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THE FINER HISTOLOGY OF THE NORMAL GLOMERULUS*

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INTRODUCTION

The object of this paper is to review the literature and to present some new facts regarding the histology of the normal human renal glomerulus.

I. REVIEW OF LITERATURE

Bowman's Capsule: In 1688 Malpighi discovered the renal glomerulus by means of injections through the renal artery. He considered it a gland which might possibly give origin to the uriniferous tubule. Schumlansky, 1782, suggested in a diagram some connection between glomeruli and tubules. Littre, 1705, and Johannes Müller, 1830, were the first to describe the capsule. Huschke, 1828, and Müller believed the capsule to be closed except where the vessels entered. Bowman, 1842, proved the union of tubule and glomerulus by a method of successive injection of saturated solutions of potassium bichromate and lead acetate. In both human and animal kidneys the precipitate which formed in the vessels often burst through the glomerular tuft and passed down the tubule. He described the capsule as consisting of an external tunic of transparent homogeneous tissue lined by epithelium. These epithelial cells were non-ciliated, flat and continuous with those of the convoluted tubules. These findings were confirmed in 1845 by Bidder who also noted the continuity of the capsular and tubular basement mem-

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branes. Roth, 1864, and His, 1865, were the first to demonstrate cell boundaries with silver preparations. Ludwig, 1872, described the capsule as consisting of "a mosaic of cells closely resembling those composing the wall of the blood and lymphatic capillaries with a little connective tissue around the outer surface." Drasch, 1877, saw that the nuclei of adjacent cells lay side by side in eccentric positions. Herring, 1900, after a comprehensive review of the embryology of the kidney, concluded that the cavity of Bowman's capsule should be regarded as a body cavity, especially differentiated for urinary secretion.

Mall, 1896, showed the capsular basement membrane to be composed of longitudinally and circularly disposed reticular fibrils, which when very dense and compressed, gave a homogeneous appearance. They anastomosed with the fibrils of adjacent tubules. In spite of these facts, von Ebner in 1902 described the membrane as structureless and glassy. In 1902 Mall was able to show that there were two basal membranes, an inner one homogeneous and structureless, applied to the bases of the epithelial cells, and an outer one interlacing and fibrillar. The latter was part of the reticular stroma of the kidney. Rühle, 1897, Russakoff, 1908, and Corner, 1920, confirmed Mall on these points. Corner believed the fibrillar membrana propria to be produced by the endothelium of adjacent capillaries. von Frisch, 1915, although agreeing that the tubules have a double basement membrane, definitely stated that the capsular membrana propria is a structureless glassy skin. Schäffer, 1927, concluded that the membrane must be considered as a cuticular excretion of the epithelial cells.

Glomerular Endothelium: The history of the cytology of the glomerular tuft begins with Bowman, 1842. He described the vascular loops as lying naked within the lumen of the capsule, held together only by their mutual interlacement. "The Malpighian capillary system stands alone among similar structures in being bare." Among his supporters were Johnson, 1850, Frerichs, 1851, and Henle, 1873. Henle stated: "The vessels in the glomerulus have the calibre of capillaries. Their framework is a structureless wall possessing elliptical nuclei." Many attempts were made to find cell boundaries between these capillary nuclei. Chrzonszczewsky, 1864, Ludwig, 1872, Drasch, 1877, Ribbert, 1879, Hortoles, 1881, and Buday, 1906, after numerous silver injections, were unsuccessful although they

could easily demonstrate boundaries between the endothelial cells of the vas afferens and vas efferens. Langhans, 1879, described the endothelial layer as having very few nuclei. Eliaschoff, 1883, found that these nuclei were more conspicuous in rabbits than in other animals. In 1886, Nussbaum demonstrated cell boundaries in the endothelium of the frog's glomeruli. These cells projected into the lumen and were very distinct in cross-section. von Moellendorff, 1927, described the endothelium of the human glomerulus as a fine layer with a few nuclei and visible cytoplasm only where such nuclei lay. He could not find cell boundaries.

Glomerular Epithelium: The epithelial covering of the glomerular tuft was first described by Gerlach in 1845 and 1848. By injections through the ureter he was able to show that the vascular loops were separated from the capsular space by cells which he believed were the essential elements of a gland. These cells formed a layer over the tips and crevices of the glomerulus. Bidder, 1845, suggested but could not prove conclusively the presence of glomerular epithelium. Carus, 1850, von Wittich, 1851, Koelliker, 1854, McDonnell, 1855, Chrzonszczewsky, 1864, Duncan, 1867, and Toldt, 1874, all supported Gerlach. In 1857 Isaacs injected glomeruli by way of the ureter and tubules until the capsules ruptured. With a dissecting microscope he examined through the hole in the capsule the epithelial covering of the loops. His illustrations showed how much larger these cells were than those lining Bowman's capsule. Moleschott, 1862, measured the glomerular and capsular epithelial cells and found the diameters to average 0.01 and 0.006 mm., respectively. Steudener, 1864, saw a fine covering over the glomerular loops but could not recognize it as epithelium. Schweigger-Seidel, 1865, and Seng, 1871, observed the presence of epithelium over the tips of the loops in the embryo. Ludwig, 1872, saw that the walls of the capillaries were separated from the capsular contents by "a layer of not very well defined cells with spherical nuclei." He was not sure that these were continuous from lobule to lobule. R. Heidenhain, 1874, injected the renal arteries of cats, birds, rats, field mice, rabbits, guinea pigs, sheep, pigs and cows, and found the epithelial cells forming a continuous layer over and between the loops. His work was confirmed by the findings of Frey, 1875, Langhans, 1879, Ribbert, 1879, and Nauwerck, 1884. Ribbert stated that the numerous nuclei observed in a normal glomerulus were for the most

part epithelial. Drasch, 1877, and von Ebner, 1902, believed this epithelium was in the form of a syncytium. Ziegler, 1879, preferred to consider it as endothelium comparable to the lining of the serous cavities. Nussbaum, 1886, clearly distinguished the large glomerular epithelium from the smaller endothelium. He believed the epithelial cells were often multinucleated and that amitosis occurred in them. He recognized the continuity of glomerular and capsular epithelium. Hansemann, 1887, with Isaac's technique isolated the glomerular epithelium and described the cells as flat, often multinucleated, and taller than those lining the capsule. He pointed out the more rapid postmortem digestion of the epithelial than of the endothelial cells. In 1900, Herring's review of the development of the glomerulus explained completely the position and derivation of glomerular epithelium. In a 1909 Harvey lecture, Huber stated that the columnar glomerular epithelium of the embryo became pavement epithelium in the adult. Mertz, 1918, in a quantitative study of the cells in the average 10 micron section of a human glomerulus, was unable to find sufficient morphological difference between endothelium and epithelium to count them separately. Löhlein, 1910, Gross, 1919, Fahr, 1925, Munk, 1925, and Elwyn, 1926, all described glomerular epithelium and its pathological changes. Gross preferred to think of it as a syncytium rather than true epithelium. Fahr stated that glomerular epithelium was so closely related to tubular that it would seem to be secretory. Zimmerman, 1911, 1915 and 1923, demonstrated boundaries between these cells in cats and hedgehogs, but preferred to call them pericytes. von Moellendorff, 1927, described the "deck" cells or glomerular epithelium as morphologically similar to the adventitial cells or pericytes of the capillary bed. He believed these cells have long, branching, anastomosing processes which form a network over the glomerular loops. He ascribed to their mesenchymal origin, their ability to take the form of adventitial cells and to transform into free round cells in pathological conditions. Vimtrup, 1928, adhered to the older conception of an epithelial covering closely applied to the surface of each capillary loop. Volterra, 1928, described these cells as perithelial but did not see any processes on them. He concluded that the cell branches described by von Moellendorff belonged to the glomerular basement membrane and were a part of the connective tissue adventitia of the capillary tuft. Bargmann, 1929, studied the glomeruli of many species and believed

with von Moellendorff that the branching processes belonged to the "deck" cells.

Glomerular Basement Membrane: The possibility of a membrana propria in the glomerular loops was evidently considered by Bowman and rejected for he wrote: "The capsular basement membrane is perforated by the afferent and efferent vessels and is certainly not reflected over them." Seng, 1871, saw and illustrated the presence and continuity of the glomerular and capsular basal membranes. Toldt, 1874, confirmed this finding in both embryonic and adult human glomeruli. Drasch, 1877, after injection of silver nitrate into the glomerular vessels, saw a formation which depended on a porous condition in a membrane. Langhans' illustrations, 1879, show a basement membrane which he described as a very fine doubly-contoured border. Nussbaum, 1886, after studying the embryology of the malpighian body, searched unsuccessfully for a glomerular membrane and concluded that the wall of a glomerulus had only two layers, endothelial and epithelial. Mall, 1896, after boiling kidney tissue in water, digested frozen sections with pancreatin and found a homogeneous striped membrane still present in the glomerular loops. Rühle, 1897, injected a rabbit's kidney with alcohol and was able to see an indistinct membrane in the glomerular loops. Fibers from the capsular basement membrane passed into the glomerular membrane. During digestion with pancreatin the epithelial and endothelial cells disappeared leaving a regularly striped fibrous membrane showing numerous fine pores. This confirmed the work of Drasch. Regaud and Policard, 1903, studying the kidneys of ophidians stained with alum hematoxylin, demonstrated a thin homogeneous membrane separating the endothelium from the synctyial epiglomerular layer. Hueter, 1908, stained the glomerular basement membrane with Ribbert's connective tissue stain. Gross, 1919, found that the membrane took a gray or brown color with Heidenhain's iron hematoxylin. Ohmori, 1921, obtained a very clear differentiation of the membrane with a rein blau-picric acid dye. Hung, 1922, was able to stain it distinctly if the tissue were boiled before fixation and later put through hematoxylin-eosin, Weigert's elastic tissue stain or Mallory's anilin blue. Krauspe, 1922, using Bielschowsky's method found the glomerular wall to consist of homogeneous gray or black membrane lined inside by endothelium and outside by epithelium. He saw the transition into Bowman's base-

ment membrane but could not detect the fine streaking mentioned by Rühle. Schäffer, 1927, noted the presence of the glomerular membrane but did not consider its structure to be fibrillar. von Moellendorff, 1927, demonstrated a homogeneous membrane with Heidenhain's azan-carmine and with his own eosin-methylene blue. Volterra, 1928, described the membrane as a continuous, argyrophil, net-like, reticular adventitia resting on endothelium but not formed by it and adherent to the pericytes. The processes which von Moellendorff assigned to the "deck" cells were, according to Volterra, the connective tissue fibrils of the membrane. Bargmann, 1929, described the glomerular membrane as a deep black or brown granular line when impregnated with silver.

Glomerular Connective Tissue: Key, in 1865, described star-shaped cells which he considered connective tissue between the glomerular loops. Ludwig, 1872, stated that the capillaries of the tuft had an investment of connective tissue. Klebs, 1863, and 1889, thought there were small numbers of such cells in all glomeruli. Toldt, 1874, saw central cells in the crevices of the tuft which were different from the epithelial cells. However, as the glomerulus developed and became spherical these connective tissue elements were no longer visible. In 1880, Waller confirmed Key's finding. In normal cat glomeruli he distinguished epithelium from "connective tissue corpuscles" which were situated between the lobes and stained with logwood after carmine and gelatin injections. He studied the glomeruli as a whole under a dissecting microscope and considered these cells to have a special affinity for vegetable coloring matter. Greenfield, 1880, also believed there were connective tissue cells within the glomerular tuft and Ribbert, 1879, described their nuclei as being small, spindle-shaped, and more intensely stained with carmine than the larger round finely granular epithelial nuclei. Opposing this view were Drasch, 1877, Langhans, 1885, Nauwerck 1886, Nussbaum, 1886, Hansemann, 1887, Orth, 1893, Mertz, 1918, and von Moellendorff, 1927. Nussbaum concluded that the connective tissue which he expected to find, in consideration of the embryological development, must have been resorbed. Herring, 1900, Mallory, 1914, and Vimtrup, 1928, have stated that some connective tissue persists around the hilum probably continuing into the glomerulus to bind the capillaries together.

With regard to the presence of reticulum within the tuft, John-

ston, 1899, believed these fibrils in Bowman's capsule were not reflected over the glomerulus. As the afferent vessel pierced the capsule, fibrils arose which penetrated the glomerulus, passing in all directions between its capillaries. These became less and less numerous as the periphery was approached. Luna, 1920, using the method of Achūcarro–del Río-Hortega, saw an occasional adventitial sheath in the glomerular capillaries. Corner, 1920, decided that the endothelium of the glomerular tuft was never provided with a reticulum. Krauspe, 1922, employing the Bielschowsky–Maresch technique, after a study of 150 human kidneys, could not find *gitterfasern* in the glomerular capillaries. Foot, 1925, decided that no reticulum was seen in the human renal tuft under ordinary circumstances. Allen, 1927, using silver impregnation concluded that occasional glomeruli showed reticulum fibrils in the tuft, usually near the pedicle. A few fibers radiated peripherally with no constant relation to reticulum cells or capillary endothelium. Bargmann, 1929, saw an argyrophil network deep in the capillary wall but he could not say to what it belonged.

Shape and Size of Glomerulus: Vimtrup, 1928, described the human malpighian body as oval with an average diameter of 200 microns as compared with Fahr's figure of 237 microns.

Mertz, 1918, found that the total number of cells in 10 to 15 micron sections through the greatest diameter of normal glomeruli was constant, and at most 145. Of these 3 to 30 were leucocytes, leaving 130 endothelial and epithelial. von Moellendorff, 1927, did not make a quantitative study but concluded that there were at least ten times as many epithelial as endothelial cells. Bargmann, 1929, made the same observation.

Development of the Glomerulus: According to Herring, 1900, and Huber, 1909, the malpighian body, convoluted tubules, Henle's loops, junctional tubules, connective tissue framework and capsule arise from the kidney blastema, a mass of cells formed from the intermediate cell mass. Blood vessels are partly of the same origin and partly branches from the renal artery. Malpighian bodies and their tubules begin to appear at the end of the second month. Each arises as a solid mass of cells which acquires a lumen and becomes S-shaped. The lower limb of the "S" becomes the malpighian body, the upper and middle limbs form the convoluted tubules. The convex side of the lower limb is formed by the epithelium which later lines

Bowman's capsule, the concave side by the epithelium which later covers the glomerulus. The glomerulus is at first non-vascular and is formed by a thickening of the epithelium rather than by an invagination. The capillaries form *in situ* from mesenchymal connective tissue cells close to the base of the glomerulus and are joined by a branch of the renal artery. The division of the glomerulus into lobes is due to the penetration of the epithelial cells between the capillary loops.

Summary

To summarize the present status of the histology of the normal glomerulus, it may be said:

1. The shape is oval and the diameter varies between 200 and 237 microns.

2. The capsule consists of a basement membrane lined by flat epithelial cells which become taller near the opening into the tubule. The structure of the membrane and its relation to the glomerular membrane are not agreed upon.

3. The wall of the glomerular loop contains a basement membrane whose porosity and fibrillar or homogeneous character are unsettled subjects.

4. Within the glomerular membrane are a few endothelial cells between which, boundaries have not been definitely established.

5. Outside the glomerular membrane is a layer of cells whose epithelial, adventitial and syncytial characters are controversial points.

6. The presence of reticular fibrils in the tuft beyond the wall of the vas afferens is indefinite as is also the existence there of connective tissue cells.

II. Methods Used and Results Obtained in this Study

Fixation of Tissues: In general the results were best following Zenker or Helly fixation. However, most of the tissues available for this work had already been fixed in 10 per cent formalin. Davidoff, 1928, described a method of taking nerve tissue from formalin to Zenker. This was tried on kidney tissue and was found to work very successfully. The technique may be applied to the tissue in blocks or to paraffin sections.

(*a*) For paraffin sections of formalin-fixed tissues.

1. One hour in ammonia (40 drops to 10 cc. of water).
2. One hour in running water.
3. One hour in Zenker's or Helly's fluid.
4. One hour in running water.

(*b*) For blocks of formalin-fixed tissue.

1. Two days in paraffin oven at 40° C in ammonia (40 drops to 100 cc. of water).
2. Twenty-four hours in running water.
3. Zenker twelve hours, or Helly five hours.
4. Twelve hours in running water.

Staining of Tissues: The following stains have been used: Hematoxylin and eosin, Mallory's eosin-methylene blue, methyl green-pyronin, Van Gieson, Weigert's elastic tissue stain, Ohmori's rein blau-picric acid, Mallory's anilin blue, Heidenhain's azan-carmine modification of Mallory's anilin blue, Lee-Brown modification of Mallory's anilin blue, Bielschowsky–Maresch, Bielschowsky–Perdrau (Bailey and Hiller), Bielschowsky–Ferguson, Bielschowsky–Foot, Hortega–Foot silver carbonate.

The technique for the three stains which were found to be the most useful is as follows:

(*a*) Mallory's anilin blue (Heidenhain's azan-carmine modification*).

1. 1 per cent azan-carmine G (1 gm. in 100 cc. of water, heat, cool, filter at room temperature and add 1 cc. glacial acetic acid). Thirty to forty minutes in this stain in the paraffin oven at 56° C.
2. Wash in water.
3. Differentiate in anilin alcohol (1 cc. anilin oil in 100 cc. 95 per cent alcohol). Watch under the microscope until the nuclei are red and the cytoplasm pale pink. This step requires from one to three minutes, depending on the thickness of the sections.
4. Remove anilin with acid alcohol, about one minute.
5. Three hours in 5 per cent phosphotungstic acid.
6. Wash quickly in water.
7. Three to six hours in:

anilin blue	0.5 gm.
orange G	2. gm.
glacial acetic acid	8. cc.
distilled water	100. cc.

Boil, cool and filter. Dilute one-half with water.

8. Wash in water.
9. Differentiate in *absolute alcohol, watching under the microscope.*
10. Xylol.
11. Balsam.

* Some changes were made in this technique so the directions do not correspond with the original as given by Heidenhain.

Nuclei orange-red, cytoplasm pink, connective tissue and reticulum blue, fibrin red.

(*b*) Ohmori's rein blau-picric acid.

1. Stain the nuclei with acid fuchsin or lithium carmine at least one-half hour.
2. One minute in rein blau-picric acid (to a concentrated aqueous solution of picric acid add a concentrated aqueous solution of rein blau until a dark green color appears).
3. Differentiate in absolute alcohol.
4. Xylol.
5. Balsam.

(*c*) Mallory's anilin blue, Lee-Brown modification.

1. Phosphomolybdic acid 1 per cent for thirty seconds.
2. Distilled water for 1 to 2 minutes.
3. Mallory's stain:

anilin blue	0.5 gm.	for 1 to 5 minutes
orange G	2. gm.	
phosphomolybdic acid	2. gm.	
distilled water	100. cc.	

4. Distilled water for 2 to 5 minutes.
5. Phosphomolybdic acid 1 per cent for 30 seconds.
6. Distilled water for 1 to 2 minutes.
7. Dehydrate, clear and mount.

The Capsular Basement Membrane: The outer layer of Bowman's capsule is composed of argyrophil fibrils which anastomose with the intertubular stroma of the kidney and with the reticular covering of the tubules. The inner layer of Bowman's capsule is an apparently homogeneous membrane which stains red with Van Gieson, blue with Ohmori and dark blue with the Mallory–Heidenhain azan-carmine. This structure is continuous with the glomerular and tubular basal membranes.

The Capsular Epithelium: These cells form a single layer completely lining the capsule. Their cell borders are distinct and as would be expected from their embryological origin they are directly continuous with the glomerular and tubular epithelium. Their nuclei are elongated, with finely dispersed chromatin and one or more large nucleoli.

Glomerular Epithelium: These are the cells which, in the embryo, form the concave side of the lower limb of the "S" (the convex side of the capsular space). During fetal life and early childhood the arrangement is columnar, this gradually becoming flattened in the adult.

These cells form a complete single layer of covering over the tips and crevices of the capillary tufts. At the hilum they are continuous with the capsular, and thus with the tubular epithelium. They lie outside the glomerular basement membrane which separates them from the endothelium. The arrangement is not syncytial and cell boundaries are easily seen. They are much more numerous than endothelium.

Each cell has abundant cytoplasm and a large oval nucleus situated far from the base. The chromatin is finely dispersed near the nuclear membrane and there are one or two nucleoli. The cytoplasm takes a basophilic tint with Mallory's eosin-methylene blue. The morphology is very similar to that of the capsular epithelium.

Glomerular Basement Membrane: The S-shaped mass of cells destined to form the glomerulus and its tubule is surrounded by a membrane. The portion of this structure covering the concavity of the lower limb of the "S" becomes the glomerular basement membrane. It is closely associated with the glomerular epithelium and is present before the glomerular capillaries appear.

In sections stained with anilin blue or with rein blau the membrane is a single deep blue line lying between endothelium and glomerular epithelium and forms the most striking portion of the glomerular capillary wall. It does not stain with any of the silver impregnation methods used.

For the most part its structure seems to be homogeneous. However, near the hilum there is sometimes a lamellated appearance. Whether the membrane is fibrillar or whether the extra fibrils belong to the connective tissue cells of the vascular pedicle has not yet been determined.

The vas afferens with its supporting framework passes well into the center of the glomerulus before it breaks up into capillaries. Its subendothelial connective tissue seems to fuse with the glomerular basement membrane.

The lumen of each glomerular branch of the afferent vessel is narrowed at fairly regular intervals with openings into numerous small capillary loops. At each of these orifices the basement membrane appears thickened and contracted while in all other portions of the capillary wall it is thin and quite uniform.

The continuity of the glomerular capsular and tubular membranes is evident in any fetal or adult kidney stained with anilin

blue or with rein blau. While differentiating these sections in absolute alcohol the glomerular basement membrane decolorizes before any other membrane or connective tissue in the kidney.

Glomerular Endothelium: These cells are continuous with the endothelium of the vas afferens and efferens and are situated inside the glomerular basement membrane. Their nuclei are widely separated and are much less numerous than those of the epithelium. A continuous layer of cytoplasm lining the membrane and connecting adjacent cells is rarely visible. The nuclei are small and elongated with a thick nuclear membrane and coarse, evenly distributed chromatin. The small amount of cytoplasm at each end of the nucleus makes the cell appear stretched and flattened against the basement membrane. The question of cell boundaries has not been investigated.

There is another type of cell in the wall of the capillary which is probably endothelial also. It is always situated inside the passageway between loops or adjacent to the orifice. In this way it lies next the thickened portions of the glomerular membrane and seems to be almost surrounded by it. This cell cannot be considered epithelial because it is inside the basement membrane. With the stains used in this study the nucleus cannot be distinguished from that of typical endothelium. Its cytoplasm is extremely minute, perhaps because of its position in the constricted portion of the capillary. There is a possibility that it is a connective tissue cell enclosed in the membrane. Further studies on this point are in progress.

Connective Tissue Cells: These accompany the afferent vessel almost to the center of the glomerulus and are always visible in sections through the greatest glomerular diameter. Reticulum argyrophil fibrils also enter at the hilum, pass into the glomerulus and end in finer fibrils or very small clusters. They do not accompany the basement membrane of the capillary loops but seem rather to be associated with the afferent vessel.

Summary

The following conclusions have been reached after studying oil immersion fields of tissues stained as described previously.

1. The glomerular, capsular and tubular basement membranes are continuous and stain red with Van Gieson, blue with Ohmori and

dark blue with Mallory–Heidenhain azan-carmine. The capsule and tubules have an additional external, reticular, argyrophil covering. The glomerular basement membrane is thinner than that of the capsule and tubules. Pores have not been demonstrated, nor any elastic fiber content.

2. The glomerular, capsular and tubular epithelium are continuous. The glomerular epithelial cells have abundant cytoplasm and large vesicular nuclei with one or more prominent nucleoli. These are the only cells which lie outside the glomerular basement membrane. They form complete covering for the loops following closely both tips and crevices. They are arranged in a single layer and not in a syncytium.

3. The glomerular endothelium lies inside the basement membrane and therefore cannot be confused with epithelium. The cytoplasm is very small in amount and the nuclei have a thick nuclear membrane enclosing much coarse chromatin. Endothelial cells are much less numerous than epithelial.

There are cells, probably endothelial, which lie inside the glomerular basement membrane but are partially surrounded by it. Their nuclei seem to be identical with those of typical endothelium and they have very little cytoplasm. Their situation at the orifices between loops makes examination very difficult. Further study to decide their nature is in progress.

4. Connective tissue cells and reticulum fibrils pass in at the hilum accompanying the vas afferens until it subdivides near the center of the glomerulus.

BIBLIOGRAPHY

See following paper for bibliography.

DESCRIPTION OF PLATE

PLATE 104

FIG. 1. Diagram of section through greatest diameter of a normal glomerulus. C. tub. = convoluted tubule; aff. a. = afferent artery; c.t. = connective tissue; c.b.m. = capsular basement membrane; c.ep. = capsular epithelium; gl.ep. = glomerular epithelium; gl.b.m. = glomerular basement membrane; end. = endothelium; end. l. = type of endothelial cell found at passageway between loops; r.b.c. = red blood cell; l. = leucocyte; t. = thickening of glomerular basement membrane often seen at orifice into another loop.

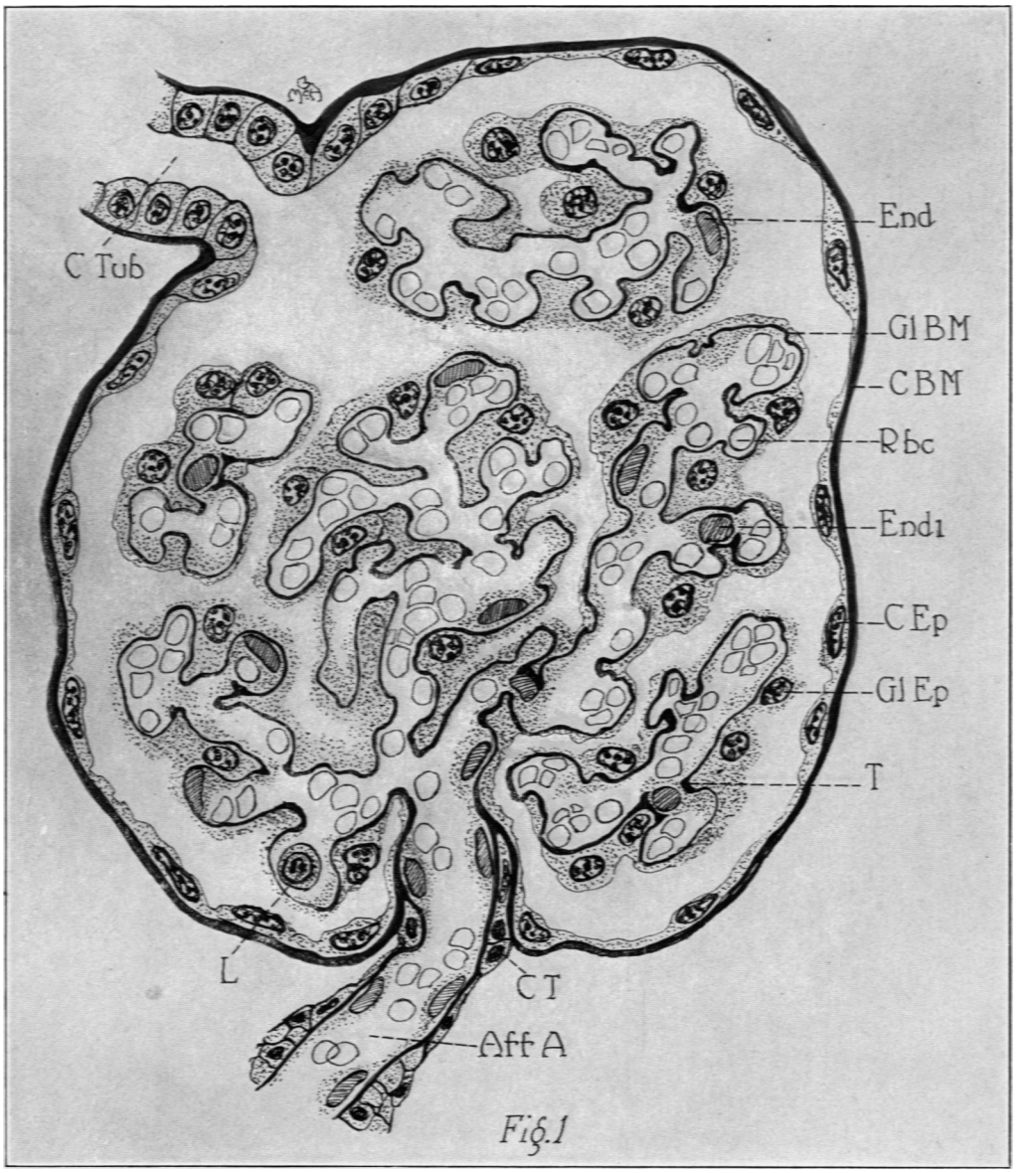

Fig. 1