances are perceived. The former he refers to an inordinate turgescence of the vessels, or even to certain nervous affections of the retina; and the latter to a morbid change in certain portions of the membrane itself.

Rudolphi‖ was of opinion, that muscæ depend on a sort of cramp or oscillation of the retina, similar to what takes place in many other parts, only that here visual appearances are the result. Hence, he thought, the endless changes in the form of the figures seen—a false fact, for muscæ present no such protean character.

That the pearly muscæ are not the result of any affection of the retina, such as insensibility of its fibres, caused by the pressure of its vessels in a dilated state, or by such vessels preventing the access of light to the sentient parts of the retina, appears fully proven by the real motions of the muscæ—a fact which can be explained only by supposing that the cause is floating in one of the moveable parts of the eye. As I have already noticed, also, the double images of the pearly and other entohyaloid muscæ seen in *Exp.* 7, set at rest the question as to the nervous or proper substance of the retina being the seat of the disease; for, were it so, no double image of the muscæ could be produced. I shall not pretend to decide that the cellulo-vascular lamina may not sometimes be the texture in fault, especially in cases where the cause

* Praelectiones publicae de Morbis Oculorum, p. 57. Gottingae, 1746.

† Doctrina de Morbis Oculorum, p. 201. Vinnae, 1777.

‡ Handbuch der theoretischen und practischen Augenheilkunde, Vol. ii. p. 509. Wien, 1830.

§ B. C. R. Langenbeck, de Retina Observationes Anatomico-Pathologicæ, p. 159. Gottingæ, 1836.

‖ Grundriss der Physiologie, Vol. ii. Erste Abtheilung, p. 239. Berlin, 1823.

is no farther from the sentient part of the retina than $\frac{1}{8\frac{1}{3}}$th of an inch, which is one of the measurements of Sir David Brewster. (§ 23.)

Besides, vision is not affected by the entohyaloid muscæ. Between the several portions of the muscæ, and by the side of them, the eye still sees everything with perfect distinctness, which could scarcely be the case were the disease the result of any morbid condition of the sentient texture of the retina. Even the portions of this membrane, over which the shadows which cause the appearances of the muscæ fall, are found by the patient, when the corpuscles ascend out of the field of vision, to be perfectly sensible.

7. *Choroid.*—The arguments now stated apply also to the conjectures of Ware and Tyrrell, that *muscæ volitantes* depend on certain diseased states of the choroid coat, affecting the retina.

Ware* considered it probable, that muscæ depended "on a steady pressure on one or more minute points of the retina which are situated near the axis of vision." He supposed such pressure might be produced by "small portions of lymph diffused irregularly between the choroid coat and the retina; by some minute particles of the *pigmentum nigrum*, larger or more uneven than the rest, or by one or more of the villi of the choroides itself."

Tyrrell† referred the cause of *muscæ volitantes* to a preternatural dilatation of some of the vessels of the choroid. "I cannot consider them," says he, "when of an evanescent character, (which nearly all the varieties occasionally are,) as the result of a morbid deposit; because I hardly conceive that such a deposit could take place, and again be removed with a rapidity equal to the appearance and subsidence of the muscæ." The evanescence here attributed to *muscæ volitantes*, like the endless changes in their form ascribed to them by Rudolphi, is a false fact. It is probable that neither Rudolphi nor Tyrrell had any personal experience of the disease.

§ 23. *Size of the elementary filament of the pearly spectrum. Its distance from the retina. Structure of the vitreous body.*

Every spectrum appears larger, in proportion as the ground upon which it is viewed is more remote from the eye; while its angular magnitude, of course, still continues the same. The size of the convoluted or agglomerated muscæ is quite indefinite. Sir David Brewster informs me, that a musca, which he sees, "would cover the moon, for it consists of a knot of filaments." But it is an interesting question, what is the size of the elementary or single filament of the pearly spectrum, or rather of the globules, by the concatenation of which the pearly thread is formed? Sir David, by looking through a very minute aperture at two bright sources of light, obtains, by two divergent beams, double images on the

* Op. cit. p. 264.

† Practical Work on the Eye, Vol. ii. p. 19. Lond. 1840.

retina of all objects placed within the eye-ball, and by this means determines the diameter of the musca or its filaments, its distance from the retina, its locality, and the form of the cavity by which its excursions are limited. "The filaments or muscæ in the anterior part of the vitreous humour," he says, "will have their double images very distinct: those in the middle of it will have their double images much nearer: those near the retina will have their two images close or perhaps overlapping each other; while any object on the retina itself, any black spot arising from defective sensibility, will have only one image, as it were. Now, if we measure the distance of the two sources of light from each other, and also their distance from the centre of visible direction, when the two images of the filaments, &c. are just in contact, we may determine the size of the filament and its exact position, as well as its distance from the retina. In making this experiment, I first found that the angle of apparent magnitude of the shadow of the filament, A, B, C, [referring to an elementary filament,] was eight minutes, and, consequently, that it subtended this angle at the centre of visible direction. Now, if we take the radius of the retina as 0·524 of an inch, the diameter of the shadow of the filament will be 0·00122, or $\frac{1}{820}$th of an inch, and its distance from the retina 0·0118, or $\frac{1}{85}$th part of an inch."

I have tried to find the diameter of the shadow of an elementary filament which I see with my right eye, by projecting the spectrum of it upon a micrometer, and marking its apparent size. It measured $\frac{1}{600}$th of an inch, which is not very far from Sir David Brewster's calculation.

Sir David speaks of the cells of the vitreous humour, between the retina and the back of the lens, as being only four or five in number, and yet very small, and the motions of the filaments within them of very limited extent. It seems extremely probable that the motions of filaments placed so close to the retina as $\frac{1}{85}$ inch will be very limited; but if there are no more cells than four or five between the retina and the back of the lens, they cannot be very small. The structure of the vitreous body still requires to be specially investigated. Exceedingly fine and transparent filaments have been detected* within it, and even fine membranous laminæ, pale, and finely granulated, as I am informed by Mr Wharton Jones; but any thing like cells has never been made out. The following fact would lead me to doubt the existence of the alleged vitreous cells; or, if they do exist, they must be very easily broken up. In a disease which I lately had occasion to describe,† namely, *postfebrile ophthalmitis*, I repeatedly observed an effused film of a whitish colour,

* Pappenheim's Gewebelehre des Auges, p. 182. Breslau, 1842.
† London Medical Gazette, Vol. xxxiii. p. 225. London, 1843.

probably lymph, waving in the vitreous humour. Its excursions were far from being limited in the way we should expect, were the vitreous body made up of small cells. On the contrary, as the head was bent from side to side, the film traversed a space equal to at least a quarter of the diameter of the eye-ball. This was very apparent when the pupil was dilated by belladonna.

§ 24. *What are the filaments and corpuscles in the vitreous humour which cause the watery, insulo-globular, and pearly muscæ?*

Upon this point, we are not only left entirely to conjecture, no decisive observations, either in the living or in the dead subject, bearing upon it, but objections occur to every supposition which can be suggested.

As by means of proper experiments (§ 12), the pearly spectrum is rendered visible to all eyes, whether young or old, (and the same holds, I believe, with respect to the watery and the insulo-globular,) the efficient cause, or object seen, can scarcely be the result of disease, however much the being sensible of these spectra to the extent of what is termed *muscæ volitantes*, must be admitted to be the effect of some abnormal condition of the eye.

I have already referred (§ 21), to the opinions of Aepinus, Young, and Weller, respecting the nature of the filaments which produce pearly muscæ; the first supposing them to be varicose lymphatics, and the others blood-vessels.

"Were they fixed or regularly distributed," says Sir David Brewster, speaking of the filaments in question, "we might regard them as transparent vessels which supply the vitreous humour; but, existing as they do in detached and floating portions, they resemble more the remains of some organic structure whose functions are no longer necessary."

I have already noticed Andreæ's objection, viz. that the filaments, though twisted, are single, and not ramified, as blood-vessels are—an objection with which I cannot altogether concur, for the pearly muscæ often present a branched appearance.

Sir David Brewster has pointed out an error, into which I fell in the first edition of my Practical Treatise on the Diseases of the Eye. When I published that edition, I had not been troubled with *muscæ volitantes*, but drew my account of them from patients who had consulted me respecting them. On the authority of some of these, I stated that the globules of the pearly muscæ are sometimes seen in motion, within the tubes which seem to contain them. I was led to conjecture, from this statement, that the globules, seen in the pearly muscæ, were nothing else than blood-globules passing through the vessels of the retina or of the vitreous humour. I by and bye found, by my own experience,

that the globules had no progressive motion, and, of course, corrected my former statement in my second edition.

The observation of Sir David Brewster, that the filaments, existing in detached and floating portions, resemble more *the remains of some organic structure, whose functions are no longer necessary*, than vessels actively engaged in nourishing the vitreous humour, tallies remarkably with the two following facts :—

In the *first* place, the globules, seen in the pearly muscæ, are at rest in the tubes, within which they seem contained.

In the *second* place, the artery or arteries which traverse the vitreous humour, or *capsular* arteries, as they are often called, generally two in number, springing from the central artery of the retina where this vessel enters the cavity of the eye, and passing through the vitreous body to the posterior capsule of the crystalline, although undoubtedly occupied by circulating fluid in the fœtus, have never been injected in the adult, but are always in a contracted, and, according to some anatomists, in an obliterated, or ligamentous state.

Sir David Brewster was perhaps not aware of the latter fact, which coincides so remarkably with his conjecture. In the vitreous humour, and stretching from the entrance of the optic nerve, forwards and outwards to the back of the crystalline, there lie what we may call the exuviae of *an organic structure whose functions have ceased*, consisting of filaments or contracted blood-vessels, none of them likely to exceed $\frac{1}{300}$ inch in diameter, and most of them probably much smaller. It does not seem unreasonable to suppose these filaments partially filled with arrested blood-globules, more so perhaps in some subjects than in others, and capable of being refilled on certain occasions. The appearance, too, of globules within tubes, as is seen in the pearly muscæ, is such as we might suppose minute vessels and blood-corpuscles to present, each globule seeming to be supplied with a central nucleus.

Still we must receive all this as mere conjecture, to which every objection which can be started must be weighed. Dr Schroeder van der Kolk states,* that the vessels in question vanish completely in the adult. Were this the case, the above conjecture would fall to the ground, and we should be forced to seek for some other probable efficient cause of the phenomena. I believe, however, that after immersing the vitreous body in alcohol, the obliterated vessels will always be found, surrounded by the prolongation inwards of the hyaloid membrane called the *canalis*

* Anatomisch Pathologische Opmerkingen over de Ontsteking van eenige Inwendige Deelen van het Oog, en bijzonder over Choroiditis als Oorzaak van Glaucoma. Amsterdam, 1841.

hyaloideus. Home noticed* the *canalis hyaloideus* in the ox as bearing a resemblance to a lymphatic vessel.

The exterior surface of the hyaloid membrane is covered with blood-vessels, especially in the fœtus, as is mentioned by Arnold.† Schroeder van der Kolk describes four arteries, under the name of *vasa longa membranæ hyaloideæ*, which branch out from the central artery of the retina, upon the external surface of the vitreous body. If we suppose even a very slight mobility of the hyaloid membrane, the diffracted shadow of these vessels on the retina might account for the appearances of the pearly muscæ, while the insulo-globular and the watery might be ascribed to the remains of the capsular arteries.

Guttone‡ distinguishes two varieties of muscæ volitantes, the one with good, and the other with bad sight. He places the seat of the former in the humour of Morgagni, and ascribes the latter to a breaking loose and a waving of the hyaloid membrane within the vitreous body, where, however, no distinct membrane is to be found, but merely exceedingly fine laminæ and filaments. (§ 23.)

Andreæ's conjecture I have already mentioned, namely, that opaque depositions in the hyaloid membrane throw their shadows on the retina, and thus cause muscæ. The corpuscles and filaments, however, which cause the pearly, as well as the insulo-globular and watery spectra, are transparent. The partial opacities which they produce is the result of their peculiar action on light, as I shall presently explain. (§ 25.)

Donné§ detected the same sort of globules in the vitreous humour which he saw in the aqueous.‖ As the appearance of a tube, containing globules, in the pearly muscæ, may be entirely the result of diffraction, the whole phenomena of the insulo-globular and pearly spectra may be referred, with much probability, to a concatenation of transparent globules attached to the hyaloid filaments. The watery spectrum, viewed neither with the naked eye, nor through a fine aperture, exhibits any appearance of globules, and is therefore likely to depend simply on fine transparent filaments in the anterior part of the vitreous body.

The suspicion that muscæ volitantes are caused by entozoa in

* Philosophical Transactions for 1798, p. 339. London, 1798.

† Anatomische und Physiologische Untersuchungen über das Auge des Menschen, p. 107. Heidelberg, 1832.

‡ Ammon's Zeitschrift fur die Ophthalmologie, vol. ii. p. 47. Dresden, 1832.

§ Op. cit., p. 114.

‖ Mr Wharton Jones, whose character as a microscopic observer in physiology and pathology stands so high, informs me that the number of corpuscles in the aqueous and vitreous humours is very considerable, some being elementary granules, but most of them resembling one stage of the lymph corpuscle. Most of them measure between $\frac{1}{4000}$ and $\frac{1}{5000}$ inch in diameter. They are of less specific gravity than the fluid in which they are contained.

the vitreous humour, seems to have been seriously entertained by Nordmann,* while Neuber, it is stated by Himly,† proposed to kill the creatures by galvanic shocks passed through the eye! But the motions of muscæ volitantes are excited only by those of the eye-ball, and bear no resemblance to the voluntary movements of an animal. Besides, the filariæ, monostomata, and distomata, which have been detected in the human eye, have all been resident in the crystalline, none of them in the vitreous humour.

Parfait-Landran supposes‡ that, in one case, he discovered in the living eye the bodies which cause muscæ volitantes. The patient saw black points and other spectra with his right eye, such as Demours describes. On examining the eye, Parfait-Landran observed minute bodies dancing within the eye, of a phosphoric splendour. On dilating the pupil by belladonna, he convinced himself that the bodies in question were in the vitreous humour. He says they resembled powder of liquorice, and that some of them shone like fine gold filings. On allowing the eye to rest, they fell to the bottom of the vitreous humour, and rose again on the least motion of the eye, then becoming visible to the patient. This is, no doubt, a curious and anomalous case, but cannot be regarded as throwing any light on the cause of muscæ volitantes. I once saw the crystalline, after I had divided it for cataract, resolve itself into thousands of shining silvery atoms.

§ 25. *Action of the filaments and corpuscles, which cause muscæ, on light.*

Sir David Brewster agrees with Porterfield, in regarding the filaments and corpuscles which cause muscæ volitantes, as transparent; but differs from him as to their mode of action on light. Porterfield§ conceives that the rays which pass *through* the corpuscles and filaments, having their *refraction* thereby increased, will be made to meet nearly at the retina, where they will form luminous figures with dark and shady borders, just as a convex lens when exposed to the sun, forms its luminous focus in the middle of a very strong shade with which it is environed. On account of their perfect identity with the phenomena of the *diffraction* of light, produced by transparent fibres and films of different forms, Sir David Brewster, on the other hand, ascribes the appearances seen to shadows, formed on the retina by divergent light, passing *by and through* transparent filaments and particles; a view of the matter which had already occurred to Prevost.

* Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere. 1es. Heft, p. 24. 2es. Heft, p. xi. Berlin, 1832.

† Krankheiten und Missbildungen des menschlichen Auges, vol. ii. p. 464. Berlin, 1843.

‡ Revue Médicale, Tome iv. p. 203. Paris, 1828.

§ Treatise on the Eye, vol. ii. p. 78. Edinburgh, 1759.

When Sir David says "divergent light," he refers to those experiments by which the light which falls on the retina is made to diverge from a point within the eye-ball. No doubt, the muscæ are seen very distinctly when we look through a fine aperture, or through a lens, so as to produce divergent light within the eye; but the phenomena of diffraction are visible when the rays of light are convergent or parallel, as well as divergent, and so also are the pearly muscæ. Indeed, the identity of the phenomena of the pearly muscæ with those of diffraction by fibres, is more strikingly displayed when the muscæ are regarded with the naked eye against the sky, than in any other way of viewing them. What appears, when seen through a minute aperture, as a string of globules, assumes, when viewed against the sky with the naked eye, the form of a tube, with a central dark line running through the middle of it, the result, no doubt, of the two streams of light, which flow round the filament, interfering with one another. Sir David Brewster states, that the two lines bounding the filaments which he sees are coloured, and have, on the outside of each of them, one or more coloured fringes,—another circumstance which is to be referred to the interference of light.

The identity of the phenomena displayed by muscæ volitantes with those of diffraction by fibres may be shown in various ways. The following is one of the easiest:—

Exp. 12. In front of a convex lens of one-fifth of an inch focus, place any fine fibre, such as one of silk, cotton, wool, or glass, and through the lens direct the eye towards a candle at the distance of twenty feet. The rays of light, passing by the edges of fibres, are diffracted, and a magnified image of the fibre is seen, bearing a close resemblance to the appearance of the pearly muscæ, when viewed with the naked eye against the sky. The shadow of the fibre presents a number of parallel streaks or fringes, alternately light and dark. The central line is narrow and light.* On each side of this line is a broad dark stripe, then a light stripe on each side, then a narrow dark stripe. The dark stripes are the consequences of certain of the rays which bend round the fibre interfering with one another; while the other rays combine and produce the light stripes.

The sharply defined insulo-globular spectrum is also plainly referrible to the diffraction of light by minute spherules; but the obscurely defined insulo-globular and the watery spectra betray much less distinctly alternate rings or stripes, owing, no doubt, to the comparatively greater distance at which they are placed from the retina, or screen on which the diffracted shadows are

* This is evident enough in the experiment; but, probably from its extreme minuteness, the central light line is not perceptible in the pearly muscæ. At least, I have never been able to detect it.

thrown, and which, to display distinctly the phenomena resulting from interference, requires to be at a certain determined distance from the body whose shadow it receives.

I have already mentioned (§ 18,) that the threads of the pearly muscæ sometimes seem to terminate in dark bulbous extremities, which Weller supposes to arise from one end of the thread turning itself, so that it points towards the retina. It is much more probable that the appearance in question is owing merely to the fringes widening, and becoming convex, as they always do at the angular termination of the bodies which cause them, or assuming the crested form described by Grimaldi, as they do when the termination is rectangular.

§ 26. *Subjects of the pearly muscæ volitantes.*

Speaking of the filaments by which *muscæ volitantes* are produced, Sir David Brewster observes, that "as they exist in all ages, whether young or old, they are neither the result of disease, nor do they indicate its approach." Certain it is, that the pearly spectrum is recognisable by all eyes, when sought for through a pinhole, or through the eye-glass of a compound microscope. (§ 12.)

It is also true, that the same objects which produce pearly spectra are seen by many individuals, who do not make any formal complaint of *muscæ volitantes*, or ever fancy that they are affected with any disease of their eyes. "I was consulted," says Demours, "not long ago, by a lady, who was firmly persuaded that these floating phantoms, which she had begun to perceive, would lead to blindness. I found in her house twenty persons, whom I begged leave to question: out of the twenty, seven had seen them for a great number of years, without having ever spoken of them: one young person added, that she amused herself greatly in seeing them descend in the air." * "These muscæ," says Weller," are evidently not observed, or are entirely neglected by those, who, taken up by business, want leisure to think of their disease." On the other hand, they are never so troublesome as when they coexist, either with some other affection of the eyes, such as asthenopia, or with disease of some other organ, such as dyspepsia. Any disorder which unfits one for exertion, and leads to brooding over one's complaints, such as hypochondriasis, is extremely apt both to lead to the detection of *muscæ volitantes*, and to fill the mind with apprehensions regarding their result.

§ 27. *Condition of the eyes of those affected with entohyaloid muscæ.*

The eyes of those troubled with the *muscæ volitantes*, which we have hitherto described, present no objective symptoms, by

* Traité des Maladies des Yeux, Tome iii. p. 422. Paris, 1818.

which the existence of such an affection can be detected. Yet eyes of normal conformation are seldom subject to *muscæ volitantes*. On the contrary, when a person complains much of this symptom, we always find him myopic or presbyopic ; or perhaps myopic with the one eye, and presbyopic with the other.

The pupil of an eye affected with muscæ is generally small, even when the eye is myopic.

When the one eye is myopic, and the other presbyopic, the muscæ seen by the former appear smaller than those seen by the latter, and do not display so strikingly the striped appearance arising from interference.

If the over-refraction of a myopic eye is compensated by a concave glass, or the under refraction of a presbyopic one by a convex glass, the muscæ seen by those eyes become somewhat less evident for the time.

These facts show, that however true it may be, that the pearly muscæ are the result of diffracted shadows thrown upon the retina, and are not seen, as Porterfield believed them to be, by rays which pass through dense particles having suffered a greater refraction than those which pass by them, yet the interception of the rays, proceeding from external objects, by the filaments in front of the retina, or even the formation of magnified shadows by diffraction, produces comparatively little effect when the remainder of those rays are brought accurately to focal points upon that membrane. Dilution of the images of external objects favours the perception of the muscæ, which, in their turn, are, to a certain extent, extinguished in perfect vision.

§ 28. *Exciting causes of entohyaloid muscæ.*

Most of the patients who complain of pearly muscæ ascribe the origin of the affection to some exciting cause. It is extremely probable, however, that in many instances there is merely a coincidence, in point of time, between the circumstances blamed by the patients and their first remarking the existence of the muscæ, and no such relation as that of cause and effect.

The following are among the exciting causes most frequently mentioned.—

1. Over-use of the eyes upon minute objects, as in reading, writing, painting, and the like. As often connected with this cause, may be mentioned intense application of the mind. Nor are the want of proper exercise and the bent posture of the body to be omitted as concurrents.

A gentleman, who had been a few years in practice as a surgeon, and who had attended my lectures on the eye, came to me, complaining of muscæ. On inquiring whether he could trace them to any cause, he told me that he ascribed them to his having po-

sitively read through Cooper's Surgical Dictionary, a large book printed in a small type. He died not long after of apoplexy.

Charles Bonnet consulted Van Swieten about pearly muscæ which he saw, and which he attributed to too much use of the microscope. Van Swieten replied, that having employed the microscope himself too frequently, when a young man, in the examination of anatomical injections, he had brought on the very same appearances as his correspondent.*

Hanmann says,† he brought on myodesopia by straining his eyes in the study of Greek, at a period when they were already weakened by previous disease.

Nothing serves so much to increase the perception of *muscæ volitantes*, as often searching for them through pinholes, lenses, &c. Such experiments seem to rouse them into existence, and he who has thus brought himself to discover them, continues to see them, and cannot get quit of them. "Almost all the mathematicians and all the microscopical observers that I know," says Walther,‡ "have *muscæ volitantes*, which is, therefore, an appearance referrible to the strained state of the eye, and the too great use of sight."

2. It is a common opinion that muscæ are a sign of congestion in the head and eyes, and often the precursors of apoplexy. Overuse of the eyes probably acts detrimentally, by producing congestion; and other influences, likely to cause a determination of blood to the brain, are sometimes referred to by patients, as having brought on muscæ. Thus, the excitement attendant on sexual connection, while under the influence of wine, was mentioned to me by one patient as the cause which suddenly gave rise in him to *muscæ volitantes*.

3. Febrile diseases are very apt to bring on muscæ, and none more so than the epidemic catarrhal fever, called influenza.

I have already referred to Dr Stark's account of his own case, which is a very interesting one, notwithstanding his confounding together several different kinds of spectra with which he was affected. He attributes the origin of his complaint to a severe course of study while labouring under influenza, and at the same time straining his eyes in microscopic pursuits.

4. Inflammatory diseases of the eyes are frequently followed by the pearly muscæ and their congeners. I have known not only retinitis and iritis to produce them, but even catarrhal conjunctivitis.

* Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, Tome v. p. 262. Genève, 1832.

† Ammon's Monatsschrift für Medicin, Augenheilkunde und Chirurgie, Vol. iii. p. 427. Leipzig, 1840.

‡ Grafe und Walther's Journal der Chirurgie und Augen-Heilkunde, Vol. iii. p. 19. Berlin, 1822.

5. Want of the due quantity of sleep, the being roused from rest night after night, and above all watching during a number of successive nights, with little sleep even during the day, appear in many instances to bring on myodesopia.

6. Disordered digestion is regarded as a cause of muscæ. Nothing is more common, when such an affection of the eyes is spoken of, than for both patient and practitioner to exclaim, It is the stomach! Certain it is, that the disease is often met with in patients who are labouring under disorder of the stomach and bowels, being troubled with want of appetite, indigestion, acidity, flatulence, and costiveness.

7. Mr Wardrop has pointed out a disturbed action of the heart, as a cause of muscæ.* In consequence of some change in the action of the heart, or of its actual hypertrophy, the blood is distributed, he thinks, unequally to the brain and nerves, and amongst other effects, muscæ, which he terms "ocular spectra," are produced. Agitation of the circulation, a peculiar thrill in the pulse, swimming in the head, whizzing noise in the ears, and increased impulse of the heart, are amongst the attendant symptoms.

8. Another cause to which the origin of muscæ is often attributed, is what is styled nervousness, weakness of the nerves, an impaired state of the nervous system, or a morbidly sensible state of it. Thus, Mr Lawrence speaks of the disease occurring "when the energy of the nervous system is impaired by pressure of business, by anxiety and distress, by severe and continued affliction, or overwhelming grief."†

Mr Ware tells us, that when "a morbid sensibility is excited, like that which general debility or much anxiety is apt to occasion, the retina, (which has a larger quantity of nervous medulla spread over it, in proportion to its dimensions, than any other part of the body,) becomes morbidly impressed by any little points or projections that happen to be in contact with it." A steady pressure, then, on one or more minute points of the retina, along with a morbid sensibility of the membrane, are regarded by Mr Ware as the conditions on which muscæ depend. "The more common exciting cause of these motes," he adds, "appears to me to be too close application of the mind to objects that occasion anxiety or distress."

Before making a few remarks on the exciting causes above enumerated, it may be proper to mention, that the entohyaloid muscæ, independently altogether of the degree of light to which the eyes are exposed, or the general state of body and mind of the person affected, are liable to vary from time to time in number and intensity, although much less considerably and less sud-

* Lancet, September 13, 20, 1834, pp. 887, 924.

† Treatise on the Diseases of the Eye, p. 582. London, 1841.

denly than some authors have represented. Hence the question, whether, invisible under ordinary circumstances, they become visible in consequence of an increased sensibility of the retina.

"This supposition," observes Sir David Brewster, "is by no means probable, because the muscæ are not visible by any light of their own, and an increase of sensibility in the retina would affect equally the luminous field on which they are seen. But as this point is of some importance both in a physiological and a medical aspect, I have submitted it," he goes on to say, "to direct experiment. With this view, I examined the muscæ in the morning before the sensibility of the retina had been diminished by exposure to day-light, and found that they were neither increased in number nor intensity. I varied this experiment by diminishing the sensibility of the retina. This was done by holding a bright gas flame close to the eye, and near the axis of vision, till the retina lost its sensibility to all the rays of the spectrum, except a few of the more refrangible ones. In this case, too, the muscæ were as numerous and distinct as before, and we may therefore consider it as certain, that the muscæ described by Mr Ware, in so far as they were of the same character as those in the healthy eye, are not affected by any variation in the sensibility of the retina."

To recur to one of the most certain exciting causes of pearly muscæ, How do the ophthalmiæ, it may be asked, lead to this disease? It is well known, that in every severe ophthalmia, whatever be the texture primarily or principally affected, the whole blood-vessels of the eye become injected. In iritis and retinitis, this is attended with dimness of sight, often to a great degree; in iritis, from effusion of opaque lymph into the pupil, and in retinitis, from a similar effusion on the surface of the retina or into the vitreous body. As the effusion in either case is removed, vision clears, but of *muscæ volitantes* the patient now almost invariably complains. It has already (§ 23,) been stated, as a conjecture, that the most common kind of muscæ, the pearly, may perhaps be the result of the blood-vessels, which run forwards through the vitreous body towards the lens, becoming perceptible, by means of their diffracted shadows, and that the circumstance of their being seen much more by some than by others should be attributed to their obliteration being less complete in some subjects than in others. If this conjecture be true, may not the occurrence of muscæ after a severe ophthalmia be the consequence of the contracted vessels yielding to the push of the blood from the central artery of the retina, of which the vessels in question are branches, so as to readmit a certain quantity of blood, which either remaining there or becoming effused, gives rise to *muscæ volitantes?*

Almost the only cause by which the contracted vessels which advance through the vitreous body could become more visible to some individuals than to others, is what I have just now stated; namely, a partial refilling with blood. Perhaps a minute effusion of blood may sometimes happen. The globules, whether within or without the vessels, will probably form only single rows, so that were either the arteries in question, or the little chains formed by their effused contents, lying before us, out of the eye, they would measure no more than from $\frac{1}{4000}$ to $\frac{1}{2000}$ inch in diameter, and be therefore invisible to the naked eye; but within the eye, close to the retina, and seen by light which is first strongly converged and then diffracted, they may produce the sensation of the insulo-globular or the pearly spectrum.

If we examine into the probable mode of action of the several exciting causes of muscæ, besides the ophthalmiæ, we shall find that all of them have a tendency to produce a determination of blood to the vessels of the head and eyes. Over-use of the eyes upon minute objects, intemperance, the venereal orgasm, a union of these, febrile diseases, extraordinary excitement or actual disease of the heart, it will readily be granted have this tendency. As for disordered digestion, which is often blamed for producing myodesopia, I suspect that in most cases the disorder of the stomach and the affection of the eyes are merely coincident effects, arising from one and the same cause; such as improper diet, neglect of the bowels, a torpid condition of the liver, and very frequently, even when it is least suspected, the use of alcohol, especially in the shape of drams and cordials. Pressure of business, anxiety, distress of mind, and grief, which form another set of exciting causes, operate in all likelihood exactly in the same way, producing, (it may be in persons of feeble health,) congestion of the head and eyes, and filling with blood the contracted capsular vessels.

Nor is want of sleep an exception to the general principle, that all the exciting causes of myodesopia act by producing congestion. Whether watchfulness arises from disease, artificial means employed to produce it, as the use of coffee, which Bereis* particularises as a cause of muscæ, the urgent calls of professional occupation, or prolonged study, it always leads to an irregular action of the circulating system, and an unnatural determination of blood to the organs of vision.

§ 29. *Prognosis in cases of entohyaloid muscæ.*

As the muscæ of this class often occur suddenly, the patient is apt to be alarmed by their appearance, and to suppose that he is

* Dissertatio de Maculis ante Oculos volitantibus, Helmstädt, 1795, quoted by Andreæ, op. cit. p. 24.

about to lose his sight by cataract or by amaurosis. We may calm his fears on these heads, for with neither cataract nor amaurosis have these spectra any connection whatever. Even on the supposition that a gradual increase of the muscæ is to take place, not even the greatest possible accumulation of them can ever end in the production of an amaurosis, and much less of a cataract. It will be well, however, in any case in which the practitioner is consulted, to ascertain whether, independently of the muscæ, there be any symptoms of either of these two diseases present. The presence or absence of cataract we ascertain by the use of the catoptrical test, that is, by moving a lighted candle before the suspected eye, and observing whether the inverted image, formed by the reflection of the light by the posterior surface of the crystalline body, is distinct or not. If perfectly distinct, there is no cataract. We have no such simple or certain test of amaurosis. But if the pupil moves with its natural vivacity, and the patient is able to read a small type with the suspected eye, we may assure him it is not affected with amaurosis.

A question, which the patient is very likely to put to us, is, whether the floating motes and threads which he sees are not liable to increase, and that to such a degree as at length to deprive him of sight. That they increase is true, although only very slowly, and never to such an extent as materially to interfere with vision. Even when the whole field of view presents entohyaloid spectra, the patient is still able to read, although, as he continues to do so, the muscæ sometimes gather together, so as to render portions of the page before him temporarily obscure. Very often they remain stationary for ten or twenty years, or increase by almost insensible degrees; and, although alarming at first, the patient gets habituated to them, and troubles himself no more about them. I believe the increase of myodesopia arises more from the eye becoming in a greater degree susceptible to the impressions of the bodies which cause this disease, than from any increase of the bodies themselves. This increasing susceptibility arises from over-use of the eyes, and from searching for and examining the muscæ too much.

Sir David Brewster takes rather a gloomy view of the matter, when he tells us, that "it is quite possible that some of the cells near the retina and around the optic axis might be filled up with accumulated muscæ, and produce a considerable degree of blindness;" and that, "though these filaments have no morbid character, they may, nevertheless, obstruct and even destroy vision."

The remark, that "these filaments have no morbid character," is founded, I presume, on the fact, that their existence may be detected in some degree by every eye, if recourse is had to the methods formerly (§ 12) described. Arriving, however, to such

a pitch as to attract notice as *muscæ volitantes*, they may fairly be considered as constituting a disease. If this disease consists in seeing the branches of the central artery of the retina, which advances through the vitreous humour towards the lens, or those which ramify over the external surface of the hyaloid membrane, the danger of their filling up any of the cells of the vitreous humour, or accumulating round the optic axis, so as to destroy vision, may be regarded as chimerical. If the corpuscles, which are seen, be an extravasation or deposition from the vessels, certainly we might conceive them accumulating more and more, till they proved a complete barrier to distinct vision; but experience gives no support to such an apprehension.

Many authorities might be quoted to prove, that entohyaloid muscæ increase only with extreme slowness, or remain entirely stationary, and sometimes become even less perceptible.

"I know many people who have complained to me of such things fifteen and twenty years ago, and who are still at this moment in the same state." Maître-Jan.*

"These kinds of phantoms, which increase sometimes very slowly during the first five or six years, continue during the whole remainder of life without any kind of inconvenience. * * * I know a great number of persons who have seen them thirty, forty years, and more, without their number or their figure having undergone the slightest change." Demours.†

"Twenty-five years after I had been first consulted in this case I again saw the patient. She then enjoyed good health and spirits. The motes were still occasionally perceived, but they had become so faint, that she could only see them in a strong light, and when she took pains to look for them. It ought, however, to be mentioned, that at this time her daughter was just married, whereas, when she first consulted me, she had lately lost her husband." Ware.‡

"Twelve years afterwards, I had occasion to see this gentleman again, when he informed me that he retained the perfect sight of both eyes, and could distinguish the most minute objects with either of them. In a bright light, however, he still perceived the motes as before, if he took pains to look for them; but he was now so much accustomed to their appearance, that they did not occasion any uneasiness." Ibid.§

"It is certainly for from twenty to thirty years that I have seen these same appearances," says Prevost, at the age of 50; and, at the age of 79, he adds, "Since, up to a very advanced

* Traité des Maladies de l'Œil, p. 281. Troyes, 1711.
† Traité des Maladies des Yeux, Tome iii. p. 421. Paris, 1818.
‡ Op. cit. p. 258.
§ Ib. p. 260.

age, I have enjoyed very good sight, I may support, by my case, the opinion of the oculists who reckon these appearances of small importance."*

"They are quite innocent in their nature, and exist in persons whose powers of vision are most acute. I have been subject to them from childhood." Müller.†

§ 30. *Treatment of entohyaloid muscæ.*

Entohyaloid or floating muscæ are not much under control, and are very seldom removed by medical applications. If of old standing, and not increasing, it is needless to interfere. When of recent origin, and the exciting cause evident, they are sometimes cured.

The treatment most likely to be useful is as follows:—

1. The patient must be put on his guard against the exciting causes, and carefully avoid them; such as, too much straining of the sight, excess of every sort, night-watching, the use of alcohol in any form or quantity, and the like. "The only means which often does good in this disease," says Walther, "is rest of the eyes, and abstaining from every employment which strains the sight. I know patients who have got completely free of *muscæ volitantes* which they had seen for several years, by giving their eyes long-continued rest, which, however, again appeared, as soon as they wrought for some days, so as to strain their sight."‡

2. If the stomach is weak, and the bowels costive, a course of laxatives, followed by tonics, should be prescribed. To strengthen the constitution, and especially the nervous system, should by every likely means be attempted. This indication will best be answered by cinchona, steel, and the cold bath. Richter mentions the case of a lady, who was troubled with this disease after a difficult labour, and who was completely freed of it by the continued use of sulphuric ether. In another case, in which the digestion was much impaired, and the patient troubled with acid eructations, a mixture of ox-gall and assafœtida was of great use.§

3. A torpid state of the liver requires small doses of the blue pill, either by itself or combined with purgatives. I have known a gentle course of mercury successful in curing the disease, probably by its sorbefacient powers. Iodide of potassium, I have also found completely successful in removing *muscæ volitantes* of recent standing.

4. Where the symptoms of determination of blood to the head are well marked, venesection or arteriotomy, leeches to the head or cupping, and counter-irritation are indicated. Of twelve cases

* Op. cit. p. 247.
† Elements of Physiology, translated by Baly, Vol. ii. p. 1214. London, 1842.
‡ Op. cit. p. 20. § Op. cit. 514.

treated by Dr Schlagintweit, eight, we are told, were cured by solvent and derivative medicines, and by bleeding at the foot.* Dr Wallace reports two cases, in which cupping was very beneficial.†

5. When muscæ appear dependent on disease of the heart, leeches are recommended by Mr Wardrop to be applied over this organ till its impulse is diminished. The fulfilment of this indication may be promoted by small doses of antimony and the use of laxatives. If the patient complains of cold feet, the warm pediluvium is to be used at bed-time; and it may be remarked, that this simple remedy is of great importance, where the disease is connected with a difficulty of obtaining sleep. An irritable state of the heart, remaining after its impulse is subdued, Mr Wardrop endeavours to remove by the exhibition of sulphate of iron.

6. Antispasmodics appear to have been chiefly confided in by Ware in the treatment of muscæ; such as, two or three times in the day a small dose of the volatile tincture of valerian, mixed with an equal quantity of tincture of castor, and joined occasionally with the camphor mixture, or with infusion of cascarilla.

7. Exercise in the open air, and a change of residence, with such occupations and amusements as are likely to withdraw the mind from any source of anxiety or distress, are found to be beneficial. A course of mineral waters has sometimes been successful, probably more from the change of scene, hilarity of mind, exercise of body, and regularity of habits, by which such a course is accompanied, than from the effects of the waters themselves.

8. If the eyes feel hot, heavy, or uncomfortable, they should be bathed with either some cold or some warm application, according as the patient feels the one or the other the more agreeable. Cold water, or a cold lotion, consisting of equal parts of water and the *spiritus ætheris nitrosi*, will answer in the one case; tepid water, or a tepid infusion of any aromatic herb in the other. Sponging the forehead, temples, and outside of the eyelids, morning and evening, with camphorated spirit of rosemary, eau de Cologne, or the like, is also to be recommended.

9. Rust, it seems,‡ continued to recommend the practice of puncturing the cornea in cases of myodesopia, a plan originally proposed with the view of allowing the cause to escape out of the eye, and tried unsuccessfully by Demours; but which in Rust's hands was followed, we are told, by the vanishing of the muscæ. If it really was so, the operation probably acted in a similar way as it is known to do in cases of ophthalmia, by giving relief to the turges-

* Ammon's Zeitschrift für die Ophthalmologie, Vol. ii. p. 47. Dresden, 1832.
† London Medical Gazette, Vol. xxiii. p. 110. London, 1839.
‡ Chelius' Handbuch der Augenheilkunde, Vol. i. p. 371. Stuttgart, 1843.

cent state of the vessels. On one occasion, however, under the care of Dr Helmbrecht, the operation of puncturing the cornea, not merely cured the eye of myodesopia, but gave exit, we are told, to the efficient cause—a microscopic conferva, of the exact shape of the *musca volitans* previously seen by the patient!*

IV.—Circulatory Spectrum.

§ 31. *Vision of blood-corpuscles moving through vessels of the eye.*

When I look fixedly for a few minutes at the clear sky, I begin to perceive a multitude of lucid points, darting in every direction through the field of view. The motion of these points is rea and altogether independent of any movement of the eyeball; and is so exactly like that of the circulation in the web of a frog's foot as seen with the aid of the microscope, that I have no doubt this spectrum is owing to the blood-corpuscles passing through the vessels either of the retina or of the choroid.

On sneezing, coughing, yawning, or straining to evacuate the bowels, it is well known that the eyelids close instinctively, for the purpose of sustaining the eyeball, and preventing the bad effects which these forcible acts of expiration might otherwise have on the delicate textures within that organ, in consequence of the regurgitation of the blood through the veins. The pressure of the eyelids, as they close in these acts upon the eye, often produces a flash of light, similar to the sensation of a luminous spectrum which is experienced when the eyeball is pressed on one side with the finger. But if we happen to sneeze, cough, yawn, or strain with our eyes open, or rather chance to open our eyes during one or other of these acts, the circulatory spectrum becomes very evident, and continues for some seconds.

Purkinje,† in his description of what I conceive to be the circulatory spectrum, says, that the lucid points which spring up in the field of vision, without having changed their places, suddenly disappear, leaving behind them black points, which even as suddenly vanish. To my view the lucid points career, as if in pursuit of one another, with a motion, which, though rapid, can still be easily followed. The appearance of black points, succeeding the lucid ones, I have witnessed only after sneezing. Purkinje does not attribute the phenomena he describes under the title of "aufspringende Lichtpünktchen," to the circulation of the blood, but to a conflict of contraction and expansion of the nervous substance. Müller,‡ on the other hand, considers the appearances as evidently due to the motion of the blood, and r

* Revue Ophthalmologique de l'Année 1842, p. 251. Bruxelles, 1843.

† Beobachtungen und Versuche zur Physiologie der Sinne, Vol. i. p. 67. Pra 1823.

‡ Op. cit. p. 1211.

marks, that of the same nature is the much more definite appearance of dark bodies with tails, flying and moving about in all directions, which is sometimes seen by persons labouring under plethora, or congestion of blood in the head, on rising suddenly from the stooping posture. This description, I suspect, refers to the phenomenon denominated "fliegende Mücken" by Purkinje, under which head, instead of the common *muscæ volitantes*, he describes numerous insulated lucid points, which move in different directions through the field of vision, with a shadow on that side of the points which is turned from the middle of the field. His figure represents them with tails. He attributes them to the presence of blood-globules in the aqueous humour. They differ, he says, from the "aufspringende Lichtpünkten," in being visible only when the eyes are open, and a sufficient quantity of light present, whereas the others may be discerned in the dark, and with the eyes shut.

§ 32. *Upon what set of vessels does the circulatory spectrum depend?*

Were it admitted, that the circulatory spectrum is due to the motion of the blood, it would next become a question, through what vessels of the eye the blood is moving, which produces the appearance? The most ready answer seems to be, The ramifications of the central artery of the retina, which are placed in front of the nervous or sentient substance of the membrane. It may admit of doubt, however, whether it be not rather the blood moving through the vessels of the choroid, which is the cause of the circulatory spectrum, and that for the following reasons:—

1. The circulatory spectrum embraces the centre of the field of view, and must, therefore, affect the vertex of the retina, a part which is generally considered as entirely destitute of vascularity.

2. When we look at the vessels of our own retina, as in the well-known experiment of Purkinje, to which I shall hereafter have occasion more particularly to refer, (§ 35,) they are seen merely as dark lines, without the least appearance of globules, or of lucid points, moving along their course.

For these reasons, although I am aware of the fact, that pressure on the concave surface of the retina is sometimes productive of a luminous appearance, I am, on the whole, more inclined to consider the gentle compression of its nervous substance, or *stratum bacillosum*, by the current of the blood over its convex surface, in the vessels of the choroid, as the cause of the circulatory spectrum.

I shall not stop here, to inquire into the probable connection of this spectrum with the symptom called *photopsia*. I may merely notice the fact, that if any cause operates on either surface of the

retina, so as to produce gentle pressure of its nervous substance, the result is a luminous sensation, whereas if the pressure is much increased, the membrane becomes for the time totally insensible.

§ 33. *Sensation of muscæ volitantes produced by the circulatory spectrum.*

A perception of the circulatory spectrum, in the ordinary use of sight, and not searched for by gazing steadily at the sky, is, in some cases, one of the earliest symptoms of amaurosis, degenerating gradually into the sensation of gleams of light, fiery sparks, and coloured coruscations. After a time, the pressure on the retina still continuing and increasing, these luminous appearances are changed for others of a totally opposite character, such as I shall afterwards describe under the head of *fixed muscæ*. (§ 37.)

The following amusing instance of the circulatory spectrum being taken for the effect of actual insects moving in the air, I met with in a newspaper in February 1832, a period when the animalcular origin of Asiatic cholera was a subject of speculation. It is contained in an extract of a letter.

"On my way from Haddington," says the writer, "the day after cholera appeared there, I observed the atmosphere for miles crowded with a small white animal, in colour like a drop of water. I can observe them *here* at present with the naked eye, but not in such numbers. Place yourself opposite the window, and keep your eye fixed steadily on the same point for a minute, you will notice something like water in the air, and then the animalculæ will become distinct, whirling and careering round in all directions. The phenomenon may be common at all seasons, but I must say I never noticed them before."

V. Vascular spectrum. Accidental colours. Retinal and choroidal muscæ. Fixed muscæ.

§ 34. *Fixed spectra.*

The fact, that there occur certain *fixed muscæ*, which, once fairly formed, never change their position, either with respect to one another, or to the optic axis, naturally leads us to seek for some natural example of a fixed spectrum, analogous to the prototypes of the various sorts of muscæ already considered, all of which possess a real as well as an apparent motion. The *vascular spectrum*, as produced in the experiment of Purkinje, and the familiar appearances known by the name of *accidental colours*, and which are called forth by subjecting portions of the retina either to greater or to less excitement than usual, are the only examples of the kind required, which occur to me.

§ 35. *Blood-vessels and central spot of the retina as seen in the experiment of Purkinje.*

Exp. 13. The eyelids of the unemployed eye, say the left, should not be closed, but the light should be prevented from falling on it, by the hand or any other covering. The right eye, then, being steadily directed forwards, move a lighted candle, (the room being otherwise dark,) slowly upwards and downwards at the temporal side of the eye, or right and left below it. In a few seconds the blood-vessels of the retina, with all their ramifications, are distinctly seen, of a dark hue, projected on a grayish-white ground, as if about a foot before the eye, and greatly magnified.

It is indispensable that the light be in motion, for as soon as it becomes stationary the image breaks into fragments, and vanishes. Although an example of a fixed spectrum, it is to be observed, that during the motion of the light the image also moves, and in a direction contrary to that of the light, a consequence, I presume, of the distance between the vessels and the nervous substance of the retina. No spectrum arises when the light is moved to and from the eye, nor when the eye is alternately shaded and uncovered.

When it is the right eye which is the subject of the experiment, the part of the spectrum corresponding to the entrance of the optic nerve is, of course, to the right hand of the observer, and from that part two vascular trunks are seen to go upwards and two downwards, whence they are prolonged in an arched form towards the left, vanishing towards the middle of the field. The part of the spectrum corresponding to the central spot of the retina, Purkinje describes as presenting a circular concave appearance. Were it certain that the central fold of the retina is actually raised into a convexity towards the vitreous humour, we should regard this appearance as an optical deception, of the same sort as that by which a cameo sometimes seems an intaglio. But anatomists are not agreed to regard the central fold as existing during life. On the contrary, this is denied by Zinn,* Home,† D. W. Soemmerring,‡ and others, and in a dissection of a human eye by Mr Dalrymple,§ a very few hours after death, no fold was detected, but at the usual place of the central spot a minute cup-like depression, with an elevated yellow lip around it.

Purkinje has offered no explanation of this very striking and beautiful experiment. The following attempt to supply the omission, I presume to be from the pen of Mr Wheatstone.‖

* Descriptio Anatomica Oculi Humani, p. 98. Goettingæ, 1780.

† Op. cit. p. 388.

‡ De Oculorum Hominis Animaliumque Sectione Horizontali, p. 25. Goettingæ, 1818.

§ Anatomy of the Human Eye, p. 293. London, 1834.

‖ Journal of the Royal Institution of Great Britain, Vol. i. p. 111. London, 1831.

"Were the blood-vessels which are spread on the anterior surface of the retina entirely opaque, they would prevent the transmission of light to the nervous matter beneath them, and their distribution would be constantly visible; but they are transparent, and in ordinary cases the intensity of the light which passes through them does not materially differ from that which falls directly on the retina. When, however, the retina is fatigued by a strong light, the veins become visible, because the retina is rendered insusceptible to a portion of the light they transmit; but this effect is only momentary, for those parts which are thus shaded from the more intense light promptly recover their usual susceptibility, and the images vanish; but they may again be made perceptible by displacing them on the retina, and by making them constantly change their places the images may be rendered permanent."

Purkinje and Wheatstone have pointed out methods by which the more minute vessels of the retina may be rendered visible, as well as the central spot. The following is one of the readiest:—

Exp. 14. Before one eye, directed towards a plate of ground glass, or sheet of paper, held close before a candle, move from side to side in a tremulous way, a black card with a hole in it, one tenth of an inch in diameter. The image of the light upon the retina being in this way continually displaced, an extremely complicated net-work of blood-vessels appears, of a grayish white colour, in which the ramifications of the upper trunks are seen to anastomose with those of the lower, while in the very centre of the field there is a small dark circle, in which no trace of vessels appears, the spectrum of the central spot.

§ 36. *Accidental colours.*

Out of the numerous and diversified class of phenomena known by the names of *accidental colours* and *ocular spectra*, I shall select, as an example, one of the simplest.

Exp. 15. Out of a card, cut the figure of a triangle, each side measuring an inch in length. Blacken the one surface, and let the other remain white. Lay it on a sheet of white paper, with the black surface up, and look steadily at it for a minute. On moving the eye a little, the figure of the triangle will be seen on a white part of the paper whiter and more luminous than the other parts of the paper.

Exp. 16. Reverse the experiment. Lay the figure of the triangle on a sheet of black paper, with its white surface up. After regarding it steadily for a minute, turn the eye to a sheet of white paper, and a black spectrum of the triangle will appear.

In these two experiments, the part of the retina which has received the luminous part of the image remains for a certain period in an excited state, while that part which has received the dark

part of the image is left in an unexcited, and therefore excitable condition. Hence, when the eye is turned away from the figure of the triangle, the parts of the retina upon which the dark portion of the previous image had fallen receive a much more intense impression from the surface looked at than those upon which the luminous portions of the image were directed; and hence the inversion of the light and dark parts of the image in the spectra.

If instead of black or white, the object with which the retina is fatigued be coloured, the spectrum is of the colour which is complementary of that of the object, that is to say, the one colour is what the other wants to form white light. Thus, if the retina is fatigued by looking at a red wafer, a bluish-green spectrum will be produced; if fatigued with a bluish-green wafer, a red spectrum will follow. Fatigued by a red object, the sensibility of the retina to red light is diminished, and, consequently, when the eye is turned from the red wafer to the white paper, the exhausted portion of the retina will be insensible to the red rays which form part of the white light reflected from the paper, and will see the paper of that colour which arises from all the rays in the white light of the paper but the red; that is, of a bluish-green colour, which is therefore called the *complementary* colour of red.

In such experiments as those above referred to, the spectrum, though fixed when the eye is at rest, moves with the motions of the eye, upwards or downwards, or from side to side, on our calling into action the appropriate muscles, and this even although the eyelids are shut. If we make an impression on the retina in the manner described, and merely shut the eye, as the pupil is somewhat raised in this action by the eyeball becoming equipoised between the rectus superior and inferior, the spectrum appears in a horizontal direction or a little elevated, and continues so till by a voluntary exertion we turn the eye into some other direction. Immediately on again calling into activity the *orbicularis palpebrarum*, the eyeball rolls upwards, and the spectrum rises.

The spectra in the above experiments are evanescent, but by increasing the light by which they are produced to an intense degree, they may be rendered more or less durable. Thus, by looking at the image of the sun reflected from a mirror, Sir Isaac Newton produced a luminous spectrum edged with colours, to get quit of which he was obliged to shut himself up in a dark room for three days.* Buffon tells us, that one of his friends having looked at an eclipse of the sun through a small hole, observed a coloured image of that body upon all objects for more than three weeks.†

* King's Life of Locke, Vol. i. p. 405. London, 1830.

† Mémoires de l'Académie Royale des Sciences, pour 1743, p. 155. Paris, 1746.

§ 37. *Persistent spectra. Fixed muscæ.*

There is reason to believe, not only that *fixed muscæ*, as they are termed, bear, in some instances, a resemblance to the spectra of which we have been speaking, (§ 35, 36,) in their form and in the sort of affection of the retina upon which they sometimes depend, but that they are in certain cases nothing else than persistent spectra, the consequences of over-excitement of the nerve of vision, and exhaustion of its sensorial power. Buffon's own case may be quoted as an instance of this kind.

"I have seen," says he, "black points for more than three months, in so great a number that I was very uneasy about them. I had apparently fatigued my eyes in making and too often repeating the preceding experiments, [on accidental colours,] and in looking sometimes at the sun, for the black points appeared at that very time, things which I had never seen before. At last they annoyed me so much, especially when in broad day-light I looked at objects strongly illuminated, that I was obliged to turn my eyes away; yellow especially was insupportable to me, and I was obliged to change the yellow curtains in the room which I occupy, and to put up green ones. As I avoided looking at all colours which were very strong, and at all brilliant objects, gradually the number of black points diminished, and at present I am no more troubled with them. What convinced me that those black points arose from too strong an impression of light, is that after looking at the sun, I always saw a coloured image which for a certain time covered all objects, and watching with attention the different gradations of this coloured image, I observed that it lost its colours by degrees, so that at last I saw upon objects only a black blotch, at first pretty large, but which gradually diminished, and ultimately was reduced to a black point."*

Some fifteen years after the attack above described, Buffon, who studied much and was very short-sighted, had another, commencing with photopsia, followed by the spectrum of a dark ring or disk before his left eye, covering all objects and preventing him from reading. After a day and two nights it grew less, so as to allow him to see objects to the right and below. For fifteen days he could not see the pen with which he wrote. His eyes then became inflamed, which obliged him to give them rest, and after the space of some months, the spectrum broke up into fragments, and his sight was restored.†

§ 38. *Various appearances of retinal or fixed muscæ.*

Fixed muscæ are sometimes single; often more numerous. They are of different sizes, and present a great variety of forms.

* Mém. de l'Académie Royale des Sciences, pour 1743, p. 156. Paris, 1746.
† Histoire de l'Académie Royale des Sciences, pour 1760, p. 55. Paris, 1766.

They are not always fixed from the very first, but after affecting one side of the optic axis may shift to the opposite side, a fact indicating perhaps their dependence on an effusion of blood from the retinal vessels. They are sometimes semitransparent at first, but afterwards their colour is generally black, or at least much darker than the colour of the floating or entohyaloid muscæ. They are often so black that even when both eyes are open, although the musca affects only one, a person's countenance standing before the patient seems obliterated, or his head cut off, or the flame of a gas-lamp extinguished. Their colour changes, however, in a remarkable manner, appearing of a grayish-white while the eye is shut, and instantly assuming a velvet black colour on opening the eye in the light. Sometimes on shutting the eye the musca is seen of the colour of the object which last impressed the retina.

White objects, in consequence of fixed muscæ, sometimes seem to have black, ill-defined, large blotches on them. Sometimes the patient sees the appearance of black letters, like T or X, for instance, in the air. In other cases, he describes himself as seeing through a riddle, the interstices of which become gradually less and less, till the disease ends in total blindness.

A fixed musca, occupying the centre of the field of vision, and gradually expanding its circumference, ends in one of the most intractable varieties of amaurosis. It is to be attributed to a change of structure in the central spot of the retina, the evident result, in some instances, of over-excitement of the eye in the continued observation of minute objects. "The appearance I see," said a literary man to me, who was losing his sight, "is that of a dark wafer covering the middle of objects. It is getting broader and broader, for formerly I could read past the edge of it, but now I cannot."

Müller tells us, that the vascular figure, observed in Purkinje's experiment, is sometimes seen with a luminous character. "I have frequently seen," says he, "this luminous ramified figure in the dark field of vision, when, after ascending a flight of stairs, I have found myself suddenly in a dark place, and also when I have suddenly immersed my head in bathing. The luminous appearance is evidently the effect of the pressure of the vessels filled with blood upon the retina."* Now, moderate pressure on the retina always produces a luminous sensation; but if the pressure is increased, darkness is the result. Patients sometimes mention the appearance of a spider, with its legs stretched out from it, as a spectrum which they observe; but this, I believe, will generally be found, when the patient is directed carefully to examine it, to

* Op. cit. p. 1211.

be a pearly or floating musca. Were it ascertained in any case to have no real motion, and not to throw a double image on the retina when exposed to two divergent beams of light, we should be led to ascribe it to a varicose state of the blood-vessels of the retina. That this was the cause of a peculiar appearance in a poor woman who was under my care, completely amaurotic of one eye, and fast losing the sight of the other, seemed not improbable. "For some time," said she, "I have seen like two bushes before this eye, and now the two are meeting."

As the eyeball moves, the fixed musca seems to move with a corresponding velocity. The figure of a mouse running along the floor is a spectrum, which I have known to arise from an insensible portion of the retina, and to be the precursor of total amaurosis. The distinction, then, of the fixed from the floating muscæ, requires considerable attention and power of observation on the part of the patient. Sometimes he is affected with both sorts. Thus, Hellwag tells us, that on looking through a pinhole in a card, he saw two sorts of appearances, viz. five fixed dark spots, which changed their position with respect neither to one another nor to the optic axis, together with a semitransparent moveable web of twisted chains.*

§ 39. *Vascular diseases of the retina probable causes of fixed muscæ.*

That the diseased state of the blood-vessels of the retina, in which they become suddenly distended much beyond their natural diameter, or even give way, so that blood is effused on the surface, or into the substance of the membrane, (*apoplexia retinæ*,) may, by compression, give rise to a partial abolition of vision and to fixed muscæ, is generally admitted. The same is likely to hold true of partial dilatation of its arteries and varicose enlargements of its veins. The central artery has been met with in a state actually aneurismal.

§ 40. *Fixed muscæ from partial paralysis of the retina.*

It has been presumed that the nervous substance of the retina is liable to become insensible in certain portions of its extent, altogether independently of any affection of its blood-vessels. Andreæ compares this supposed state of the retina to the condition of the brain in nervous apoplexy, and calls it a loss of power from want of sufficient vital support. He says, that the muscæ depending on this cause vanish for a time, under the influence of different physical and moral stimulants, such as a jovial meal, a glass or two of wine, or a cheerful conversation.

* Op. cit. p. 21.

§ 41. *Fixed muscæ from melanosis and neuromata of the retina.*

It can scarcely be doubted, that both the small black points, which, in certain cases, are deposited on the concave surface of the retina, constituting what is termed *melanosis retinæ*, and the larger red bodies, which, in other cases, are met with on its convex surface, and are called *neuromata*, must give rise to fixed muscæ.

The younger Langenbeck relates the case of a man, long and exceedingly troubled with muscæ. On dissection, neither the aqueous humour, carefully preserved, and examined with the microscope, nor the lens, nor the vitreous humour, showed any thing unnatural. The retina, to the naked eye, and the coats of the eye, seemed normal. The vessels of the retina were not enlarged, and were neither more numerous nor fuller of blood than usual. On examining the retina microscopically, the whole internal surface was seen to be covered with blackish or brown points, formed apparently of molecules of *pigmentum nigrum*, accumulated into little globules, about ten times bigger than the medullary globules of the retina. They were disposed equally, and in a certain sort of order, over the retina, following chiefly the course of the blood-vessels. They were detected in each retina, but were blacker and more numerous in the left.

The patient was never altogether free from myodesopia, although, at certain times, especially after drinking spirits, the disease increased. Certain of the phantasms which he saw floated before his eyes; others, and these the more numerous, remained fixed. In writing, he complained that the paper seemed sprinkled over with snuff, and so similar were the spectra which he saw to grains of snuff, that he often tried to brush them away.

The little tumours, called *neuromata*, appear to arise from chronic retinitis; they cover the convex surface of the retina, being of a red colour, pellucid, and somewhat prominent; some of them are visible to the naked eye upon dissection, being twice as big as poppy seeds, others so small as not to be seen without the microscope. They are mixed with black points, and surrounded by striæ of *pigmentum nigrum*. Some of them are depressed in the middle into a sort of umbilicus, and have a black point within. They are imbedded in the cortical substance of the retina, and may perhaps be morbid enlargements of the medullary globules of the retina. The cellulo-vascular layer of the retina, in such cases, is thicker and firmer than natural, of a whitish colour, furnished with red vessels, and easily separable from the other layers. Such is the account of this morbid state of the retina, which is given by Langenbeck.*

It is merely a conjecture, that neuromata will in an early stage

* Op. cit. p. 170.

cause fixed muscæ. Ultimately they produce complete amaurosis, or, at any rate, are met with in eyes which were completely deprived of sight.

We cannot be too cautious in coming to conclusions respecting the pathological states likely to give rise to certain symptoms which affect vision, or on the other hand respecting the symptoms likely to attend certain morbid alterations of the retina. Retinitis, for example, which, contrary to what might perhaps be expected, is not attended with pain, produces, by an effusion on the concave surface of the retina, a general dimness of sight, and after this abates under treatment, the appearance, not of fixed, but of floating muscæ. Neuromata, being seated on the convex surface of the membrane, are more dangerous to vision than melanosis, which, on the other hand, is more apt to produce fixed muscæ, without causing total blindness. The intimate relation which exists between the different portions of the retina, considered as a sensorial surface, and the reciprocal action which they have upon one another, are probably much stronger on the convex than on the concave side of the membrane, belonging, in fact, more to its nervous than to its vascular structure. Hence, neuromata may, by irradiation, produce complete amaurosis, while melanosis merely causes fixed muscæ. The melanotic points, although extremely numerous, do not destroy vision, because they are seated in the least important of the textures of the retina; the neuromata, although fewer, so as to leave numerous spaces where the natural substance of the retina is probably uninjured, abolishes sight entirely, from the morbid condition of one part of its nervous matter having a certain influence on the neighbouring parts, as is well known to be the case with respect to the retina in the healthy state.

§ 42. *Diseased states of the choroid probably productive of fixed muscæ.*

If we are obliged to speak with some reserve even of the retina, as the seat of the efficient causes of fixed muscæ, with still less confidence can we assign such causes to the choroid. Necroscopic observations are here entirely deficient, so that we can state it merely as a probability, that partial thickenings of the choroid, dilatations of its vessels, or depositions on its surfaces, by pressing on the retina, may cause photopsia in the first instance, and afterwards fixed muscæ.

§ 43. *Diseased states of the optic nerves, and of the brain, probably productive of fixed muscæ.*

As diseases of the optic nerves, and of the encephalon, cause luminous sensations, even after the eyeball is extirpated, so they

are the causes of dark spectra, and of partial amaurosis. Disease of the brain is well known to produce hemiopia.

Dr Delafield relates* the case of an elderly gentleman, who afterwards became totally blind, one of whose early symptoms was, that in walking he imagined he saw objects on the ground which intercepted his path, and which he endeavoured to avoid by taking long and high steps. These spectra were perhaps fixed muscæ. On dissection, the eyes seemed in all respects sound, and had the plumpness and clearness of health. No mention is made, however, of any microscopical examination of the retina. The ventricles of the brain were greatly surcharged with fluid and the optic nerves to and from the *ganglion opticum* [chiasma ?] shrunk, or rather absorbed; so that they appeared flat, and were of a straw colour. Only the sheath of the nerve remained, the medullary substance having entirely disappeared.

§ 44. *Symptoms coincident with fixed muscæ.*

In most of the cases in which fixed muscæ are a prominent symptom, there will be found a combination of various other subjective symptoms; such as photopsia, or the sensation of coruscations and halos of light; floating muscæ; the retina unnaturally retentive of impressions; ocular spectra; the alternate disappearance and reappearance of small objects; hemiopia; partial and oblique vision; chrupsia; the sensation of an undulating cloud before the eyes, with occasional openings in it, through which small objects are seen by fits, and then are obscured again; bright objects exhibiting a tremulous, undulating light and shade; the edges of objects ill defined and shaggy, as if fringed with hoarfrost; perpendicular lines appearing disfigured, printed letters broken or indented, and circular objects deprived of their regular figure. What belongs to the fixed muscae must not be confounded with what depends on other causes. An interesting case of this mixture of symptoms, the reader may find recorded by the patient himself, Mr Keir, in the Lancet for October 1, 1842. The case of Professor Boze affords another example of the same thing. Besides the sensation of a disc before one of his eyes, objects appeared curved, misshapen, and fringed; letters seemed broken; objects were as if coloured blue and green; the disc grew broader and more opaque, and at last the vision in one-half of the retina was extinguished, the other half seeing as if through a thick fog.†

§ 45. *Treatment of fixed muscæ.*

Most of the cases of fixed muscæ are incurable, as may be con-

* Notes and Additions to Travers' Synopsis of the Diseases of the Eye, p. 514. New-York, 1825.

†Histoire de l'Académie Royale des Sciences pour 1760, p. 54. Paris, 1766.

cluded from the nature of the efficient causes upon which they depend. The cases susceptible of treatment are most likely to be benefited by depletion of various kinds, mercury, iodide of potassium, and counter-irritation, followed up by general and local tonics, so as to relieve the over-distended state of the vessels, and restore them to their natural diameter. If the disease arises from the suppression of any habitual discharge, an attempt should be made to renew this, or to procure a substitute for it. The best local application is cold water, applied to the eyes and face by means of folded pieces of cloth. Richter remarks, that by this means alone, the disease has sometimes been completely removed; an instance of which, indeed, seems to have occurred in the case of Boerhaave, as thus related by himself. "In aestu solis summo mihi equitanti per loca arenosa enascitur magna macula in fundo oculi. Cogitanti succurrit mihi, medicamentum optimum fore aquam frigidissimam, quae a me applicata remedio fuit: Inflammatio ergo procul dubio erat in fundo oculi, et saepe etiam fit tali in casu, hinc optimum remedium est, quod subito retropellendo omnia vasa constringit, ut aqua frigida."* The length to which this paper has extended must be my excuse, for not entering into a detailed consideration of the remedies above mentioned.

§ 46. *Conclusion.*

I must here quit the highly interesting and important subject, the present amount of our knowledge of which I have thus attempted methodically to digest and arrange. While I have endeavoured, as much as possible, neither to introduce extraneous notions into the consideration of it, nor to exclude any part of the case before us, I am fully sensible that much remains to be investigated respecting the VISION OF OBJECTS ON AND IN THE EYE, and that, in fact, by attempting thus to discriminate what is strictly known upon the subject from what is merely conjectural, I have done little else than pioneer the way for still more strict and scientific inquiries. "In rebus quibuscumque difficilioribus non expectandum, ut quis simul, et serat, et metat, sed praeparatione opus est, ut per gradus maturescant."

Fig. 1. Illustrating experiment 2d, p. 42.
Fig. 2. Showing the appearance of the pearly spectrum, (*a*); the watery spectrum, (*b*); and the insulo-globular spectrum, (*c*), p. 48.
Fig. 3. Showing the appearance of the tubulated spectrum, p. 53.
Fig. 4. Illustrating description at p. 54.
Fig. 5. Illustrating experiment 10th at p. 58.
Fig. 6. Illustrating description at pp. 62 and 63.

* Op. cit. p. 62.

Glasgow, 30th December 1844.

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OLD ASSEMBLY CLOSE.

Fig. 1

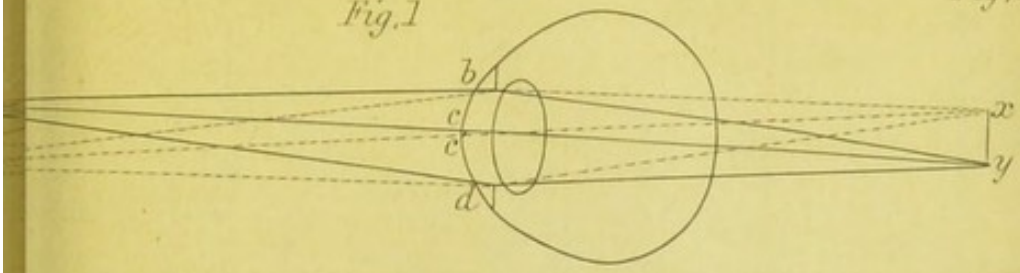


Fig. 3

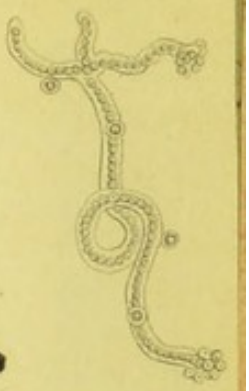
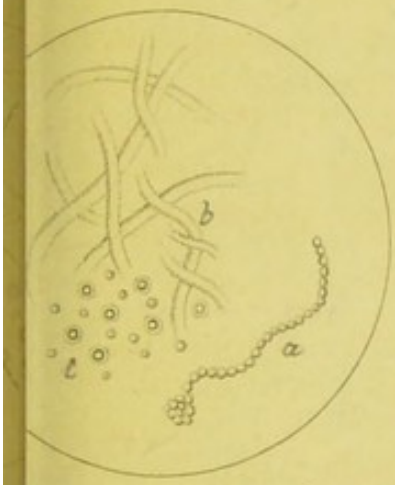


Fig. 2



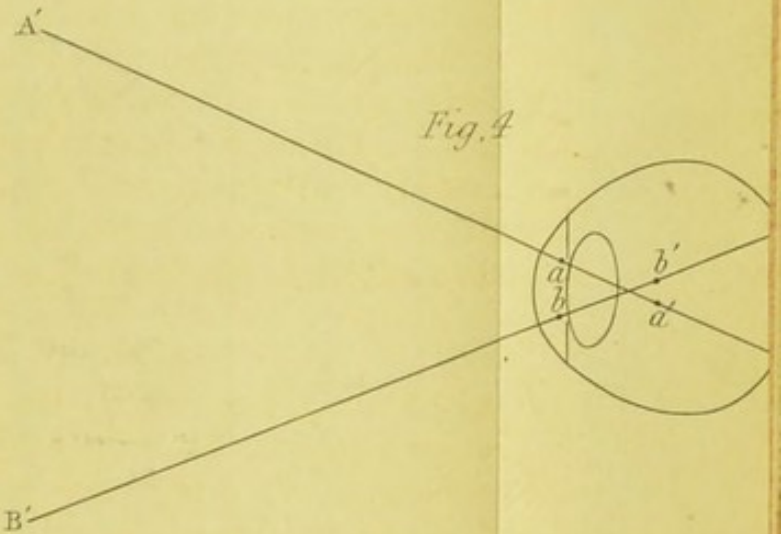


Fig. 4

Fig. 5

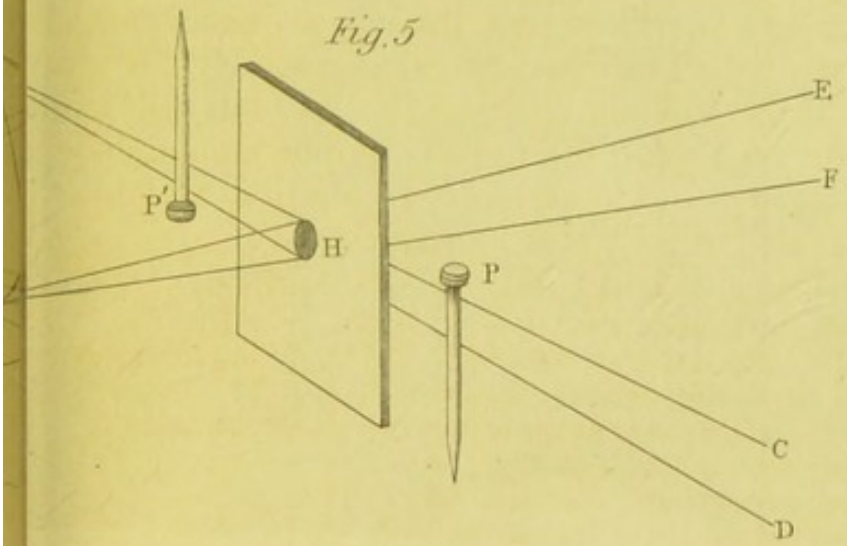


Fig. 6