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Modern Development of the German Drama

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#3.

Peripheral Nerve-endings in the Cat.

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Preparation of Material.

In the preparation of material for the study of nerve endings, I have followed Golgi, [See Piersol's Normal Histology, page 427], Ranvier [Whitman's Methods in Microscopical Anatomy and Embryology, page 187] and Bristol, [American Naturalist Sept. 1894] Golgi's method was discarded after the first trial, because the tissues were decomposed before they were sufficiently stained. A modification of Ranvier's method was employed in which citric acid took the place of lemon juice. This stain was only partially satisfactory, because the tissues were stained too darkly on the outside and had little or no stain on the inside. The gold chloride method of Bristol produced a very good stain, and gave the best material for study.

Several preparations were made before really satisfactory results were obtained. At least two reasons may be assigned for the poor results, first, that the tissues were allowed to remain in water some minutes before placing them in acid water, second,

that they were prepared in the afternoon and remained over night before being exposed to the sunlight.

Silver nitrate, borax-carmine, and Delafield's haematoxylin were also used for Pacinian bodies.

The tissues were prepared for sectioning by being hardened in alcohol and embedded in paraffin.

The parts taken were skin from the toe, nose, and lip, mucous membrane from the lip, portions of the tongue containing fungiform and circumvallate papillae, cornea, tendon, artery, pancreas, stomach, intestine, muscle, and mesentery containing corpuscles of Vater. The nerve endings in the cornea, tendon, stomach and corpuscle of Vater were studied and a full description of them will be given.

Nerve-endings in general

From one point of view the nervous system may be said to have a center and a periphery. The centre is made up of the brain and spinal cord, from which the nerve fibres radiate. The ultimate ends of

the nerve fibres may be called the periphery of the nervous system or the peripheral nerve endings.

The nerve trunks, when they leave the nerve centers, are composed of medullated and non-medullated fibres. As the nerves pass toward the exterior they subdivide many times. There are two kinds of divisions, one in which there is merely a seperation of the fibres, and the other in which the fibres themselves are divided. In the medullated nerve, when the fibres bifurcate, the points of bifurcation correspond in position to the nodes of Ranvier, and at some one of these bifurcations the medullary substance or white matter of Schwann ends.

The nerves, now alike in structure, pass on to their destination, being covered with the neurilemma and nerve corpuscles. These coverings become gradually thinner until the neurilemma is entirely lost. As the nerve proceeds, the corpuscles occur less frequently and finally altogether disappear. On account of so many divisions the nerve at this point in its course is very small, it may be a single axis-cylinder or a small bundle of nerve

fibrillae, which is later divided into a number of single fibrillae.

Classification.

The final endings of the fibres may be divided into the general classes of sensory and motor nerve endings. The sensory nerves have two kinds of endings, those within cells, and free ends.

Among the organs of special sense are found the best known endings within cells. The hair cells of the ear, the nasal epithelium, the rods and cones of the retina, and the gustatory cells of the taste buds, may be mentioned as examples.

The free ends may be simple and modified or special. The axis cylinder fibres of those sensory nerves from which the simple ends are derived, as they near their destination, first form a rich ground plexus. These are nucleated, triangular shaped, nodal points formed at the junction of the axis-cylinders. From this plexus small bundles of fibrillae are given off, which unite to form a network or terminal plexus. This plexus is situated in the connective tissue of the organ to be supplied, and from it arise the fibrillae

which penetrate the epithelium. These fibrillæ terminate between the cells in pointed or club-shaped knobs, which seem to be a mere expansion of the ends of the fibrillæ.

Many sensory nerves have specialized free endings. The simplest of these are found in the tactile cells. The latter are found in the deeper layers of the epithelium. They are oval or fusiform in shape, nucleated, resembling ganglion cells in appearance. Applied to the centrally directed surface of the cells is a meniscus or tactile disk with which the nerve fibre is connected. The other special free endings are modifications of the tactile cell. They occur when two or more tactile cells together receive the nerve fibre. The neurilemma and Henle's sheath of the nerve unite with the connective tissue covering of the cells. There is a tactile disk between the cells, in which the axis cylinder ends. The nerve loses its medullary sheath where the axis cylinder enters the tactile disk.

The next higher modification is found in the tactile corpuscle. This is an oval-shaped

body, covered by a capsule composed of connective tissue, the neurilemma and the sheath of Henle of the nerve. The interior is made up of a connective tissue framework, through which the nerve fibrillae pass in a spiral direction. The nerve fibrillae end in terminal disks which are found in various parts of the corpuscle. The so called spherical end-bulbs of the conjunctiva and mucous membranes and the articular corpuscles may be placed in this class of endings.

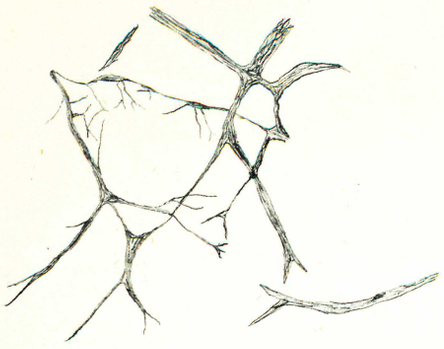
The cylindrical end bulb is the highest modification of the tactile cell. The cylindrical end bulb from the conjunctiva of the calf and the corpuscle of Vater belong to this class of endings. Nerve endings of this kind have three parts, the capsule, the inner bulb and the nerve fibre. The difference between the two end-bulbs mentioned depends on the difference in arrangement and development of these three parts.

The motor nerves are the nerves of muscle. The fibres supplying involuntary muscle are for the most part non-medullated with a few white fibres intermixed. In each

muscle, as the fibres near their termination they form complicated plexuses. The external plexus has coarse fibres and wide meshes with ganglion cells sometimes occurring at the nodal points. As the nerves come closer to their termination, the plexuses are more narrow meshed and possess smaller fibres. From the external plexus fibrillae are given off, the termination of which is not definitely known.

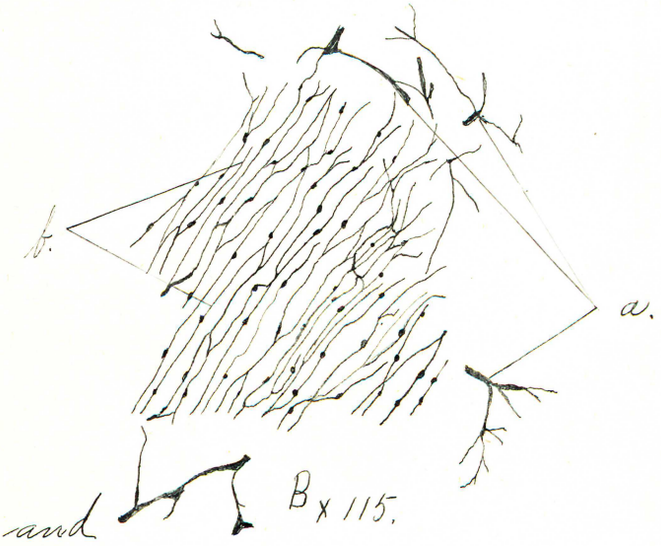
In voluntary muscle there are both sensory and motor nerves. The medullated nerve fibres of the motor nerves of the muscle, form a plexus between the fasciculi of the muscle. Fibres are given off in such a way that each muscle fibre is supplied with one medullated axis cylinder. When this nerve fibre ends the muscle fibre the medullary substance ends, and the neurilemma unites with the sarcolemma to form the telolemma. The axis cylinder continues for some distance between the muscle sheath and the sarcous substance before it breaks up into its ultimate fibrillae. These fibrillae have a tortuous course and end in rounded or thickened

Plate I.



A. Ground plexus from the substantia propria of the cornea.

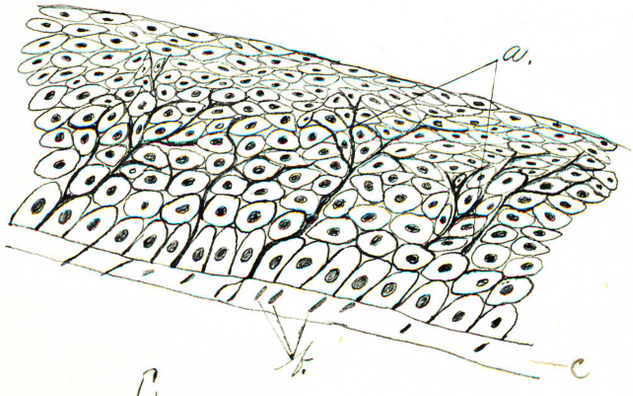
A x 75.



B x 115.

B. Subfascilar and subepithelial plexuses of the cornea.
a. Subfasilar plexus.
b. Subepithelial plexus.

C. Nerve endings of the epithelium of the cornea. Oblique section.
a. Fibrillae given off from
b. cut ends of subepithelial fibres.
c. Basement membrane.



C. x 550.

bulbous extremities. A flattened, nucleated mass, composed of granular protoplasm is formed on the surface of the muscle substance, in which the terminations of the nerve are imbedded. This is called the sole-plate, and it, together with the nerve-endings, makes up the motor disk or end-plate.

Description of preparations.

The cornea is well supplied with nerves, especially in the anterior layers. About sixty radially disposed twigs, each composed of from three to twelve fibres, enter the cornea at the limbus. Within a distance of .5 m.m. from the limbus they become non-medullated.

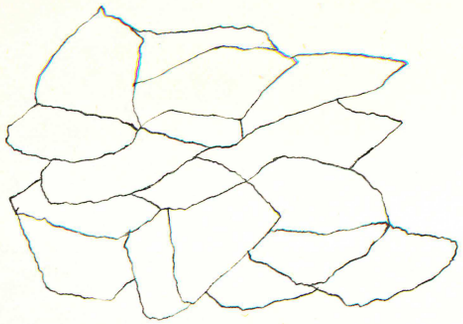
The nerve fibres form a coarse ground plexus, within the substantia propria, near the middle third of the cornea. [See Plate I. A] Some fibres are given off from this plexus to supply the more internal layers of the cornea; the other fibres pass outward to form the subbasilar plexus, which lies just beneath the anterior elastic membrane [Plate I. B.] Fine fibrillae are given off from the plexus, which pass outward to the nuclei,

bodies of the epithelium where they form the subepithelial plexus. [Plate I B.] A fibrillae enter the epithelium and end between the cells as the intra-epithelial plexus. [Plate I C.]

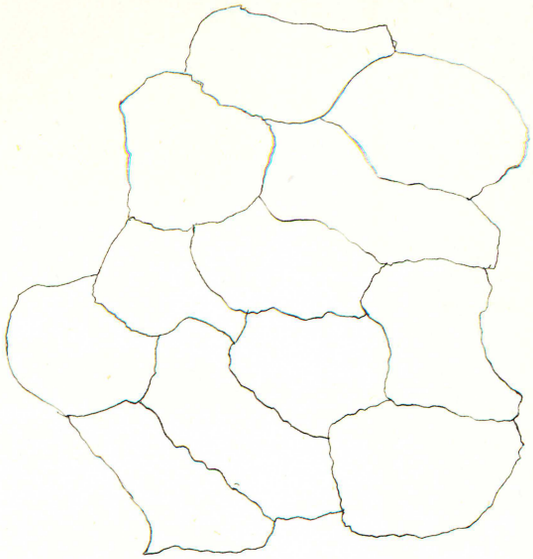
The Pacinian body or corpuscle of Vater is the most highly specialized of the sensory nerve-endings. [Plate I. A.] They are widely distributed throughout the body of the cat, the one described was taken from the mesentery. On the outside they are covered by a layer of endothelial plates, a continuation of those covering the mesentery. In form they are regularly oval bodies near ⅛ of an inch long and ⅛ of an inch wide. Each body is attached to the main nerve trunk by a slender stalk made up of connective tissue, a blood vessel and one medullated fibre covered by its perineurium.

The three parts of the corpuscles are the capsule, the inner bulb and the nerve fibre. The capsule is made up of twenty-five or thirty concentrically placed lamellae. Each lamella has two layers of fibres, an outer transverse and an inner longitudinal layer. The lining of the lamellae is a single layer

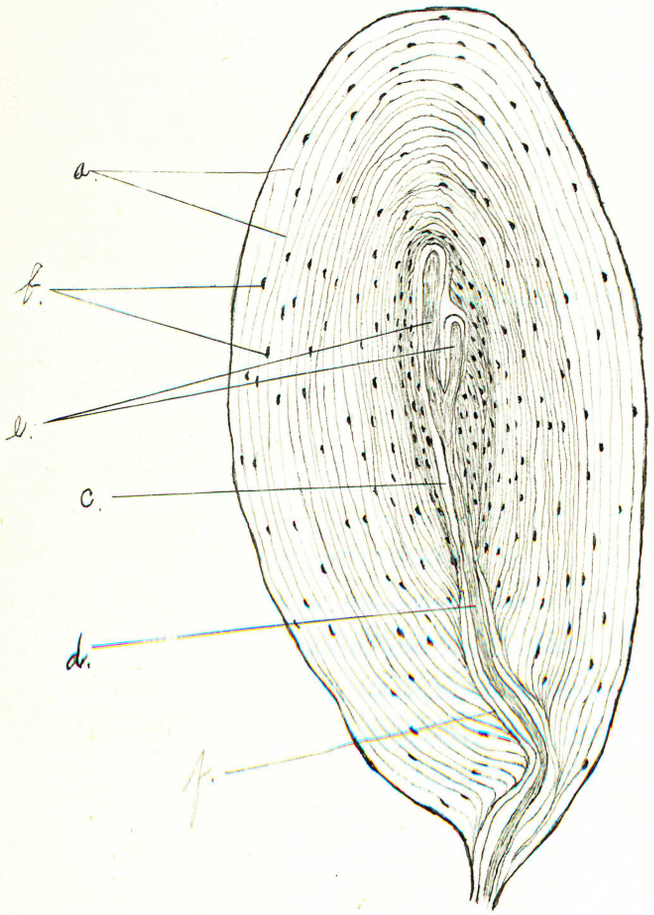
Plate II.



C. x 195.



B. x 825.



A. x 195.

A. Pacinian body, or corpuscle of Vater. from the mesentery.

a. Lamellae of the capsule.

b. Nuclei of endothelial cells.

c. Core. f. Intra capsular ligament.

d. Nerve fibre.

e Terminal branches of the axis-cylinder.

B. Endothelial plates from the mesentery covering the corpuscle.

C. Endothelial plates lining the lamellae.

of endothelial plates, whose nuclei are seen in the sections of the corpuscle. (Plate II. c.)

The outer lamellae are thicker and are placed farther apart than the inner ones. The space between them is filled with a clear, serous fluid, resembling lymph, and sometimes containing lymph corpuscles.

Next inside the capsule is the inner bulb. It is made up of a tissue more or less homogeneous, closely resembling protoplasm. This mass of tissue is cylindrical in shape, and a little granular or striated in appearance. Sometimes nuclei or fibrils are contained in this protoplasm.

The nerve which enters the Pacinian body is covered by several layers of perineurium which unite with the outer layers of the capsule, and help to form the intra-capsular ligament. Some of the inner lamellae unite with the inner border of the outer layers, and thus have a part in the formation of the ligament. The more internal lamellae have rounded ends which lie along the margin of the nerve canal.

The nerve loses its medullary substance

at the point where it enters the core.

Beyond this point its appearance is changed. If its flat side is seen it seems like a pale, finely striated and indistinct band or stripe; but when the edge is seen it appears darker and is a better defined narrow line. The end of the fibre is a knot, an expansion of the axis-cylinder, situated at the upper extremity of the core. Sometimes processes are given off from the knot but their termination is not understood. The axis-cylinder sometimes divides after it enters the core, the point of division is not fixed, as the latter may occur soon after the nerve enters the core or just before it reaches its termination.

Blood is carried to the Pacinian body by means of an artery which enters it along with the nerve. This artery divides into capillaries which pass between the tunics. Loops are formed to carry the blood into a vein which takes it away from the corpuscle. One capillary follows the axis cylinder as far as the core.

The use of the corpuscle of Vater is not known, but it may be inferred that

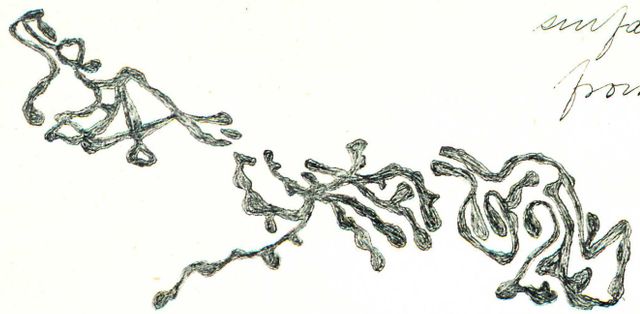
it is a nerve-ending in which pressure on the lamellae and the fluid between them affects the axis cylinder in such a way as to produce results similar to those produced on the other nerve endings.

The organ of Golgi in the tendon consists of a so-called tendon spindle, which is provided with a nervous network. These spindles are found in the tendon near the places where it joins the muscle. They are greatly elongated elliptical masses made up of several tendinous bundles, more or less fused into one. One end of the organ is connected with the tendon, and the other, usually, with some muscle fibres.

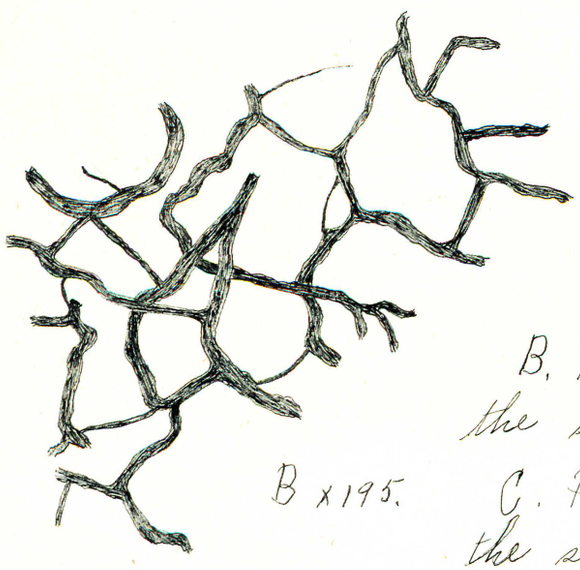
The spindle is enclosed in a connective tissue sheath which is united with the sheath of the tendon bundles. Endothelial plates cover the surface of the spindle within the sheath. A few medullated nerve fibres enter the tendon spindle either at the centre or at one end. They divide several times, and the pale non-medullated fibres spread out on the surface of the organ. The axis-cylinders pass between the tendon bundles and their fusion

Plate III.

A. Nervous network on the surface of a tendon spindle, from Tendo Achillis.



A x 195.



B x 195.

B. Plexus of Meissner from the stomach.

C. Plexus of Auerbach from the stomach

C. x 120.

forms an irregularly meshed network, which, to some extent resembles the end plates of the muscles. [Plate III A.] The termination of the axis-cylinders are pea rounded knobs, the expanded ends of nerve fibrillae.

The nerves supplying the stomach and intestine are derived from the sympathetic system. They contain many more non-medullated than white fibres. The non-medullated fibres are nucleated and are covered by the perineurium. They pass through the serous coat of the stomach and form the plexus of Auerbach between the circular and longitudinal muscular layers. [Plate III C.] This is a rich, coarse plexus with ganglion cells at the nodal points. From this plexus fibres are given off to supply the serous coat, the outer longitudinal layer of muscle, and the outer part of the circular muscular layer. Other fibres pass through the circular muscular layer, and form the plexus of Meissner in the submucosa. (Plate III B.) This is also a ganglionic plexus, but is finer meshed and made up of more delicate fibres. From it minute fibres are sent

Of, which enter the mucosa and are distributed beneath the epithelium and to the gastric glands. The exact termination of the fibrillae has not been discovered.