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OBSERVATIONS ON SENSORY NERVE-FIBERS IN VISCERAL NERVES, AND ON THEIR MODES OF TERMINATING.

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With Plate XI.

In a most suggestive paper "On the structure, distribution and function of the nerves which innervate the visceral and vascular systems," Gaskell (1) drew attention to the fact that physiological differences observed in peripheral nerves are bound up with morphological differences, so that groups of nerves of the same function can be grouped under the same morphological laws of structure and distribution. In this communication attention is drawn to the fact, that certain anterior spinal roots—namely from the 10th to the 25th—contain a relatively large number of medullated fibers varying in size from 1.8 μ to 2.7 μ and that these form the greater portion of all the nerve fibers found in the nerves commonly known as white rami; and further, that these small, medullated nerve fibers pass to the metameric sympathetic ganglia and in three main streams—upwards into the cervical sympathetic ganglia, downwards into the lumbar and sacral ganglia, and outwards into the prevertebral and terminal sympathetic ganglia. In the white rami and in the splanchnic nerves a small number of larger medullated nerve fibers were found, clearly shown in his figure (8) of a cross section of a typical white ramus as seen when stained with osmic acid. These observations corroborated in part and extended those of Bidder and Volkmann (2) who had reached the conclusion "that in the various typical nerves of the body, the smaller nerve fibers belonged to the organic or vegetative functions of the body, and that the larger nerve fibers were concerned with its psychical activities. The former they called 'sympathetic,' the latter cerebro-spinal nerve fibers. The scattered cerebro-spinal fibers found in the trunk of the sympathetic and its branches they considered to be sensory fibers."

Langley (3), in one of the first of his many important researches on the sympathetic nervous system (his observations were made on cats, rabbits and dogs), states that "when a piece of the ramus communicans, or of the trunk of the sympathetic down to the first sacral ganglion, or one of the branches running to the solar plexus or to the inferior mesenteric ganglion is teased out, after having been treated with osmic acid for a day, three sizes of medullated fibers at once catch one's attention. The fibers are about 3 μ, 5 μ and 8 μ respectively." That the medullated nerve fibers of about 3 μ or under are the visceral nerve fibers or true white rami fibers—preganglionic fibers—was clearly shown by Gaskell and Langley. Concerning the larger fibers of the sympathetic, Langley was at first inclined to adopt the view of Bidder and Volkmann, namely, that they were fibers of general sensibility. Further inquiry showed, however, that this in the main was erroneous. And while he states that: "It is well known that sensory fibers are contained in the annulus of Vieussens, in the splanchnic, and in the branches from the lumbar sympathetic to the inferior mesenteric ganglion, and that the white ramus arises from the posterior as well as from the anterior roots. Consequently, there was practically no doubt that the white rami contained sensory fibers for the sympathetic system;" he is forced to conclude, if I understand him correctly, "that many of the larger fibers, and to a varying extent in different nerves, are afferent fibers of some special sense, or subserve local visceral reflexes which escape attention under the conditions of the experiments" made by him. Edgeworth (4), in a paper which appeared about the same time as that of Langley (3) from which I have above quoted, finds in the dog's sympathetic medullated fibers 1.8 μ to 3.6 μ, and medul lated fibers 7.2 μ to 9 μ in diameter; the latter he calls large sympathetic fibers. He finds no fibers of intermediary size between these two extremes, belonging to the sympathetic, but describes medullated vagus fibers 4.5 μ to 6.3 μ in diameter, which he calls large vagus fibers, and assumes that when medullated fibers of this diameter are found in the sympathetic, they come from the vagus. As the observations of Edgeworth were at variance with these recorded by Langley (3), the latter in a short communication in defence of his investigations, points out numerous errors in the work of Edgeworth (4). Of these errors it will suffice to refer only to the ones, to which attention is drawn in the following statement of Langley (5), which has reference to the large vagus fibers and their distribution: "This assumption is unfounded, since medullated fibers of 4.5 μ to 6.3 μ in diameter are present in the sympathetic in situations where there can be no question of any admixture of vagus fibers." The foregoing quotations show clearly that the investigators mentioned were able from data obtained from the measurement of nerve fibers found in cross sections or in teased preparations of white rami and sympathetic nerves fixed in osmic acid, to reach the conclusion that two distinct varieties of medullated nerve fibers were to be found in the visceral nerves —very small ones, varying in size from about 2 μ to 3 μ in diameter and larger ones from about 4.5 μ to 12 μ in diameter.

That the smaller medullated nerve fibers above mentioned are the white rami nerve fibers has been abundantly shown by the physiological experiments of Gaskell, Langley, Sherrington and others, which have been confirmed by histological observations; that the larger medullated fibers are afferent fibers, it is my purpose to emphasize.

Concerning the white rami fibers—preganglionic fibers—it is my purpose to speak very briefly, since numerous observers who have studied the sympathetic ganglia and their nerve roots have called attention to the fact that these fibers terminate in the sympathetic ganglia in intracapsular end-baskets which enclose the cell bodies of the sympathetic neurones, and this not only in the chain ganglia, but also in the prevertebral and peripheral ganglia. "The sympathetic neurones, the cell bodies and the dendrites of which are grouped to form the sympathetic ganglia, thus become the terminal links in a neurone chain, of which the second link is formed by a neurone, the cell body of which is situated in the cerebro-spinal axis and the neuraxis of which leaves the spinal cord or medulla through the anterior or lateral root as a small medullated fiber—white ramus or preganglionic fiber—which fiber ends in intracapsular pericellular baskets, enclosing the cell of the terminal—the sympathetic neurones," as I (6) have elsewhere expressed it. The neuraxes of sympathetic neurones terminate either in involuntary muscle,—non-striated and heart muscle,—in gland cells, on the dendrites of other sympathetic neurones, or in the posterior root ganglia. The neuraxes of the motor sympathetic neurones terminate after repeated division on the non-striated or heart muscle cells. Before termination the neuraxes interlace to form the intricate primary, secondary and tertiary plexuses of non-medullated, varicose nerve fibers always found in involuntary muscles when successfully stained either with gold chloride, chrome silver or methylen blue. In all involuntary muscles, whether in the heart, intestinal canal, respiratory organs, uterus, bladder, ducts of glands, blood and lymph vessels, etc., I believe the motor supply to be as above given. Neither do I possess observations which would lead me to think that other than motor sympathetic neurones take part in the formation of the terminal meshes of the above mentioned plexuses. It is evident, therefore, that the nerve cells and nerve fibers described by Schultze (7), and which he regards as a sensory end-apparatus, have not been observed by me, neither, I may say, have I seen any confirmation of his results by other observers. In heart muscle we have essentially the same general arrangement of the motor fibers. In glands, the neuraxes of sympathetic neurones form plexuses around the gland ducts and epi- and hypo-lamellar plexuses about the alveoli, the terminal branches ending on the secretory cells of the alveoli. I have digressed briefly from the immediate subject under discussion since it seemed to me that these statements throw light on some remarks which will follow.

Nearly all observers who have investigated the sympathetic ganglia, either with the chrome-silver or methylen blue method, have called attention to the fact that in the sympathetic ganglia and nerves, as also in the white rami, neuraxes of medullated nerves larger than the white rami fibers or sympathetic fibers are to be found. These, as they have shown, pass through the sympathetic ganglia without making connection with the sympathetic neurones. That these neuraxes belong to the large "sympathetic nerves" or large medullated nerves described by Gaskell (1), Langley (3), and Edgeworth (4) there seems to me to be no doubt. That the sympathetic receives larger medullated fibers from the sensory ganglia is shown by the termination of these fibers and rests also on other data.

Langley states that the white rami receive fibers from both the anterior and posterior roots and Lenhossék has, in Golgi preparations, traced sensory fibers to the sympathetic ganglia. A statement which is found in Kölliker's (8) short account of the sympathetic system is *apropos* in this connection: "The sensory fibers of the sympathetic are finer and coarser elements which have their origin in the spinal ganglia and are distributed peripherally in the region of the sympathetic. They convey the scanty sensory impressions which emanate from the several organs. They are like certain sensory fibers in the somatic sphere, as for instance, such as end in the Pacinian corpuscles which in the mesentery have the same structure as those found in the hand and foot. All medullated fibers found far out in the periphery, i. e., those in the spleen nerves of the ruminants, in the mesentery of the intestine, in the liver, etc. I regard as sensory elements." Kölliker here indicates one mode of termination of the large medullated fibers of the sympathetic, namely the Pacinian corpuscles. These, as is well known, are numerous in the mesentery, in the peritoneum lining the posterior portion of the abdominal cavity and in and around the pancreas. That painful sensations may have their origin in the Pacinian corpuscles would seem to be shown from observations which Warthin (9) has made. He has found the Pacinian corpuscles pathologically altered in a number of cases in which there was present diffuse and often intense abdominal pain. Of his report, attention may be drawn to two cases (VI and VII) in which there was a history of abdominal pain. Ovariotomy was resorted to as a means of relief. With the ovaries and tubes there were removed small hyalin bodies found in the mesentery. The ovaries showed only changes peculiar to the menopause and no pathological conditions were found in the tubes. The hyalin bodies proved to be pathologically changed Pacinian corpuscles. No doubt other large and small medullated nerves, especially of the hypogastric nerves, terminate in the peculiar, encapsulated sensory endings described by Timofeew (10) and found by him in the connective tissue capsule and between the muscle bundles and glands of the prostate gland of the dog and cat and in the membranous portion of the urethra of the same animals. I have seen these endings in the mucous membrane of the membranous portion of the urethra in a female cat and could readily duplicate his figures. Such special sensory nerve endings would not, however, account for all the larger medullated fibers, which we have regarded as afferent fibers, which are found in the sympathetic system. We possess, however, a number of observations which go to show that medullated nerve fibers terminate in the viscera and gland ducts in free sensory endings.

Some years ago Arnstein (11) and the writer (12) described free sensory endings in the larger ducts of the salivary glands. Ploschko (13) has described sub-epithelial and intra-epithelial sensory endings in the epiglottis, larynx and trachea. He further describes relatively large medullated fibers which pass through the sympathetic ganglia found in the trachea and end in rather compact arborizations situated in the involuntary muscle of the trachea. It was above stated that the plexuses found in involuntary muscle were formed by the division and interlacement of the neuraxes of motor, sympathetic neurones. The above apparent exception does not, it seems to me, necessitate a modification of this general statement. Since the sensory endings described by Ploschko differ widely from the primary, secondary and tertiary plexuses found in involuntary muscle tissue, and could not be mistaken for them, I feel warranted in saying that so far as my observations go, such sensory endings in involuntary muscle tissue have not a wide distribution. I have never met with them in numerous methylen blue preparations of the intestine, bladder or gland ducts. I have dwelt somewhat fully on this observation of Ploschko, since I believe, as will appear later, that sensory nerves to the viscera do not end in the muscular coat. Berkley (14) in his account of the intrinsic pulmonary nerves of mammalia, describes nerve fibers which come from the larger nerves accompanying the bronchi—presumably medullated nerves—and pass into the folds of the bronchial mucous membrane, and end in arborizations; also nerves which end in arborizations between the epithelial cells of the smallest bronchi. These, it seems to me, must be looked upon as sensory nerve fibers of the bronchi. More complicated sensory endings found in the lung of the frog have been described by Smirnow (15); he speaks of them as "Nervenendknäuel." They are formed by the repeated division of the neuraxes of medullated fibers, the terminal branches interlacing and anastomosing. Cuccati (16) has described similar endings in the lung of the frog. Smirnow (17) has described sensory nerve endings in the endocardium and pericardium, and Dogiel (18) has corroborated and greatly extended these observations. Ehrlich (19) in his first paper on the methylen blue method, mentions a peculiar terminal apparatus found in the bladder of the frog, to which the name "Endbäumchen" was given. The terminal arborizations found in the frog's bladder were further described by Cuccati (20) and on a former occasion the writer (6) has figured them and otherwise called attention to them. While this account was being written there came into my hands an article by Grünstein (21) working in Arnstein's laboratory, in which he gives the results of observations, made with the methylen blue method, on the innervation of the bladder in the frog, mouse, rat, cat and dog. In this article Grünstein calls attention to relatively large medullated nerves which pass through the ganglia found in the wall of the bladder (well shown in Fig. 6, Pl. I, of his article) which end in large terminal arborizations. I hope to make further reference to his observations on the termination of the ultimate branches of such arborization somewhat later. On account of the many observations here referred to, I should not have felt a need at the present time of calling special attention to the subject under discussion, had I not found in Barker's (22) recent and most admirable volume on the nervous system, which must be looked upon as summarizing in a concise and impartial way our knowlege of the nervous system, the following statement :

"Whether or not the complex feltwork of fibers found throughout the heart have to do with the mediation of centripetal impulses or whether they are concerned wholly with the carrying of motor impulses to the heart muscle fibers has not been determined. Similar doubt exists concerning the nature of nerve endings in smooth muscle; enormous numbers of fine fibrils have been found in smooth muscle membranes, and their exact relation to the fibers has, in some cases, been carefully studied; but how many of them are motor and how many of them are sensory, remains for further investigation to determine. Certain it is that the walls of tubes which have smooth muscle coats are well supplied with sensory nerves. To make this clear I have only to mention the intestine, the bile duct, the bladder, the uterus and blood vessels." "Whether the pain in these is the result of stimulation of sensory nerve fibers beginning in the muscle itself or in the connective tissue is not known."

The writer has for some years made use of the methylen blue method for gaining a clearer understanding of the innervation of the various tissues and organs of examples of the different classes of vertebrates, and although the sensory visceral nerves have not been the subject of a special research, he has had frequent opportunity to study preparations which throw light on the subject undeı discussion and it is my purpose to give, in the remaining portion of this paper, some general conclusions reached, rather than give in detail many fragmentary observations which I have been able to make. I may state that the great majority of such observations have been made on living tissue injected with a 1 per cent. solution of methylen blue in normal salt. The tissues after the nerves were stained were fixed in a saturated aqueous solution of ammonium picrate and cleared and mounted in an ammonium-picrate-glycerine mixture. As may readily be seen, the most serviceable preparations are obtained from mucous membranes which may be studied without further sectioning, and in which, if well stained, nerve fibers may be traced for long distances, through various branchings and often to their termination.

I have previously touched on the destination of the axis cylinders of many of the larger medullated fibers found in the sympathetic nerves in speaking of their termination in the special end-organs mentioned and of their entire ending in free sensory endings. It is particularly the latter, the more common form of termination, that I desire to bring to your notice. When it is possible to trace such medullated fibers to their endings, it may be observed that before terminating they undergo repeated division before losing their medullary sheaths, such division taking place at the nodes of Ranvier, the resulting branches diverging at angles which vary greatly. This division takes place mainly in the mucosa of the hollow organs in which the nerve terminates. (In this general discussion reference is not had to the intestinal canal unless especially mentioned). The extent of this division is, I believe, greater than is generally supposed, and may, therefore, receive fuller consideration. It may best be studied in preparations occasionally obtained, in which, owing to the precariousness of the methylen blue method, only a few, perhaps only one large axis cylinder with its many branches and endings, is stained in a given region, and if, perchance, such a fiber is stained to its finest terminal branches, the extent of this division is surprising, even to one familiar with methylen blue preparations.

I have reproduced in the accompanying figure the medullated and non-medullated branches of one afferent fiber, found in the mucous membrane of the urethra of a female cat, just distal to the neck of the bladder. This fiber was traced out with the aid of the camera lucida. In this ending twenty medullated branches may be counted, almost every one of which gives off one to several non-medullated branches before losing its medullary sheath and terminating. The area covered by the branches of this nerve I estimate to be 1.4 mm. by .8 mm. It should, however, be stated that only rarely is it possible to obtain preparations which contain endings such as here sketched. More often only a portion of such an ending seems stained or a number of them overlap to such an extent that it is impossible to trace them individually. However, in the urethra, bladder, ureters, uterus (cat and rabbit), vagina, gall bladder and bile duct, other gland ducts, and in the respiratory mucous membrane of the nose, relatively large axis cylinders, which could be traced through a varying number of divisions have been observed by me, with now and then endings as large or nearly as large as the one above mentioned; although in the bile duct and ureters I have never found such large endings. That the majority of the branches of the larger medullated nerves ending in hollow organs or gland ducts, are above the muscular coat, I think my preparations show clearly. In the one from which the accompanying figure was sketched, the muscular coat had been dissected away before mounting the preparation. Furthermore, as is well known, methylen blue stains readily non-striated muscle, so that by focusing the observer is usually able to make out the existing relations between the nerve fibers and their branches and the muscular fibers of the preparations under discussion. I do not, however, wish to be understood as saying that the medullated nerve fibers going to the hollow organs or gland ducts do not branch external to, or in the muscular coat, for this is often seen in suitable preparations, especially of the bladder wall and gland ducts; yet such branches can often be traced through the muscular coat into the mucosa, where further and more frequent division of the fibers is observed.

It may be of interest to consider, at this point, this repeated division of the large, medullated visceral nerves in connection with the fact that all the earlier observers, who described large medullated nerve fibers in the white rami and the sympathetic nerves found only a few in each ramus. Gaskell (1) in his figure of a typical white ramus shows a very small number of large medullated fibers. The numbers given by Edgeworth (4), for the large medullated fibers in the white rami of a small dog, vary from 6 to 28 for the different rami examined. I infer that Langley (3) would place the number higher, although the exact numbers are not always given. Yet he states: "In the white rami there are, in most cases, more fibers larger than 4 μ than are shown in the particular white ramus figured by Gaskell." It would, therefore, it seems to me, not be unreasonable to suggest that the relatively small number of medullated afferent fibers going to the viscera is in some measure compensated for by the repeated division of these fibers and by the relatively large area covered by their branches. My own observations have led me to conclude that the medullated fibers under discussion terminate, after dividing as above stated, in numerous arborizations. These as Grünstein (21) has correctly stated, and as has been shown by me in a former paper, may be terminal arborizations—'terminales' Bäumchen—the endings of the medullated branches after losing their medullary sheaths, or lateral arborizations—'lateralen' Apparaten—the terminations of non-medullated, collateral branches, given off, at the nodes of Ranvier, from the medullated branches. The nerve fiber reproduced in the accompanying figure ends in some 45 to 50 arborizations, of which about one-half are terminal arborizations, the remainder lateral arborizations. The arborizations are formed by a subdivision of the medullated branches after losing their medullary sheaths or by a subdivision of the collateral, non-medullated branches. The ultimate branches show both in Golgi and methylen blue preparations varicosities varying in shape, size and number, and terminate in small terminal nodules or discs, which also vary in shape and size. It may not be necessary to call further attention to the fact that the afferent nerve fibers which terminate in the hollow organs and gland ducts (also in other parts of the body) end not in one arborization but in a relatively large number of them. I have felt, however, that especially figures drawn from Golgi preparations are apt to give a wrong impression, since such figures are usually drawn from sections of tissues so stained and can, as must be obvious on a moment's reflection, give only a portion of the entire ending, at most only here and there a portion of one or several arborizations, and these usually not in connection with the larger nerve branches.

That many of the terminal branches of the arborizations here mentioned end in the epithelium it seems to me can not be questioned. Arnstein (11) and the writer (12) have shown nerve fibers in the epithelium of the salivary ducts; Ploschko (13) in the epithelium of the trachea and epiglottis; Berkley (14) in the smaller bronchi; Smirnow and Retzius (23) in the oesophagus (this Dr. DeWitt has corroborated as will be published later); Retzius (24) has described nerve fibers in the epithelium of the bladder and Grünstein (21) finds intra-epithelial pericullular nerve endings in the bladder of the cat, although in the dog, if I read him correctly, he speaks of finding only "intermusculäre Endapparate."

I have observed intra-epithelial nerve fibers in numerous preparations stained in methylen blue in which I was able to trace some of the terminal branches of arborizations, such as above mentioned, into the epithelium. Such observations, I may say, are most satisfactory if made on unfixed tissue, which after injection with methylen blue and after removal from the animal, is examined at a time when the nerve fibers have reached their maximal stain. The purplish-blue, terminal fibers may often be clearly seen between the epithelial cells, which are either only faintly stained, or if stained have a more greenish blue color. In methylen blue preparations fixed in ammonium picrate the epithelium is usually somewhat macerated, so that on mounting the preparation much of the epithelium is lost. Usually, however, some patches remain in which terminal branches of nerve fibers may be found, it must be confessed not so clearly as in unfixed specimens. Of the methylen blue preparations which I have made and examined more recently with reference to this point I may mention the following: Bladder of the frog, cat and rabbit, in each of which terminal branches of arborizations could be traced into the epithelium; also in the urethra of cat and rabbit. In the preparation from which the figure was made, here and there intra-epithelial nerves were found, although in that portion of the preparation from which the figure was drawn, very little epithelium remained; I assume, therefore, that not nearly all the terminal branches of this one fiber are shown in the figure. I believe I am warranted in drawing this conclusion by reason of the fact that in other parts of this preparation much more branched arborization may be seen, some of the terminal branches of which end in the epithelium. In a number of methylen blue preparations of the ureters of the cat and rabbit, which I have recently made for the purpose of ascertaining the mode of ending of the large medullated fibers found in their connective tissue sheath, I find plexuses of varicose fibers in the mucosa, thus inside of the muscular layer, the cells of which are usually stained. In a number of preparations only partly stained, here and there arborizations with long, slender filaments were seen in the mucosa, some of the terminal branches of which I was able to trace into the epithelial lining, this especially in preparations examined before fixing. In the uterus of the cat and rabbit, arborizations were found in the mucosa under the epithelium and in a number of these, some of the branches of such arborizations were clearly above the capillary plexus found immediately under the epithelium, and were on a level with the gland mouths, the cells of which seemed to stain more readily than the epithelial cells lining the uterus. (In these preparations, as sometimes happens, the endothelial cells of the capillaries were stained so that they could be followed nearly as well as in an injected preparation.) It seemed to me that some of the terminal branches of the arborizations were to be found in the epithelium. There is, however, room for error on this point as the thickness of the epithelium is such that by focusing it may not be possible to determine whether the terminal branches of the arborizations are in or under the epithelium. In the gall bladder and bile duct, as Dogiel (25) has observed, there are to be found medullated nerves which do not end in the sympathetic ganglia. In the gall bladder, owing perhaps to the presence of the bile, or to the brownish stain of the epithelium, I have not been able to make out the endings of such fibers. In one methylen blue preparation of the bile duct of a cat, I was able to make out several arborizations in the mucosa—thus above the muscular coat—and from one of these some few terminal branches could be traced into the epithelium. This was in a preparation before it was fixed. It is of course well known that relatively large medullated fibers may be traced to the stomach and intestinal canal. Some of these may be traced through the ganglia of Meissner's and Auerbach's plexuses, as has been shown by Dogiel (26); this I can corroborate. I have, however, never been able to make out arborizations in the mucosa and only in a few instances and this in methylen blue preparations from the large intestine of a rabbit, have I been able to find nerve fibers which seemed to me to end in the epithelium. In these preparations, small varicose fibers, some of which were branched, others not, could be traced for short distances between the mouths of the crypts of Lieberkühn. These were seen in the same focus which brought to view the gland mouths and the epithelial lining of the large intestines; presumably, therefore, were intra-epithelial. Whether some of the nerve fibers described, and figured by Erik Müller (27) and Berkley (28) from Golgi preparations, as passing into the mucosa of the intestinal canal, are the terminations of afferent fibers I am not prepared to say; it would seem to me not unreasonable to accept this view.

By way of summary it may be stated that the larger medullated nerve fibers found in the hollow organs and gland ducts, on reaching their termination branch repeatedly before losing their medullary sheaths. This branching takes place largely in the mucosa, to lesser extent external to the muscular coat and in the muscular layer. The medullated fibers and their branches run together in various ways to form the primary plexuses. After losing their medullary sheaths, the fibers, now non-medullated, form plexuses with smaller meshes, to which also the non-medullated collateral branches contribute. This plexus is also in the mucosa, more superficial than the primary plexus above mentioned, and therefore nearer the epithelial lining. The non-medullated terminal and collateral branches end in arborizations, many of the terminal branches of which pass into the epithelium to terminate between the epithelial cells.

Before closing I wish to mention briefly some sensory nerve endings, which I believe, should be regarded as the terminations of sensory nerves of the sympathetic; these are, however, not confined to the viscera.

Dogiel (18) has described sensory nerve endings in the adventitia of arteries and veins of the pericardium, also in the vessels of the central tendon of the diaphragm, gall bladder and the capsule of the kidney. At his suggestion Schemetkin examined the larger vessels with reference to this point and found sensory nerve endings both in the intima and adventitia, especially in the former, in the arch of the aorta and pulmonary arteries. Dogiel states that there seems to be no doubt that the sensory nerve endings found by himself and Schemetkin are found not only in the wall of the above mentioned vessels, but are characteristic of all vessels. The writer (29) has described sensory nerve endings in the adventitia of the vessels of the pia mater. I have further observed them in the adventitia of vessels in the thyroid gland in several methylen blue preparations prepared by my assistant, Dr. DeWitt. Also in other locations, though not so clearly as in the vessels of the pia mater.

It has occurred to me that the human uterus, with its large vessels and blood spaces might with profit be studied with reference to the question of the presence of sensory nerve endings in their connective tissue coats, as it seems to me not all the large medullated fibers going to this organ are accounted for by those which terminate in the mucosa and the epithelial lining.

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DESCRIPTION OF PLATE XI.

Fig. 1. Termination of a sensory nerve in the mucosa and epithelium of the urethra of a female cat just distal to the neck of the bladder.

Stained with methylen blue, fixed in ammonium picrate and cleared in ammonium picrate-glycerine.

Camera lucida drawing; 1-6 in. objective, No. 2, eye-piece, reduced to ⅓.