ON THE

LYMPHATIC SYSTEM OF THE CORNEA.

BY G. THIN, M.D.

IN 1849, Bowman* relates that in injecting the cornea of the ox with mercury, he found "that the metal coursed rapidly along in perfectly parallel and very delicate lines for a short distance, then diverged at an angle into other similar tubes, which were found to cross the former either above or below. The tubular spaces thus injected appeared to be jointed or broken at varying intervals, and to present what in the nerve-tubes would be termed a varicose condition." He found that the whole cornea was filled with such tubes. That the varicose condition was not due to the tendency of mercury to collect itself in a globular form was proved by the same appearance being observed when the injected mass consisted of size and vermilion. He found it difficult to make similar injections in smaller animals, but, under favourable circumstances, he succeeded in finding a tubular arrangement in the human cornea. Not succeeding in pushing the injected mercury beyond the cornea, he concluded that "probably the corneal tubes do not communicate directly with any other set of vessels or natural channels."

This experiment of Bowman's has arrested the attention of all subsequent investigators into the anatomy of the cornea, and whether "Bowman's tubes" exist in nature, or are the result of the violence done to the texture by the force used in making the injection, has remained until the present time a subject of discussion.

Kölliker† relates in 1854 that he had once found in the conjunctival border of the cornea of a young cat, along with well-marked capillary bloodvessels, pale, wide vessels having a fine structureless wall, which sent projections into the cornea. He saw in the clear fluid in their interior round cells which had exactly the appearance of lymph-corpuscles. Kölliker considered that in this case he had probably seen lymphatic vessels; but, as he never saw a similar appearance again either in the cornea of the cat or of any other animal, he hesitated to express a decided opinion on the matter.

Von Recklinghausen‡ in 1862, in opposition to His, Henle, Langhans, and Teichmann, who maintained that Bowman's tubes were artificially produced, confirmed the observations of Bowman, and further succeeded in injecting from the cornea to the conjunctiva. His efforts to find an independent wall in the canalicular system of the cornea had a negative result, and he came to the conclusion that it is "improbable that in the cornea-kanälchen in general a special membrane exists." For the system of canals he introduced as a more precise designation the term "saft-kanälchen," which has passed into very general use.

Later, in Virchow's Archives,§ he urged the necessity of assuming the existence of a system of canals to account for the movements of the wandering cells observed in the fresh cornea, and showed that these canals must be in direct connexion with the fixed cornea-corpuscles first observed by Toynbee.

To show how little von Recklinghausen is inclined to associate these canals with the lymphatic system, I have only to refer to his treatise on the lymphatic vessels in Stricker's "Handbuch," Band i., p. 215, where he states that it is distinctive of lymphatic vessels that they occur always simultaneously with bloodvessels, and that "textures in which there are no bloodvessels have also no special lymph-vessels (cornea, vitreous humour, epithelium)."

C. F. Müller|| held that neither the cells of the cornea nor the lacunæ in which they lie possess a membrane, and that the latter differ in no respect from the ordinary inter-fibrillary spaces, except in that they harbour the cells, and so when injected they acquire the appearance of a canal system.

His (I quote from Leber),* by macerating the cornea in mineral acids, obtained a connected network, and, therefore, held that he had proved the existence of a membrane. Leber† proceeded also by a system of maceration, and found tubes which he held to be identical with Bowman's. He leaves it undecided if the tubes are to be themselves considered as anastomosing cells or as harbouring cells. Lawdowsky‡ agrees with Leber that the canalicular system can be separated, and that the existence of a special membrane of "some thickness" is thus proved. He denies the existence of any cells or formed elements in connexion with it, attributing appearances simulating these to excessive colouring in silver.

Rollett§ states that the general result of all "*einstich*" injections into the cornea is a springing of the texture. "From this method," he remarks, "it has been erroneously concluded that long-stretching, straight, tubular hollow spaces, corneal tubes (Bowman's), interlamellary cavities (Henle), or a net-shaped canal system (von Recklinghausen, C. F. Müller, Schweigger-Seidel), exist in the fresh cornea."

I have frequently observed in sections of the cornea treated in the usual way by nitrate of silver and chloride of gold, singly and combined, appearances that I could only explain by supposing the existence of epithelium-lined lymphatic vessels running through the structure. Recently, in re-examining preparations that had been laid aside for a time, I found that in some of them these appearances had developed to an extent and precision that place the existence of lymphatic vessels in the cornea beyond doubt.

Figs. 1 and 2 are drawn from two of these preparations. I have succeeded since in obtaining preparations equally characteristic in sections of the cornea within a few days after they were excised and subjected to the influence of the metallic solutions.

Fig. 1 represents the largest lymphatic vessel I have seen, and from its size shows well the specially distinctive epithelium of the lymphatics. Fig. 2 shows smaller vessels joining to form a larger trunk, and their relative position to the substantia propria of the cornea. They are from the rabbit.

Those who are familiar with the appearances presented by the lymphatics as demonstrated by the use of nitrate of silver in the diaphragm of the rabbit or guinea-pig, will at once identify these drawings as representing similar anatomical structures. Those who are not familiar with these appearances can satisfy themselves that they are the same by referring to the woodcuts in the works of von Recklinghausen and Klein.

A reference to Bowman's description of the corneal tubes shows how accurately, even to the varicosities, it applies to the lymphatics, and I cannot help coming to the conclusion that the mercury in his injections took the course offering least resistance, that along the lymphatic vessels.

The clear spaces in Figures 1 and 2 correspond to the lacunæ of the cornea, in which the cornea corpuscles or cells lie; and it will be observed that they communicate directly with each other, and, through those that are adjacent to the vessel, with the lymphatic system. The dark colour of the lines between the epithelial cells being due to the action of the nitrate of silver on the connecting substance, if the silver solution has penetrated only as far as the vessels, the epithelium of the vessels only is seen, as in Figures 1 and 2. But if the nitrate of silver is brought into contact with the free surface of the lacunæ, it is found that the epithelium is coextensive with the whole canalicular system. To favour the penetration of the silver solution I recommend the following method:—The anterior epithelium should be scraped off the cornea immediately after the death of the animal. The cornea is then cut out, and divided into pieces, which are put into a half per cent. solution of nitrate of silver. The pieces should be taken out at intervals, one at a time, the first one being taken out after ten or fifteen minutes. Several of the pieces should, after having the white flaky coagulum washed gently off with distilled water, be put in a half per cent. solution of chloride of gold, in which they should again be allowed to remain for different periods varying from fifteen minutes to an hour. They are then allowed to colour in the light in the usual way. Sections from the different pieces so treated

* Lectures, &c. London, 1849.
† Mikr. Anatomie, Band ii., Abth. ii., s. 621. Leipzig, 1854.
‡ Die Lymphgefässe. Berlin, 1862.
§ Virchow's Archiv, Band xxviii., s. 157.
|| Virchow's Archiv, Band xli., s. 136.

* Monatsblatt für Augenheilkunde, s. 17. 1866. † Loc. cit.
‡ Max Schultze's Archiv, 1872.
§ Stricker's Handbuch, art. Cornea.

should show all the varieties of the gold and silver tinting.

Figure 3 has been drawn from a preparation obtained by this method, and shows the direct continuation of the epithelium of a lymphatic vessel into that lining the lacunæ or corneal spaces.

In affirming the existence of an epithelium in the lacunæ, I rest my opinion firstly on the appearance of the fine lines which are seen traversing the spaces (the "sinuous endothelium" considered by Klein as characteristic of the lymphatic system), and, secondly, on its being anatomically continuous with what I venture to think no one will doubt is epithelium in the lymphatic vessel.

In studying the relations of the nerves to the lymphatic trunks, I have been repeatedly able to trace the epithelial markings in the vessel into the spaces on each side.

In regard to the relation between the appearances presented in Fig. 3 and the known general form of the lymphatic epithelium, it is necessary to bear in mind the relative size of the space and the epithelial cell, and that as the section represents only one surface of the space, only segments of the lining cells can, as a rule, be seen. As the assigning to these silver-coloured lines the interpretation of the points of contact of contiguous epithelial cells has an important bearing on the anatomy of the whole lymphatic system,* it is fitting that I should examine what has been already observed in this direction.

As far as I know, Hoyer† and Schweigger-Seidel‡ are the only observers who have figured dark lines in a clear field in drawings illustrating preparations from corneæ treated with silver, and I believe the lines they figure to be the same as those which I interpret as epithelial. As I understand Hoyer, he believed these lines to be produced by the action of the silver on the surface of the cornea-corpuscle. "Wenn nun also die in der Hornhautsubstanz ausgegrabenen Lücken und Kanälchen einerseits von Zellen und ihren Fortsätzen wirklich ausgefüllt sind, die selbst keine Silberkörnchen einschliessen, andererseits der Niederschlag dennoch in dem Lückensystem enthalten ist, so kann er sich nur zwischen der Wand und dem Inhalte der Lücken, also auf der Oberfläche der Zellen und ihrer Ausläufer abgelagert haben."

To explain them Schweigger-Seidel constructed a new scheme of the anatomy of the cornea. The lacunæ are, according to him, mere clefts in the fibrillary substance, which

FIG. I.

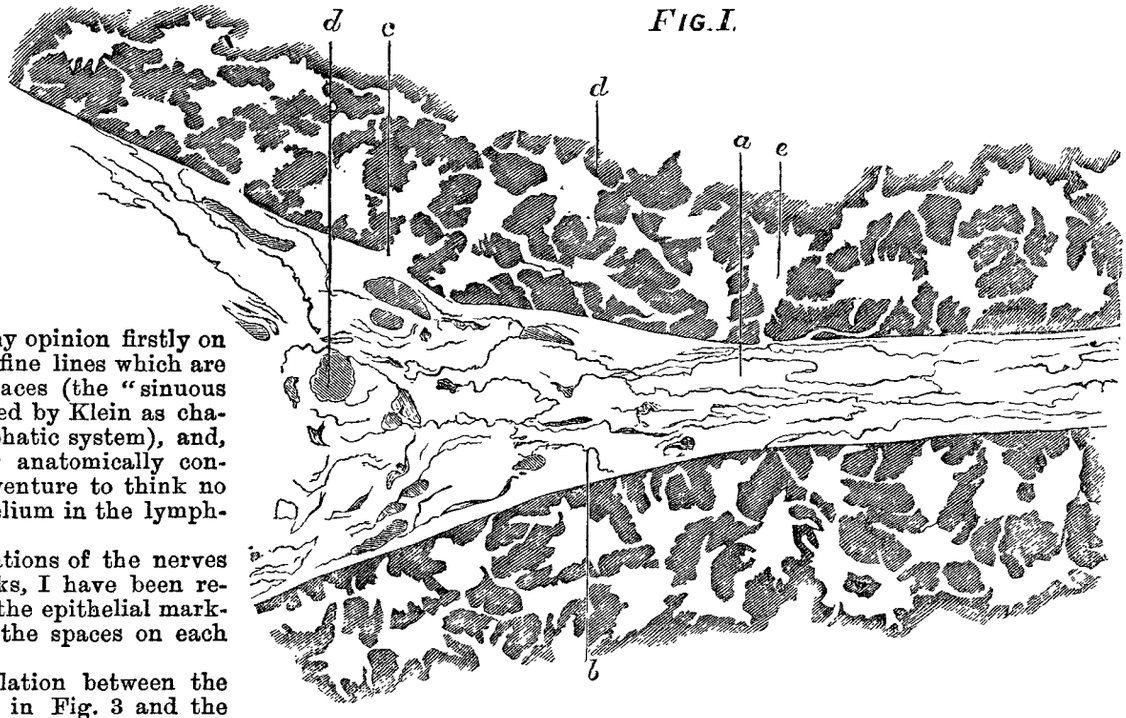
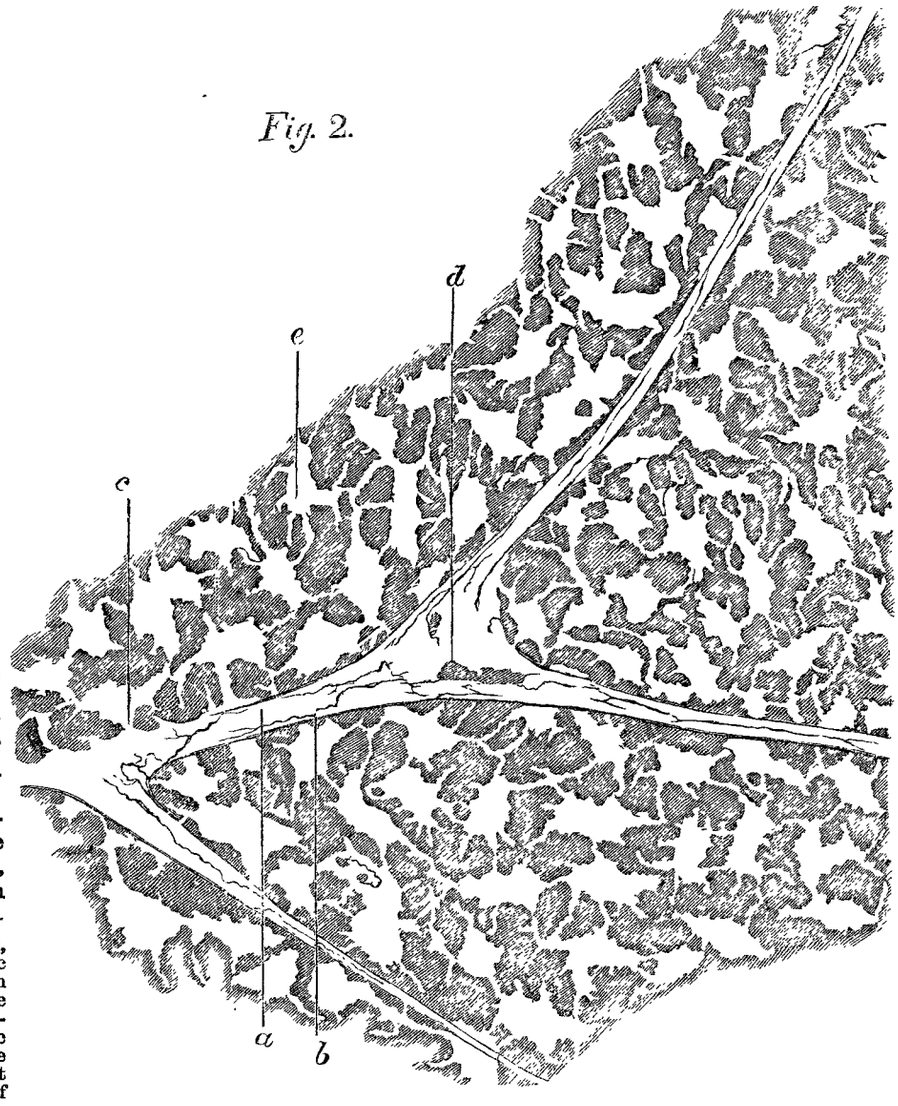


Fig. 2.



EXPLANATION OF FIGS. 1, 2, 3, & 4.—(*Magnifying power:* Hartnack Objective 7; Eye-piece 4.)

a, Lymphatic vessel. *b*, Line between the epithelial cells of the lymphatic vessel. *c*, Free opening from the lacunæ of the cornea into the lymphatic vessel. *d*, Substantia propria of the cornea. *e*, Corneal space (lacuna). *f*, Line between epithelial cells in the lacunæ. *g*, Nerve-stem. *h*, Branch of nerve. *i*, Anastomosis between two cornea-corpuscles. *k*, Cornea-corpuscle (tinting incomplete).

* Von Recklinghausen (Stricker's Handbuch, p. 231), to whom so much of our knowledge of the lymphatic system is due, makes the existence of an epithelium the test of where the *saft-kanälchen* end and the lymphatic vessel begins. He declines (p. 232) to sanction any conclusion as to the source of the lymphatic system in other organs from the *lymph-spalten* of the testicle, because His and Tommasi had proved that they are lined with the characteristic epithelium of the lymph-capillaries "to which, and not to the saft-kanälchen, they are analagous." But a comparison of my figures with that of von Recklinghausen (l.c., p. 229) shows that as to the analogy of the lacunæ of the cornea with the saft-kanälchen of von Recklinghausen there can be no question.

† Reichert u. Du Bois-Reymond's Arch., s. 204. 1865.

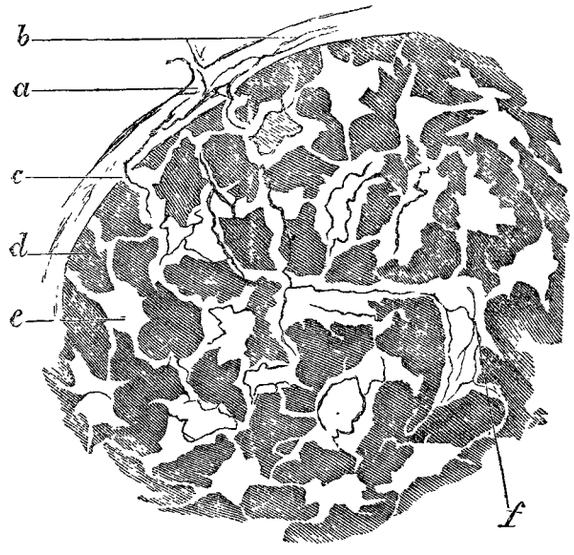
‡ Sitzungs Bericht der K. sachsischen Gesellschaft der Wissenschaften. Math. Phys. Classe. 1869.

on one side only are covered with "cornea-cells," one side of the cell being fixed to the fibrillary structure, and the other being free towards the cleft in the fibrillary substance. His cornea-cells differ from what is generally understood as a cornea-cell or corpuscle. What is accepted as the nucleus of the cornea-corpuscle is, according to him, the nucleus of a flat cell (*platten*), the cornea-corpuscle having no individuality (if I may use the term), and no nucleus, and being simply a movable substance, to which it is doubtful if the term "protoplasm" can be applied.

The figures of his isolated cornea cells probably represent the epithelium of the spaces. His theory of the non-existence of the cornea-corpuscle as an independent protoplasmic mass has not found, and is not likely to find, support.

Rollett,* in referring to the dark lines of Hoyer and Schweigger-Seidel, gives another explanation of them. He says that they are only to be found in young animals, and can be demonstrated in every young rabbit; that they mark, indeed, the limits of two adjoining cells, but that the cells are the cornea cells (corpuscles) which have not yet been separated by the growth of the fibrillary cornea substance. "It is certain," he remarks, "that the appearance is not to be seen in the developed cornea layers of grown animals." In reference to Rollett's theory, I have only to remark that the corneæ from which sections are drawn in Figs. 3 and 4 were taken from an adult bitch pregnant at the time of their removal.

Fig. 3.



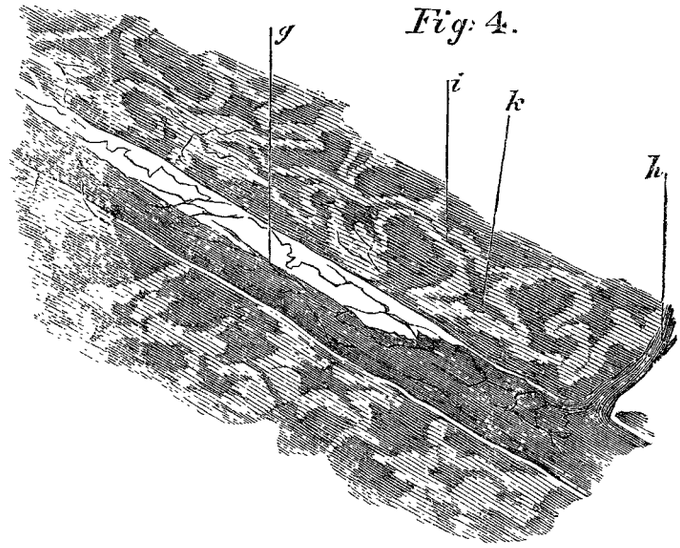
Von Recklinghausen† relates that he had observed vibrios, which had developed in corneæ that were decaying at an animal temperature, travelling along the nerve-stems, whence they found ingress into the star-shaped spaces (lacunæ) at their sides. C. F. Müller‡ found that masses urged by injection along the nerve-trunks found their way into the lacunæ (*Zellen-lücken*), and thence concluded that the nerves and the cornea-corpuscles lie in communicating spaces. Leber§ infers it as probable, from the easy passage of fluid along the nerves, that a fine fluid-filled space exists between the nerve and the cornea substance. Lawdowsky‖ considers Bowman's tubes to be "nothing else than injected nerves," and that the saft-kanälchen network of the cornea serves as conductor both for the bundles of nerve-fibres and axis-cylinders and for their fibrillary elements.

In a cornea that has been treated first with silver and then with gold, and in which the special effects proper to each metal have been produced, the lymphatic is brought out by the silver, whilst the nerve coloured by the gold is seen lying in the vessel and nearly filling it. A narrow clear space is distinctly visible between the nerve and the wall of the lymphatic.

Fig. 4 is from a preparation obtained by this method from the same cornea as Fig. 3, and has been selected because in making the section the knife has happened to carry away a part of the nerve-trunk, and has thus made the relations of the nerve to the lymphatic vessel very apparent. In other preparations from the same cornea, in which the nerve, lymphatic wall, and the clear space between them were distinctly visible, I have seen very clearly the continuation of the same relation from the main stem into the nerve-branches and smaller lymphatics.

In stating that the dark central cylindrical body is a nerve-trunk, I confirm Lawdowsky and others. I have followed it in sections, until after repeated subdivisions it has terminated in the distinctive nerve-fibrillæ, and in an oblique section of the trunk itself I have seen the dark violet axis-cylinders lying in the cut edge of the less deeply tinted nerve-sheath structure.

Fig. 4.



It has not come within the scope of the present paper to treat specially of the cornea-corpuscles. As showing that Figs. 3 and 4 are from a normal cornea, I may mention that in sections from the same cornea, in which the chloride of gold had acted exclusively, I saw the usual beautiful webbed network of anastomosing corpuscles with oval nuclei lying in an otherwise perfectly clear field. In comparing the size of these corpuscles with that of the lacunæ, the conviction is inevitable that the fluid-filled space which the easy passage of white cells in the cornea shows to exist between the epithelium and the corpuscle, must, in the normal condition, be very narrow.

In Fig. 4 the corpuscles are represented in several of the spaces fractionally and imperfectly, as they happened to be seen in the preparation.

In conclusion, I would suggest whether the dark and clear fields seen in all silver-corneæ may not be produced by a special power on the part of the epithelium to resist the absorption and reduction of the nitrate.

To Mr. J. C. Ewart, of the University of Edinburgh, for the care and fidelity with which he has executed the drawings, my best thanks are due.

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* Loc. cit., p. 1122. † Virchow's Archives, loc. cit.
‡ Loc. cit. § Loc. cit. ‖ Loc. cit.

NOTES AND PRACTICAL OBSERVATIONS UPON THE REMITTENT FEVER AND DYSENTERY OF THE GOLD COAST.

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(*Communicated by the* DIRECTOR-GENERAL OF THE MEDICAL DEPARTMENT OF THE NAVY.)

AT this time, when the attention of England is drawn towards that part of Africa—the Gold Coast—where active operations are being carried on by our countrymen against the Ashantees, it may not prove uninteresting to give a summary of the cases of remittent fever and dysentery which were the first admitted into Haslar Hospital for treatment, and which presented symptoms of unusual severity and of long continuance.

The causes which initiated the Ashantee war are known