Fisher W. Evans Esqr. with the Sincere regards of the Author

# OBSERVATIONS

ON THE

# ARRANGEMENT OF THE FIBRES

IN THE

# OPTIC NERVE OF THE LOLIGO,

AND OTHER ANIMALS.



BY

JOHN H. POWER, M.D.,

LECTURER ON ANATOMY AND PHYSIOLOGY IN THE RICHMOND HOSPITAL SCHOOL OF MEDICINE, ETC.

DUBLIN:

HODGES AND SMITH, COLLEGE-GREEN.

MDCCCXLII.

DUBLIN:
PRINTED AT THE UNIVERSITY PRESS,
BY M. H. GILL.

# OBSERVATIONS,

&c. &c.

It is universally admitted, that the study of comparative anatomy has contributed largely to our knowledge of the intimate structure and functions of the different organs of the human body; it is now considered indispensable to a correct understanding both of the anatomy and physiology of man. How many organs, whose intimate arrangement lay unknown for centuries, have been brought to light by the investigation of corresponding parts in the lower orders of animals? Let us take, for example, the liver and pancreas, two glands composed of a complicated arrangement of parts in the higher orders, so intricate, as for a length of time to elude all attempts at successful inquiry into their nature. Comparative anatomy has, however, cleared away the obscurities, and, by presenting us with different developments of the one organ, from the simplest form of a single mucous surface, to a multiplication of that surface by numerous off-sets or ramifications, and from this to an infinite distribution of it in the form of exceedingly minute tubes, till we arrive at the complex organs we have alluded to, we are led to an acquaintance with their minute organization, which, otherwise, might for ever have remained a secret.

There is not probably in the entire range of comparative anatomy, a subject more interesting and attractive in its character, than the example which it is the object of this paper to present to the reader.

The animal affording this example, is the Loligo or Calamary, one of the cuttle-fish tribe; it belongs to the cephalopodous mollusca, and although placed thus low in the scale of being, presents us with so extremely perfect an organization, as to have attracted from time to time both the attention and the admiration of the naturalist. It is described as being an animal, rapid in its motions, and of voracious habits; it is furnished with a beautiful apparatus to lay hold upon, and a strong horny beak to destroy its prey; in it we notice an early development of a spinal column according to some naturalists, according to others a rudimental skeleton, together with an exceedingly perfect nervous, respiratory, and circulatory apparatus.

It is to a portion of the nervous system that at present I would wish to direct the attention of the reader; the better to enable it to discover its prey, and to avoid danger from its formidable enemies, the creature has been provided with an organ of vision of great beauty and perfection. We find the central masses of the nervous system so arranged, as to form a complete collar round the œsophagus; from either side of the proper cerebral ganglion, we have two large short nervous trunks proceeding outwards in a horizontal direction; these are the optic nerves; they are seen afterwards terminating in two ovoidal bodies, each much larger than the cerebral ganglion itself; atone side this body receives the optic nerve, and from the other, which is directed towards the eyeball and slightly concave, stream forth the filaments which compose the retina. The eyeball is of very peculiar conformation, it is enclosed in a socket formed posteriorly by a cartilaginous cup, anteriorly by the cornea, which is very slightly convex, and on the sides by a fibro-cartilaginous substance: within this socket we have the proper organ of vision, consisting of the optic ganglion giving origin to the fibres which terminate in the retina, surrounding which there is a soft fatty mass, somewhat resembling an Haversian gland,—a considerable quantity of a serous fluid contained in a serous sac, particularly described by Professor Owen, and considered by him as analogous to the membrane of the aqueous humour, and which he supposes facilitates the motions of the eyeball,—a second sclerotic tunic perforated by the fibrils of the ganglion; and internal to their expansion, the choroid tunic, which, from the strangeness of its position with regard to the retina, has attracted a good deal of attention,—the hyaloid membrane containing the vitreous humour, and a crystalline of extremely curious construction, very closely resembling in appearance the Coddington lens. Finally, contained within this general capsule, we have the muscles moving the eyeball, together with their proper vessels and nerves. The mobility of the organ is very remarkable, the creature, when captured, may be seen turning it about in almost every direction.

All these parts have, from time to time, received the attention of the naturalist, and have been in general described with considerable accuracy. Swammerdam, nearly two centuries ago, wrote upon the anatomy of the "Sea Sepia," and in his "Book of Nature, or the History of Insects," there is a delineation of the nervous system: the optic ganglion, and its filaments, are beautifully represented: but in this as well as in all other descriptions and delineations of the nervous system of these animals, the precise relation which the filaments bear to one another has altogether escaped observation. Cuvier, in his "Memoire sur le Poulpe,"* has furnished us with beautiful engravings of the animal; but he has made the same omission. The same thing occurs in the engraving of these parts in Part I. of the third volume of the "Catalogue of the Museum of the Royal College of Surgeons, London;" and in Dr. Todd's "Cyclopædia of Anatomy and Physiology," there are engravings of the optic nerve, ganglion, and its filaments; but no notice has been taken in this valuable article on the Cephalopoda, by Professor Owen, of the peculiar arrangement of the terminal fibrils of the nerve.

It is not easy to conceive how naturalists could have overlooked the peculiarity alluded to; it might probably be accounted for by their not having viewed the parts when floating in a transparent medium. If after having carefully dissected the eye, the parts be allowed to lie flat upon the table, it is not very likely to arrest attention, but when, as was the case with the preparation from

* "Mémoires pour servir a l'Histoire et a l'Anatomie des Mollusques."

which the engraving, fig. 1, has been taken, the animal be suspended at full length in spirits of wine, the eyes so drawn out in the horizontal direction, as that the optic nerve and its connexions shall be rendered tense, the beautiful appearance here delineated cannot fail to strike the eye.

The preparation was made by my friend and colleague Dr. Mayne, in the manner I have described, for the purpose of exhibiting the nervous system; it is one of great beauty, and is at present preserved in the museum of the Richmond Hospital School of Medicine; on one occasion whilst holding it between me and a strong light, the peculiarity about to be described became exceedingly obvious.

From the entire circumference of the ganglion, as represented in Fig. 1, we see streaming forth a considerable number of fibres; they appear to spring from the margins of the ganglion, but on making an examination with a lens of moderately magnifying power, these fibres may be traced running along its entire surface backwards to that spot where the short trunk of the optic nerve is lost in its structure. After they have left the optic body, flowing from the two surfaces, the one anterior, the other posterior, as represented in the engraving, the filaments approach each other so as to form a triangular space, best seen on making an horizontal section of the parts, the base situated at the ganglion, the apex at the convergence of the filaments; at this spot they form no union with each other; those of opposite sides remain perfectly distinct from one another, nor are they bent out upon themselves, so as to become expanded from the retina. Careful observation discovers the following extremely curious and interesting disposition of the filaments: all those which flow from the back part of the ganglion pass on to the anterior part of the retina, and *vice versa,* so that when they approach each other at the angle we have already mentioned, they interlace in the most perfect manner, and so, like the crossing of the fingers of both hands, pass between one another to opposite sides of the retina. Fig. 1 is an accurate representation of this arrangement taken from nature. It will be seen also, from this engraving, that when the filaments are in the act of interlacing, they present a flattened appearance. That portion of the nerve formed by the filaments running from the ganglion to the eyeball, presents an hour-glass appearance, or two triangles united at their apices,

*Fig.* 1.

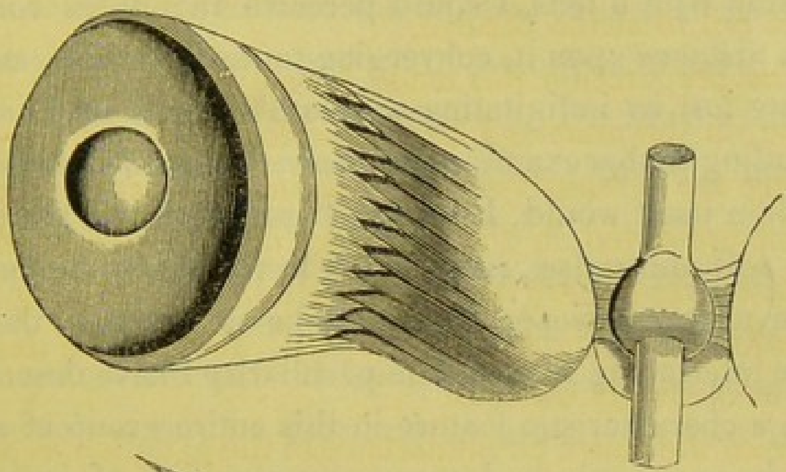
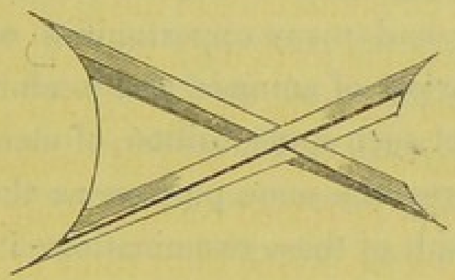


*Fig.* 2.



the base of one situated at the ganglion, that of the other constituted by the retina, whilst the union of the apices is represented by the mutual crossing of the fibres. Fig. 2 presents a diagram of a horizontal section of the fibres in the act of decussation.

After I had correctly ascertained the exceedingly interesting peculiarity now described, I had the honour of announcing it to the Surgical Society of this city, and at that time intimated my intention of investigating the subject still further, with a view to ascertain the arrangement of the fibres which compose the optic nerves in other animals, particularly in man, expressing my opinion, that a somewhat similar disposition of the parts would in all probability be found to exist. An abstract of this communication appeared in the Medical Press, vol. v. p. 103. Since then I have examined the optic nerve in the S. officinalis, and in the Octopus; in the latter the arrangement is very nearly precisely similar to that in the Loligo; in the S. officinalis, however, there is a much greater number of fibres arising from the ganglion, and this gives the appearance of a greater degree of complexity, particularly at the extremities of that body ; in these situations the fibres are so grouped together, that their arrangement is not so satisfactorily seen as in the central portion of the nerve ; nevertheless, even here, on examining the surface of the ganglion with a lens, I could perceive the fibres running for a given distance upon it, converging towards a point, and soon becoming lost by indigitating with other fibres on this body, and so eluding further examination. Any attempt to trace them into the ganglion itself would, I think, be useless, as this body is exceedingly soft and pulpy, particularly in the interior. In the centre of the nerve, however, there can be no doubt of the existence of the interlacing fibres. The peculiarity I have described seems to be a characteristic feature in this entire group of animals.

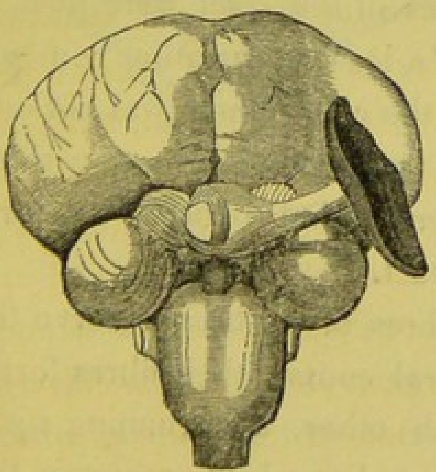
I have recently had many opportunities of examining this nerve in a great variety of animals, and in almost every instance I was able to detect such a disposition of many of their fibres, as I conceive serves the same purpose as that in the Loligo. In detailing the result of these examinations, it will be necessary to advert to the optic tract and commissure, as well as to the nerve itself. I will, however, avoid as much as possible unnecessarily dwelling on any thing connected with the anatomy of these parts, and shall merely confine my remarks to what more immediately bears upon the matter at present under consideration, particularly as my friend Dr. Mayne is at present engaged in making a series of examinations into the origin and structure of the optic nerves of various animals, the result of which I feel assured, when published, will prove both interesting and instructive.

In the Hake and Cod, as in other osseous fishes, there is no commissure, but the nerves decussate with one another without any interlacement of their fibres, and so terminate in the eyes of opposite sides ; I have observed, however, in the substance of each nerve, close to its connexion with the brain, an apparent enlargement, and at this spot I was able to discern the fibres of which it is composed, irregularly interlacing with each other in the interior of the nerve. The superficial fibres in the Cod run spirally onward towards the eyeball, and just where the nerve presents the folded appearance previously to its expansion in the retina, this arrangement is more evident.

In the Turtle, the fibres of each tract make a twist upon themselves, those lying superiorly at the origin run downwards, thus apparently contributing to form the inferior fibres of the nerve of the same side, and also a portion of the opposite nerve. In a preparation of the brain of a turtle made by Dr. Mayne, the general contour of the tract presents, in a very striking manner, the twisted appearance alluded to.

I succeeded in removing, with a great deal of care, the brain of the eagle, with the eyes attached to the optic nerves; the parts here connected with vision deserve particular attention; the tractus opticus may be decribed as arising by two bands, the fibres of which are quite distinct, the one from the anterior and superior, and the other from the posterior and inferior surface of the optic lobule; these fibres then contribute to form the tract which here presents a twisted appearance: the fibres derived from the anterior and superior part of the lobule are the most superficial or inferior in the natural position of the organ; these bending along the outside of the commissure, gain its posterior surface, whilst those arising from the posterior and inferior portion of the lobule twine under cover of the last described band, and from their general direction appear to become continuous with the fibres situated on the anterior part of the commissure, whose destination is the anterior portion of the optic nerve and retina. I have succeeded in distinctly tracing the band first decribed, upon the back part of the commissure, and then upon the posterior part of the optic nerve of the opposite side, and finally, its expansion in a corresponding portion of the retina. By the aid of a lens of strong magnifying power, a distinct decussation between the bands of opposite sides

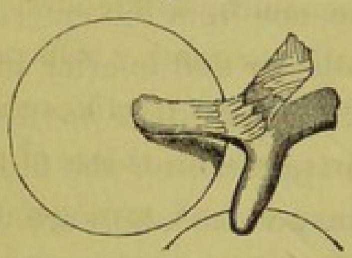
*Fig.* 3.



may be seen on the back part of the commissure. The view presented in Fig. 3 is an accurate representation of the course of the fibres I have described, when viewed through a lens of moderately magnifying power; without any assistance of the kind, however, the peculiarly twisted appearance of the optic tracts must arrest attention.

I am indebted to my friend Dr. R. Smith, for a specimen of the horned owl. I removed the brain of this bird in the manner above described; I gently drew away one of the optic nerves from the tract of the same side, thus widening the interval between them. Without the aid of a lens, the decussation of the deep-seated fibres, as represented in Fig. 4, became exceedingly obvious; this view is magnified, but not considerably: the arrangement here delineated is one with which naturalists are already familiar, and Müller describes it as existing in all birds. I have examined the parts in the eagle, and I find the same arrangement of the deep-seated fibres. In the adjoining engraving of these parts in the horned owl, there is an appearance upon the tract, which is exceedingly curious. The fibres of each tract do not run straight across from one side to the other, they are all more or less oblique in their course, and previously to the formation of the commissure, the fibres of the tract were seen, as here represented, with the aid of a lens, decussating with one another. Thus in this animal, as in the eagle, there was not only a decussation between the fibres of the nerves of opposite sides, but a decussation, though of a different kind, between the fibres of each nerve, whilst in the optic tract.

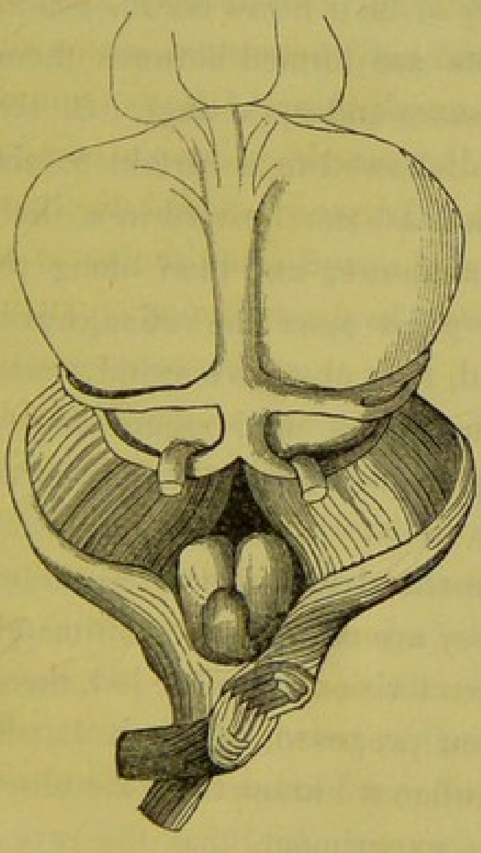
*Fig.* 4.



In the sheep, the superficial fibres of the tract observe the same arrangement; they take a spiral course, their fibres forming frequent decussations with each other, and running upon the surfaces of the opposite nerves. In order to ascertain the internal arrangement of the nervous material at the commissure, I drew the nerve gently from the tract of the same side, and whilst performing this traction, the decussation was most strikingly apparent. The inner fibres had the appearance of being arranged in plates laid one over the other, and passing between each other, to form the nerves of opposite sides.

In the human subject, the parts are exceedingly complex; on laying open the optic tract, close to its origin, and spreading out its fibres, they were seen interlacing with each other in such a way, as to elude all attempts at following their course, the superficial surface of the tract does, however, present another example of the peculiar appearance I have noticed already: the fibres are here also twisted on each other, so as to give to the tract, when perfectly stripped of all its membranes, and as it is about to form the commissure, a stranded or rope-like appearance. On performing the same tractions with these parts, as with those of the sheep and owl, the arrangement of the fibres, as represented in Fig. 5, was quite obvious; the superficial fibres are here seen torn through, and taking the same course with regard to the tract and commissure, which they appeared to do, when viewed with a lens before disturbing the parts themselves. More deeply seated we observe, in the same figure, the arrangement of the internal fibres; they may be seen in the preparation distinctly, as they are represented in the engraving, by the unassisted eye, arranged in plates, the fibres of these plates interlacing with those of the opposite side.

*Fig. 5.*



It results, therefore, from the disposition of the parts now described, that the nervous fibres do not run in such a direction from their different points of attachment in the sensorium, as to terminate in *corresponding* points of the retina ; as yet, such an arrangement has never been correctly and satisfactorily ascertained ; on the contrary, the very great probability is, that the fibres of the optic nerve, taking their attachment to the several points of the sensorium, so run in their course onward to the eye, as to form numerous interlacements with each other, in order finally to terminate in *opposite* points of the retina. This opinion is, I think, strengthened by the following facts : 1. Between the fibres of the optic nerve in the cephalopoda I have mentioned, there is a perfect decussation, so as to allow them to terminate in opposite points on the retina. 2. In the interior of these structures, as we ascend from the lower to the higher classes of animals, the complexity of their fibres becomes more intricate; numerous interlacements are formed between them, both in the interior of the commissure and optic tract. 3. The superficial fibres, which may be followed to a certain extent, with the assistance of glasses, do not run forward in a direct line from the tract over the commissure, and then along the optic nerve to a corresponding point upon the retina, but in most of the cases I have examined, they observe a spiral course with regard to these parts, and in others with regard to the nerve itself, all, however, tending towards an opposite point on the termination of the nerve.

It may be inquired, what are the deductions to be drawn from these facts? I conceive they are more or less intimately connected with the subject of "erect vision ;" we are led, therefore, to renew the inquiry so often proposed, why is it that we see objects in the erect posture, when we know from the observations of Kepler, and by direct experiment, that the rays of light coming from the upper part of an object must impinge upon, and so affect, the lower part of the retina, and *vice versa*, and in like manner too with regard to right and left?

The solution of this question was attempted by Kepler and Des Cartes, and they thought that, from use, it is a conclusion which we draw in our own minds, from the decussation of the rays of light, that the impulse which we feel upon the lower part of the retina comes from above, and *vice versa.* It may suffice to state, in objection to this theory, that our seeing objects erect is not a deduction of reason, but as Reid remarks, an immediate perception. How few are there who know any thing of the course of a ray of light through the eye, and yet are in perfect enjoyment of the faculty of seeing?

Berkeley associated the sense of touch with the sense of vision, and conceived that the errors of the latter were corrected by the former, and that thus by a regular process of education, or association between these two senses, we are enabled to judge of the erect position of objects. I conceive this explanation perfectly erroneous, for it supposes, in such a case as that operated on by the celebrated Cheselden, that as soon as the patient was restored to sight every object at first appeared inverted, but that afterwards, when his touch had educated his vision, they gradually assumed the opposite or correct position. Can we believe that this intelligent patient could have overlooked so interesting a fact as this, particularly when he so accurately noticed other sensations?

Reid observes, that "the pictures upon the retina are by the laws of nature a mean of vision, but in what way they accomplish their end we are totally ignorant;" and that "in the operations of the mind, as well as in those of bodies, we must often be satisfied with knowing, that certain things are connected and invariably follow one another without being able to discover the chain that goes between them." It is to such connexions the term "laws of nature" has been given.

"If," says Reid, "any philosopher should hereafter be so happy as to discover the cause of gravitation, this can only be done by discovering some more general law of nature of which the gravitation of bodies is a necessary consequence. In every chain of natural causes the highest link is the primary law of nature, and the highest link which we can trace by just induction, is either this primary law of nature, or a necessary consequence of it. To trace out the laws of nature by induction from the phenomena of nature, is all that true philosophy aims at and all that it can ever reach."

To apply this reasoning to the matter before us, he further observes, " it appears to be a fact that every point of an object is seen in the direction of a right line passing from the picture of that point on the retina through the centre of the eye ;" and " as this is a fact that holds universally and invariably, it must either be a law of nature, or the necessary consequence of some more general law of nature ; and according to the just rules of philosophizing, we may hold it for a law of nature, until some more general law be discovered whereof it is a necessary consequence, *which I suspect can never be done*."*

Without stopping to controvert the opinions of this philosopher, it appears, even from his own showing, that we may by possibility arrive at some more general law than that to which we have already attained : this allows a further prosecution of the inquiry.

Müller, in his Elements of Physiology, vol. ii. p. 1172, observes: "The inversion of objects being a thing of which we never can become conscious in ourselves, *it is not probable that nature has made in the brain or elsewhere any provision for the correction of the error*, which would never have been known but for the institution of optical inquiries." This opinion goes much further in arresting anatomical investigation upon this subject, than any philosopher, even of the older schools, has ever gone. It is, notwithstanding, desirable in anatomy and physiology, as well as in other sciences, to go so far in our researches as nature herself invites us, and to endeavour, from the accumulation of facts of which we may become cognizant, to arrive as closely as possible at an explanation of the phenomena of life.

The theory of Sir Charles Bell deserves attention ; it amounts

* An Inquiry into the Human Mind, p. 153, &c.

to this, that we may judge of the position of an object, not by the impression made upon the retina (for it is not, he asserts, the office of this membrane to give us ideas of position or relation), but by a knowledge of the particular muscle of the eye which is called into action, to direct the axis of vision towards that object.*

I must confess I agree with Mr. Lord in thinking this theory, and the explanation of it which he offers, by no means satisfactory, for as Mr. L. observes, "we can very well distinguish the top from the bottom of a small object placed below us, though the same muscular adjustment enables us to take in both at once; consequently, we are deprived of that sense (the exercise of the several muscles), which in the other instance enabled us to correct the position of the image."†

Müller asserts, "that every thing being seen reversed, the relative position of the objects of course remains unchanged; the position in which we see objects we call, therefore, the erect position." (p. 1171.) Notwithstanding the weight which any opinion of this distinguished physiologist is deservedly entitled to, I cannot help thinking this theory is founded in error, for it places our visual perceptions in opposition to our tangible; and it would also suppose that the patient on whom Cheselden operated, would have different ideas of the same object from his sense of vision and his sense of touch. The theory of Berkeley is so far akin to that of Müller; but the former considered there was an error in the first instance, which the education by the sense of touch taught us to correct; whilst the latter does not admit the necessity for any such association as a corrective measure.

The law of "visible direction" has been adduced as an explanation of the fact: to this there are certain objections, but that made by Volkman, as quoted by Dr. Carpenter is, I think, perfectly valid; he asserts, that the lines of direction cross each other in a point, a little behind the crystalline lens; and that

---

* Bell on the Nervous System, p. 198. † Popular Physiology, p. 451.

they will thus fall at such different angles on different points of the retina, that no general law can be laid down respecting them.

Other theories might be cited. I think it useless, however, to occupy the reader's time by quoting them. It would appear to me, that *the correct impression made upon the sensorium is the result of the rays of light impinging on the terminations of the nervous fibres in the retina, which, crossing each other in their course backward, run to be attached to opposite points of the sensorium.* This opinion is, I think, countenanced by anatomical facts, which, the more they are examined, will, I doubt not, tend the more to its confirmation.

The recent investigations of Müller, and Ehrenberg, on the origin, course, and termination of nervous fibres, seem to bear directly upon this subject. The first named physiologist, speaking upon the point of nervous anastomoses, remarks: "If the primitive fibres never anastomose, it will follow, that the cerebral extremity of each fibre is connected with the peripheral extremity of a single nervous fibre only, and that this peripheral extremity is in relation with only one point of the brain or spinal cord; so that, corresponding to the many millions of primitive fibres which are given off to peripheral parts of the body, there are the same number of peripheral points of the body represented in the brain. If, on the contrary, the primitive fibres anastomose with each other in their course within the small fasciculi, and in the frequent anastomoses and plexuses of the nerves themselves, and do not merely lie in apposition; then the cerebral extremity of a nervous fibril will be in relation with very many peripheral points, the number of which will be equal to the number of primitive fibres which have coalesced; and since, the nerves are seen to anastomose in all parts of the body, there would, if the primitive fibres likewise anastomosed, be scarcely a single point of the body represented isolated and distinct in the brain; the irritation of a primitive fibre in a single point of the skin would necessarily be propagated through all the anastomoses; in other words, no local impression on a single definite point would be perceived by the brain ; for the sensation of a single point evidently depends on the impression being conveyed by means of a single fibre to a single point of the sensorium." (Vol. i. pp. 600-1.)

Cruveilhier remarks in speaking of the structure of nerves: "In each nerve, the filaments of which the fibres are composed pass continually from one fibre to another, and enter into an immense number of combinations, *without ever becoming blended together*." "Every nervous filament (and this is a fundamental point in their anatomy) has its central extremity in the cerebro-spinal axis, and its peripheral extremity at its point of termination. During the whole of its long course it only enters into new combinations, without ever being interrupted. *Continuity is a law of the structure of nervous filaments*."* He excepts the optic nerve so far as the interlacement of its fibrillæ is concerned. This may be true with regard to the ultimate fibrillæ of the nerve itself; they may not form combinations with neighbouring fibres, as we see in other nerves ; but with reference to the larger fibres of that nerve, and those forming the optic tract, there cannot be a doubt of their decussation, if they are examined with sufficient care ; it is admitted to take place in the commissure ; and on the surface of the nerve after it has left the commissure, the spiral course which they then take may be seen even with the naked eye, in the instances I have already given.

It is admitted that as each fibre of a nerve has a perfectly distinct course from its origin, at a given pheripheral point, to its termination at another given point situated in the sensorium, any impression made upon the former is carried uninterruptedly to the brain; and may we not in addition conclude, that the interlacements and other peculiarities occurring in the different portions of the nerve of vision, such as have been detailed, constitute a special provision for the purpose of conveying to the sensorium a correct idea from the impression made upon the retina ?

* Cruveilhier's Anatomy, vol. ii. p. 1026.

During the course of these observations I have purposely omitted the use of the term "*picture on the retina;*" I cannot help thinking it unphilosophical, and from the details I have given, it is at all events unnecessary.

70, *Harcourt-st., Dublin,*
*December* 12, 1842.

THE END.