OBSERVATIONS

ON THE

CONTRACTILE TISSUE OF THE IRIS.

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Observations on the CONTRACTILE TISSUE *of the* IRIS. By JOSEPH LISTER, Esq., B.A.

OUR knowledge of the cause of the movements of the iris was till within the last few years in a very unsatisfactory condition. That this organ possessed contractile fibres was a matter of inference, not of direct observation. In the third part of the last edition of Quain's Anatomy, published in 1848, we find it stated (p. 915) that the radiating and circular fibres of the iris are generally admitted to be muscular in their nature, but the grounds for that admission are not mentioned. Mr. Bowman's Lectures on the Eye, delivered in the summer of 1847, and published in 1849, show us that the then state of histology in this country did not enable that accomplished microscopical anatomist to identify the fibres of the iris with other plain (unstriped) muscular tissue. At page 49 he says, "The fibres which make up the proper substance of the iris are of a peculiar kind, very nearly allied to the ordinary unstriped muscle, but not by any means identical with it." He afterwards goes on to argue that, as we know that the organ changes its form, and as its vessels are so distributed that it cannot be erectile, we have no other resource than to consider its fibres contractile, which conclusion he supports by reference to the striped fibres in the iris of birds and reptiles.

In 1848 Professor Kölliker announced to the world his grand discovery of the cellular constitution of all plain muscular tissue, in a full and elaborate paper in the 'Zeitschrift für Wissenschaftliche Zoologie.'* At p. 54 of the first part of the first volume of this journal, after speaking of the arrange-

* Professor Kölliker may almost be said to have been anticipated in this discovery by Mr. Wharton Jones. Through the kindness of that gentleman, I have now before me two original drawings, made by him about the year 1843, of plain muscular tissue from the small intestine. In one of these the muscular fibre-cells are characteristically shown, except that their nuclei are not apparent; one of them is wholly isolated. In the other drawing, the alternate disposition of the fibre-cells is seen after the addition of acetic acid. He also observed, as he informs me, that the unstriped muscle of the œsophagus and stomach, and also of the uterus and other organs, consisted of similar elements—a fact which he yearly communicated to his class in his public lectures at Charing Cross Hospital. He was led, from appearances in the embryo, to infer that striped muscular fibre is originally composed of similar elements, which, in the process of development, are enclosed in a sarcolemma common to many of them, and become split into fibrillæ. He thus accounted for the nuclei of striped muscular fibre, which, according to this view, are the persistent nuclei of the primitive muscular fibre-cells.—J. L.

ment of the fibres of the ciliary muscle, the sphincter pupillæ, and dilator pupillæ, he makes the following statement:—"The elements of all these muscles are undoubtedly smooth muscular fibres. In man I have but seldom succeeded in isolating the individual fibre-cells, but I have had more frequent success in the case of the sheep, where I found them in the ciliary muscle, on an average, 1-600th of an inch in length, and 1-4000th to 1-3000th of an inch in breadth. In man, in all these muscles one sees, as a rule, only parallel fibres projecting to a greater or less extent at the edges of small fragments of the tissue, these fibres exhibiting in abundance the well-known elongated nuclei, either with or without the aid of acetic acid. In man, the muscle of the choroid (ciliary muscle) has broader and more granular fibres and shorter nuclei than the iris. In the former the nuclei measure from 1-2400th of an inch to 1-1333rd of an inch; in the latter as much as 1-1090th of an inch."

Here, then, we have, so far as I know, the first and only recorded observation of tissue in the iris identical with ordinary unstriped muscle.

It is to be remarked that, where he alludes in the passage above quoted to having in rare cases separated the individual fibre-cells of the muscular tissue, Professor Kölliker speaks of the three muscles (ciliaris, sphincter, and dilator) collectively; in other words, that he does not tell us in plain terms that he has isolated the fibre-cells of the iris at all. Now, the ciliary muscle is confessedly easier to deal with than the iris. Mr. Bowman, who speaks so doubtfully of the fibres of the iris, says of the ciliary muscle, "the fibres are seen to be loaded with roundish or oval nuclei, often precisely similar to those of the best marked examples of unstriped muscle" (op. cit., p. 53). Another very eminent microscopical anatomist has informed me, as the result of his experience, that it was easy to identify the tissue of the ciliary muscle with that of other organic muscle, but that this had not been the case with the iris. That Professor Kölliker's isolation of the fibre-cells of the muscles of the eye was in reality confined to the ciliary muscle is rendered probable by the fact that, while the whole article quoted from shows a manifest desire on the part of its author to give all available detail, yet regarding the iris he mentions no facts requiring isolation of the fibre-cells for their determination; while, on the other hand, he tells us that the fibre-cells of the iris are narrower than those of the ciliary muscle, and gives the length of the nuclei in the human iris—things which are very readily observed without isolation of the fibre-cells. His figures refer to the human ciliary muscle alone; and the only measurements given by him of muscular fibre-cells from the eye refer to the same muscle in the sheep.

It would seem, then, that with regard to the iris, Kölliker's proof falls short of the test of isolation of the fibre-cells.

An operation for artificial pupil, by excision, performed by Mr. Wharton Jones, at University College Hospital, on the 11th of August of the present year (1852), placed in my possession a perfectly fresh portion of a human iris, and, without knowing that Kölliker's observations had extended to the muscles of the eye, I proceeded to avail myself of this somewhat rare opportunity of investigating the muscular tissue of the human iris. On placing under the microscope, four hours after the operation, portions of the tissue carefully teased out in water with needles, I found that some of the muscular fibre-cells had become isolated, and presented very characteristic appearances. I accordingly made camera lucida sketches of the finest specimens, which are reproduced on a smaller scale in the accompanying figures (see Pl. I., fig. 7-11). I drew the last cell (fig. 8) 9½ hours after the operation. And here I may mention that I have not found the muscular fibre-cells by any means a very perishable tissue. After an iris has been soaking two or three days in water, the muscular tissue of the sphincter is still quite recognisable, not only by the nuclei, but also by the individual fibre-cells.

Of the figures above referred to, (7) and (8) are examples of the most elongated cells that I saw. By reference to the scale it will be found that the cell (7) is about 1-125th of an inch in length, and about 1-3750th of an inch in greatest breadth; while (8) is a little shorter, but of about the same average breadth. Kölliker divides muscular fibre-cells into three artificial divisions, according to their shape, of which the third contains the most elongated and most characteristic cells. Of this third division, the cells (7) and (8) are good examples, and, in fact, correspond in their measurements to average fibre-cells of the muscular coats of the intestines. The cells (9) and (10), though less characteristic in respect of their length—(9) being about 1-333rd of an inch in length, and 1-3000th of an inch in breadth, and (10) 1-300th of an inch by 1-3000th of an inch, yet present the same peculiar delicate appearance and soft outline, and the same elongated nucleus, of not very high refractive power relatively to the contents of the cell, but clearly defined. All these cells have the same flat or ribbon-like form which is exhibited by the cell (8) at (*a*), where one edge has become turned up by a folding of the cell; at (*b*) there seemed a tendency to transverse arrangement of the granules of this cell, which tendency is more strikingly exhibited at *b* and *c* in the cell (11), which, though not isolated, is introduced on that account. This tendency to transverse arrangement of the granules was long since noticed by Mr. Wharton Jones, as that gentleman has since informed me, and is, indeed, indicated in the drawings which are alluded to in the note above. In the cells of this iris, however, it was not by any means constant. Some of them, as (7) at (*a*), and (9) at (*a*) and (*b*), exhibited something of a longitudinal arrangement of the granules, such as was noticed some years since in unstriped muscle by Mr. Bowman, who considered the rows of granules as an approach to the fibrillæ of striped muscle. These cells are more granular than I have found those of the iris of the horse to be; but I may here mention that, on comparing with these drawings the outline of a fine specimen of a muscular fibre-cell of the sphincter pupillæ of this animal, which I had sketched by the camera lucida, I find it to be almost an exact counterpart of the cell (7) as regards the shape and size of both the cell and its nucleus. The nuclei of these cells measure from 1-1400th to 1-1110th of an inch in length, and about 1-9500th of an inch in breadth. They are not, however, the most characteristic that are to be found in the iris. Fig. 12 is from a camera lucida sketch of a nucleus of the sphincter pupillæ of a horse; it measures 1-840th by 1-15,200th of an inch, and exhibits in a very marked manner the true rod-shaped figure which appears peculiar to muscular fibre-cells. On the other hand, I found some instances in the human iris of fibre-cells with considerably broader nuclei than those in the figures. The iris that yielded these cells was a blue one, apparently perfectly healthy; it was active and brilliant before the operation, which was performed on account of central opacity of the cornea, resulting from an attack of a severe form of ophthalmia fifteen months previously. I watched the case closely from the first, and there was no reason to suspect implication of the iris in the inflammation.

Having thus satisfactorily verified the fact of the existence in the iris of tissue identical with ordinary unstriped muscle, I was naturally led to inquire into its distribution in the organ: and, as this is a subject of great interest, and one about which much difference of opinion has prevailed, I may mention here the facts which I have hitherto observed, although there be not very much of actual novelty in them.

Kölliker, in the article above referred to (loc. cit. pp. 53 and 54), describes a sphincter and dilator pupillæ, the former "very readily seen in the white rabbit, or the blue iris of man, from which the uvea has been removed, about a quarter of a line broad in man, exactly forming the pupillary margin, and situated somewhat nearer the posterior surface of the iris." Of the dilator he says, while confessing the difficulty of the investigation, that he believes it to consist of many narrow bundles, which run inwards separately between the vessels, and are inserted into the border of the sphincter.

Bowman, on the other hand, states (op. cit. p. 48) that, while in some instances a delicate narrow band of circular fibres exists at the very verge of the pupil, yet, in the majority of instances, he feels *sure* that no such constrictor fibres of the pupil exist. He ascribes the contraction of the pupil to the inner part of the radiating fibres, which, he says, are joined and knotted in a plexiform manner round the pupil. It is scarcely needful to observe that such a statement from such an authority could not but go far to impugn Professor Kölliker's assertion respecting the existence of a sphincter pupillæ.

My experience, I must confess, accords with that of Kölliker, viz. that the sphincter is readily seen, while the dilator is that whose investigation alone presents very serious difficulty. In the first iris that I examined with a view to the distribution of the muscular tissue, I was struck, after removing the uveal pigment, with the appearance of a band on the posterior surface of the iris, near the pupil and parallel to its margin, quite evident to the naked eye, elastic and highly extensible. This proved to be the thickest part of the sphincter pupillæ. I have examined six human irides with reference to the distribution of the muscular tissue, but in none have I had any difficulty in recognising the sphincter, which I have also found equally distinct in some of the lower animals, viz. in the rabbit, the guinea-pig, and the horse. In man I find it about 1-30th of an inch in width, thickest towards its outer part, where it lies nearer the posterior surface of the iris than the anterior, and thinning off towards the pupil, where it forms a sharp margin, covered apparently on its anterior aspect only by some vessels and nervous threads and a delicate epitheliated membrane, which is thrown into beautiful folds when the pupil is contracted. The fibres of the sphincter are not absolutely parallel, and this deviation is probably produced in part by the dilating fasciculi sweeping in at various parts in a curved manner, and becoming blended with the sphincter. The reason for this supposition will appear hereafter. By teasing out under the microscope a portion of the actual pupillary margin, I found the sphincter to consist at this part of apparently unmixed muscular fibre-cells, without any connecting cellular tissue. Fig. 13 is a camera lucida outline of the edge of a portion of the sphincter so prepared, which edge is seen to be formed of projecting fibre cells, and similar appearances may be seen with great readiness under a high power, after stroking the pupillary margin with the point of a needle. Indeed, the great facility with which the tissue may be thus broken up appears opposed to the idea of the fibre-cells being united end to end into fibres, as the descriptions formerly given of unstriped muscle would lead one to suppose. The ends appear to separate as readily as the edges and surfaces, and it would rather seem as if the fibre-cells of a fasciculus were placed with their long axis in one direction, cohering generally to one another, but without the formation of longer fibres than each cell itself constitutes. I may here mention incidentally that in the circular coat of the aorta of the sheep, where the muscular tissue is disposed in thin layers among the elastic tissue, I have observed a distinctly alternate arrangement of the fibre-cells without any formation of fibres. Mr. Wharton Jones's drawing of alternately disposed fibre-cells in the small intestine has been alluded to in the note above. A portion of the outer and thicker part of the human sphincter pupillæ proved also extremely rich in muscular fibre-cells. In the rabbit and guinea-pig the sphincter has much the same appearance as in man, whereas in the horse it forms a wide but very flat band.

The dilating fibres of the iris present a very difficult subject of investigation.

And here I must express my belief—a belief the result of repeated and very careful observations—that the fibres described by Mr. Bowman as probably the contractile fibres of the iris are in reality the outer cellular coats of the vessels. The outer coat is very abundant in the vessels of the iris, and indeed even in the blue eye towards the sphincter quite obscures the bore of many of the vessels, and prevents the recognition of their vascular character, which can only be determined by tracing them to their more external and more obviously vascular trunks. The distribution of these vessels, radiating between the sphincter and the circumference of the iris, and forming in the region of the sphincter a close and knotted plexus, corresponds accurately with Mr. Bowman's description of the distribution of the fibres of the iris. His account of the tissue of these fibres, which he considers as probably contractile, harmonises with the characters of the cellular tissue that clothes the vessels. This is peculiar; consisting of very soft-looking fibres, whose fasciculi often require the best aid of a first-rate glass to resolve them into their constituent elements; destitute apparently of yellow elastic fibres, as in the case of the cellular tissue of the uterus, but, like this, containing abundance of free nuclei, of roundish or elongated form. The fibres are completely gelatinised by acetic acid. Now such a tissue can hardly, in the present state of our knowledge, be regarded as contractile; at any rate, if we can find any ordinary muscular tissue to account for the dilating action. On teasing out portions of the outer part of the human iris, I have found long delicate fasciculi, whose faint outline, absence of fibrous character, and possession of well-marked elongated nuclei parallel to the direction of the fasciculus, left no doubt in my mind that they were plain muscular tissue.

So far my observations regarding the dilator agree with Kölliker's, but whether or not these fasciculi are connected with the cellular coat of the vessels I have hitherto been unable to determine.

Among the lower animals the albino rabbit and guinea-pig appeared but little suited for the elucidation of this point. I have been most successful with the eyes of a horse, where, from the thickness of the iris and the abundance of pigment (for the eyes were black ones), I anticipated but little result from my examination. Having removed the uveal pigment from behind, I found that I was also able to strip off from the anterior surface a tough membrane, a portion of which, put under the microscope, appeared to be made up of peculiar short felt-like fibres, which were gelatinised by acetic acid. At and near the pupillary margin this membrane comes off in a continuous layer, leaving a delicate reticular structure, which contains the muscular tissue. It also contains vessels, as I proved by injection, and a black network, which consists of fine fibres, yellow, and highly refracting, more or less encrusted with pigment. I am uncertain whether or not this be a network of divided nerve-tubes with adhering pigment; in some spots the pigmental crust was absent from a considerable length of the fibres. The sphincter pupillæ is beautifully seen as a broad flat band, of extremely well-marked, unmixed, muscular fibre-cells; but crossing this at right angles are found, here and there, other flat bands of fibre-cells, which are in so thin a layer that without isolation the width of the individual cells cannot be seen, and they are evidently of similar dimensions to those of the sphincter. On addition of acetic acid their nuclei are also seen to be exactly like those of the sphincter. These bands divide in their course towards the pupil into several fasciculi, some of which cross over the sphincter at right angles till very near to its pupillary margin, and then seem to blend with the sphincter by making a slight curve. Most of the fasciculi, however, arch away earlier from their first course and join the sphincter in more or less oblique lines. The bands from which these fasciculi diverge may be traced away from the pupil for some distance, continuing their course at right angles to the sphincter till they are obscured by other tissues. Hence I think the inference may fairly be drawn that these are the insertions of the dilating muscular bundles. In the horse, then, the dilating fasciculi appear to consist of precisely the same tissue as the sphincter, and to blend with it in their insertion. The flat bands of muscular tissue above spoken of seemed to have no special relation to the vessels, some of which were filled with injection. In the outer part of the iris of the same horse I found a delicate muscular fasciculus lying near but not intimately connected with one of the radiating vessels of this part. In the human iris I have seen a muscular fasciculus, as it appeared from the nuclei it contained, crossing the sphincter at right angles for a short distance; this observation, so far as it goes, seems to imply that the same mode of insertion of the dilator occurs in man as in the horse.

The fibre-cells of the dilator appear to be held together much more closely than those of the sphincter, at least in the outer part of the iris; for I have never been able to define the individual fibre-cells in a perfectly satisfactory manner in the dilator, though I have often teased out portions of the outer part of the iris. The dilating muscular tissue is also probably less abundant than the muscular tissue of the sphincter; and this, if the fact, will help to account for the comparative difficulty in discovering it. I may here mention that both in the cat and in the rabbit, soon after death, dilatation of the pupils being present, exposure of one iris to the air caused it to contract at once, while the pupil continued dilated in the other eye, which was untouched. I do not know if this fact has been observed before, but it is interesting in two ways—first, as showing that the muscular tissue of the iris, like other muscular tissue, is obedient to the stimulus of exposure; and, second, as proving either that the sphincter is in these animals a decidedly more powerful muscle than the dilator, which is equally exposed to the stimulus; or else that the fibres of these two muscles have different endowments, as has been shown by Mr. Wharton Jones to be the case with the muscular tissue of the arteries and veins of the bat's wing; where, although the veins are muscular, and even contract rhythmically, yet the arteries alone exhibit tonic contraction when irritated by mechanical stimulus.

A rich network of extremely fine fibres, seen readily in the blue human iris viewed from the anterior aspect, appears to represent the nerves of the organ. The fibres are of a yellowish colour, and are possessed of pretty high refractive power; they present, if really nervous, a good illustration of the division and anastomosis of ultimate nerve-fibres; the smallest divisions visible under a high power are seen only as fine lines.

I have not seen any nerves in the human iris presenting the double contour; but in the iris of a cat, so fresh that the tissue contracted under the needles as I teased it out, the double contour of the nerve-tubes was already very strongly marked, showing the existence in this animal of the white substance of Schwann in these nerves. The double contour surrounded the ends of the nerve-fibres which I supposed to have been broken by the teasing process. This last fact seemed to confirm the general belief that the double contour is a post-mortem effect, which, however, was in this instance a very rapid one.

I believe that a further investigation of the fresh blue iris in man, and of the horse's iris, would supply the means of finally settling the question of the distribution of the dilator pupillæ.

My engagements do not allow me to carry the inquiry further at present; and my apology for offering the results of an incomplete investigation is, that a contribution tending, in however small a degree, to extend our acquaintance with so important an organ as the eye, or to verify observations that may be thought doubtful, may probably be of interest to the physiologist.

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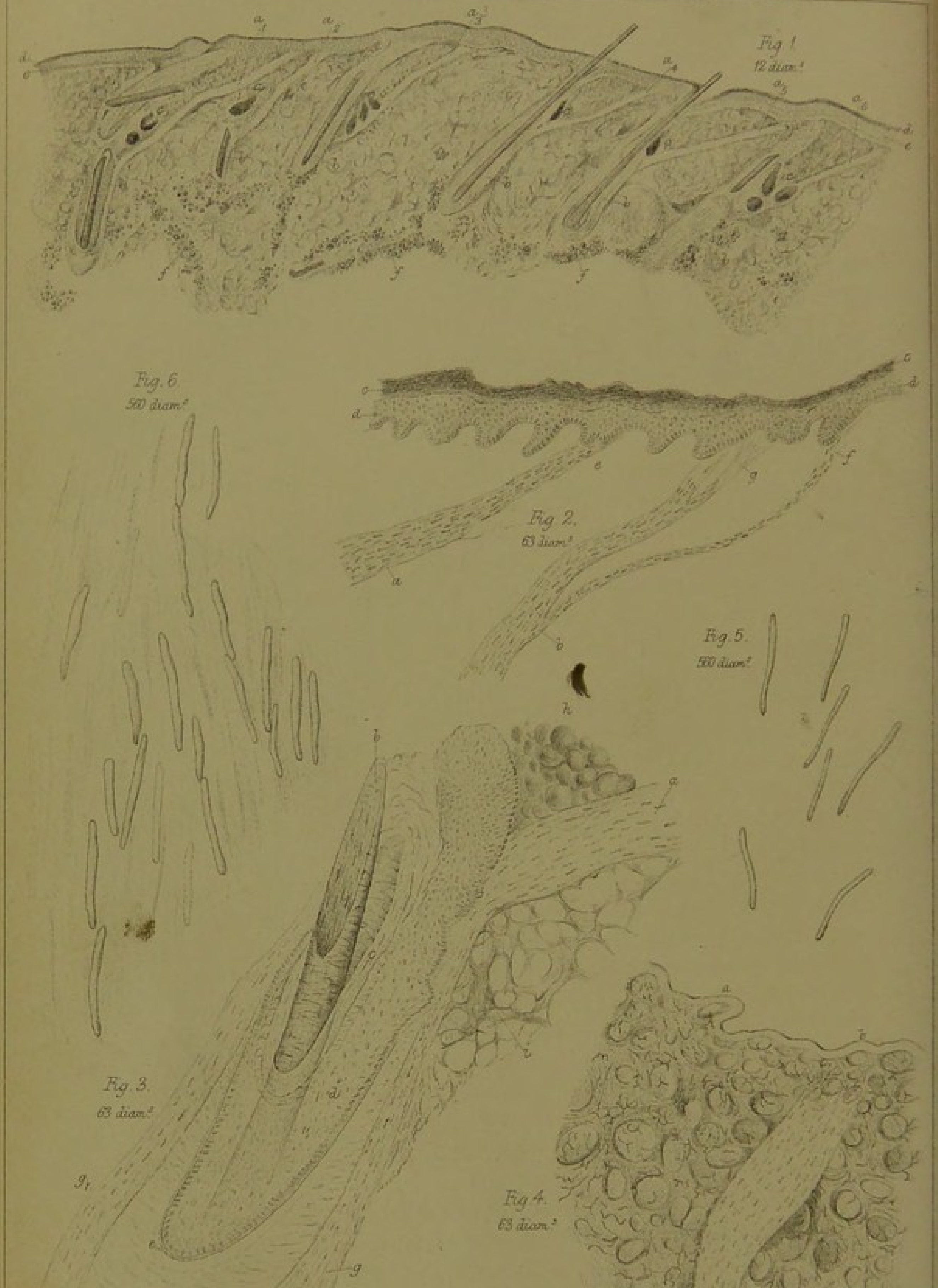

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