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كلية : العلوم - جامعة أسيوط .
رئيس القسم : د. محمد خليل النفار .

دراسات مورفولوجيه وهستولوجيه للجهاز العصبي المركزى للعقرب بوذاس كوينكستريا توس

٢- الناحية الهستولوجيه

عبد الحميد خليل ، سيد اسماعيل ، زينب البقرى

النشرة الحالية هي الثانية من سلسلة من النشرات تهتم بدراسة التشريح المقارن وهستولوجيا الجهاز العصبي المركزى في أحد العقارب المصريه . ولهذه الدراسة على العموم هدفان :

- الهدف الأول منها استعمالها كقاعدة أساسية يبنى عليها أبحاثا قادمة تجريبية . فمما لا يخفى على القارئ أن على كل مشتغل بالأبحاث التجريبية ، يجب أن يتوفر لديه أساس متين للتركيب التشريحي للحيوان موضع اهتمامه .
- الهدف الثاني من هذه الدراسة التشريحيه المقارنة والهستولوجية فهو عمل مسح لقبيلة المفصليات ، وعقد مقارنة بين الحشرات والعقارب لاختبار مدى مصداقية الأفكار التشريحيه المقارنه التي رسخت في مفهومنا بعد دراسة طويله عن التشريح المقارن في الحشرات .

وفي الحقيقة ومن وجهة النظر التشريحية المقارنه تشابهت الحشرات والعقارب في بعض النقاط واختلفت في نقاط أخرى .

أما من وجهة النظر الهستولوجيه الحاليه فالتشابه كبير من وجهة نظر أنواع الخلايا الموجودة وان كان التركيب الهستولوجي في العقرب أكثر تقدما من التركيب الهستولوجي في الحشرات ، من حيث المسارات العصبية ، والكتل العصبية التي تنشأ منها مثل هذه المسارات العصبية وتركيبات أخرى معقده وغير موجودة في الحشرات .

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Head of Dept. Prof. Dr. M.K. El-Naffar.

STUDIES ON THE MORPHOLOGY AND HISTOLOGY OF THE CENTRAL NERVOUS SYSTEM OF THE ADULT OF THE EGYPTIAN SCORPION BUTHUS QUINGUESTRIATUS (H.E.)
II- GENERAL HISTOLOGY

(With 14 Figures)

By
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SUMMARY

The detailed histology of the central nervous system of the adult Egyptian scorpion Buthus quinquestriatus is descibed in detail.

INTRODUCTION

In the first paper of the present series (KHALIL et al. 1984), the general morphology of the central nervous system of the adult of the Egyptian scorpion Buthus quinquestriatus (H.E) was discussed in detail. The aim of this second article is to describe the histology of that central nervous system.

MATERIAL and TECHNIQUES

Mature adult scorpions ((.5-7.5 cm) of Buthus quinquestriatus were collected from Abu-Roach in Giza governorate during May and June and were kept under Laboratory conditions in glass containers. They were fed on small insects (like cockroaches and crickets) and land isopods and they also were supplied with a source of water.

To study the histology of the nervous system, freshly dissected specimens were fixed in various fixatives, including aqueous Bouin, Suza-Picric fluid as recomended by HALMI (1952) and DELPHIN (1965), Carnoy's and Helly's fluid. Bouin and Suza-Picric fluids were the most satisfactory fixatives for the demonstration of the various cellular elements in the nervous tissue. in most cases the entire prosoma was fixed after the limbs, the chelicerae and the anterior tip were excised as close as possible to facilitate the penetration of the fixatives. Peterfi's celloiden double embedding method (PEARSE, 1972) was employed to facilitate serial sectioning and the results were satisfactory. Sections 6 u thick were cut and were stained for general histological identification by haematoxylin-eosin and Mallory's Triple stain.

RESULTS and DISCUSSION

General histological characteristics of the central nervous system

In the case of the animal in question the central nervous system and the nerves arising from it are covered by an outer neural lamella sheath and an inner perineurium (Fig. 1).

The neural lamella consists of collagenous fibers which stain blue by Mallory triple and Heidenhain's azan stains. In several places, that naeurilemal sheath is covered on the outer surface by an adipose tissue formed of discontinuous patches of fat cells. The perineurium sheath is formed of a single layer of fusiform cells which are considered as a special type of glial cells.

The material of the masses of the central nervous system can be generally divided into an outer cortical layer and inner neuropile mass. From a pure morphological point of view, which is the interest of the present authors, the cells entering in the composition of the cortical region can be identified according to their outer contour, general size of the nucleus and staining affinities. However, the deduced function of each type of cells will be mentioned when ever possible. The finding of other authors interested in the functional aspects of the arthropod nervous system could be of help in this respect. The above mentioned histomorphological criteria led to the identification of six types of cells which are the globuli, sensory cytons, motor cytons, glial, association and neurosecretory cells.

The histology, distribution and hsitochemistry of the neurosecretory cells will be delt with in a coming paper due to their special importance.

The distribution of the different cells and their branches described above through out the whole of the central nervous system of the scorpion studied:

When examining the distribution of cells and their processes in the brain and suboesophageal region found within the sheathes of the central nervous system described before, one can not histologically differentiate between the brain (dorsal protocerbrum and ventral tritocerebrum) and the suboesophageal ganglion both in transverse or horizontal sections. In fact, the constituent material is continuous all over those regions and one may draw arbitrary lines, depending on theortical bases, which lines separate the different morphological items. However, in the very dorsal region of the brain that corresponds to the protocerbrum a median, vertical and longitudinal fissure separates the two laterodorsal domes of the protocerebrum (Fig. 5). In he region of the ventral half of the protocerebrum a median and vertical cellular septum which septum represents an extension of the anterior cortical cellular layer, partially separates the two lateral halves of the protocerebrum (Fig. 7 & 8). In the whole structure (brain and suboesophageal ganglion) a neuropile mass is present forming a sort of a medulla and a layer of condensed cells, surrounds that medullary region to form a sort of a cortical cellular layer. However, one could differentiate certain formations such as tracts and else in the medullary region and accumulations of cells in the peripheral region. Few extra cellular spaces are located on the periphery of the neuropile mass and amongst the cortical cellular layer.

Of the above mentioned formations in the neuropile mass and in the region of the dorsal protocerebrum, there is found an anterior transverse slender commissure that extends between the lateral two halves of the protocerebrum just below its upper bilobed region. Each of the lateral ends of that commissure is connected with a globular small differentiated mass of fibers. The latter mass is the posterior of two similar masses located on each side of the protocerebrum, those two successive massess found on each side of the protocerebrum may be compared with calyces described in insects by SNODGRASS (1935). One should repeat again that the protocerebral transverse commissure and the two successive globular pairs of bodies (calyces) are nothing but differentiations in the neuropile mass (Fig. 8). More posterior and in the protocerebral region, one could differentiate an anterior mushroom shaped body and posterior transverse central body which are again differentiations in the neuropile mass. In fact, since there is no demarking line which can definitely separate between the protocerebral region and the tritocerebral region, the examiner of the slides can not tell definitely whether the above mentioned structures belong to the dorsal protocerebrum or to the ventral tritocerebrum, a fact which is not serious from an anatomical point of view. Each half of the, mushroom-shaped body is an "L"-shaped structure whose transverse limb

is directed towards the median line, while its vertical limb is directed anteriorly and is clavate. The material of that mushroom body appears punctate and this apearance is said by histologists to be due to aggregations of fibers of different thicknesses which appear as dots. The transverse central body located posterior to that mushroom body is very distinguished and it appears in both transverse and horizontal sections as three successive lamellae which means that it consists of a central transverse rod-like core which is surrounded by a transverse and cylenderical region (Figs. 7 & 8).

In the very anterior region of the tritocerebrum, there is found a transverse central body which is less distinguished than that of the protocerbrum. Just posterior and ventral to that tritocerebral central body, there is found a transverse fine commissure or biberous tract (Figs. 10 & 4).

On each of the lateral sides of the protocerebrum there are differentiated five anteroposteriorly successivbely arranged fibrous masses which can be termed optical masses. The anterior most two are the largest and are located outside the cortical cellular layer, while the posterior three are small nodules which are located between the central neuropile mass and outer cortical layer of cells. The anterior most two large optical masses are surrounded each by a cortical layer of cells. A longitudinal optical tract connects those optical masses in series and the posterior end of that tract extends towards the median line and at that line, when touching the opposite tract, it extends ventraly to enter the posterior transverse protocerebral central body. Further, a sort of branch connects the second optical mass with the central protocerebral neuropile. The tract of the median and large optical nerve enters the anterior most first optical mass, while the tract of the lteral slender optic nerve enters the second optic mass (Figs. 9 & 3).

The neuropile mass of the tritocerebrum gives on each side, a lateral extension which reaches the outer brain sheath and is continuous outside as the dorsal cheliceral nerve and the ventral accessory cheliceral nerve. A longitudinal blood vessel is always seen seperating the two nerves (Figs. 2 & 3).

Morphologically, in the tritocerebral region a certain distinct cellular accumulation of cells could be differentiated and which is, named the rostral mass or the stomodeal bridge. In horizontal sections, the rostral mass has a triangular shape with the base directed posteriorly and tip directed anteriorly (Fig. 6) while, in transverse sections the rostral mass also appears triangular in shape which means that the rostral mass is tetrahedral in form with one of the surfaces extending in the transverse direction and the tapering end extends anteriorly. The ventral surface of that tetrahedral rostral mass is saddle shaped, as it appears in transverse section forming an arch dorsal to the oesphagus (Fig. 3); hence the name stomodeal bridge (GABE, 1955). A layer of tritocerebral neuropile is located between the rostral mass and the oesophagus. A pair of very short lateral nerves extends between the rostral mass and the lateral sides of the oesophagus. The rostral nerve appears starting from the anterior tapering end of the rostral mass and extends anteriorly to supply the rostrum. A large and distinct blood vessel is always seen in the frontal sections of the rostral mass and, in fact, several small blood sinusoids are always seen in the neuropile mass of the tritocerebrum.

The examination of a series of horizontal sections in the protocerebrum shows that each lateral and globular half of the protocerebral neuropile is surrounded on its median side by a cup shaped region filled with a dense mass of globuli cells. (Figs. 5, 6 & 7). That mass of globuli cells extend ventrally in the dorsal part of the anterior region of the tritocerebrum, while the lateral cellular cortex of that neuropile mass is filled with association cells that

contain few dorslly located sensory cells. the first and second optical bodies are surrounded by globuli cells that contain few glial cells. The vertical and longitudinally extending septum that partially separates the ventral region of the lateral haives of the protocerebral neuropile mass described above consists of globuli cells (Fig. 8). In the previous texts those globuli cells found in the median region of the protocerebrum are termed the first group of globuli cells. The second group of globuli cells is found on the posterolateral corners of the ventral region of the protocerebrum. That second group extends medially to form a thin cortical layer on the posterior side of the protocerebrum (Fig. 8) and extends ventrally on the posterolateral sides of both the tritocerebrum and dorsal region of the suboesophageal ganglion (Figs. 10 & 11). The cellular cortex of the tritocerebral region contains in its antero-median region a group of sensory and association cells, and on each side of that median group of cells is located a group of globuli cells which are extensions of the first group of those cells. In each of the anterolateral corners of the tritocerebrum there is found a group of motor and association cells. However, in the ventral most region of the tritocerebrum, the ventral extension of the first group of globuli cells and the association cells and antero-median group of sensony cells disappear. Further, in that region of the tritocerebrum, some sensory cells are identified in the anterior region of the second group of globuli cells. The rostral mass consists of a mass of sensory and association cells.

When examining the series of horizontal sections in the suboesophageal ganglion it could be seen that it is histologically composed of a central core of neuropile mass which contains a number of blood sinusoids and three median vertically extending and successively arranged large blood vessels. That central suboesophageal neuropile mass is surrounded on all free sides by a cortical cellular layer (Fig. 12). Dorsally, the suboesophageal neuropile mass is continuous with the tritocerebral neuropile mass. The suboesphageal neuropile mass gives from its anterior, lateral and posterior sides branches which correspond to the nerves arising from the suboesophageal ganglion. However, those nerve tracts do not arise from the neuropile mass at the same horizontal level. For example, the tracts of the pedipalpal nerve arise at the dorsal most level, then at a more ventral level arise the tracts of the walking legs nerves and at the ventral most level arise the tracts of posterior longitudinal connectives. It should be noted that the nerve tracts of the walking legs, particularly those of the third and fourth legs, are slightly directed towards the posterior side so that, in a transversee section two tracts could be cut. A transverse commissure is obviously seen connecting each pair of lateral nerve tracts. The above described nerve tracts interrupts the continuity of the cortical cellular layer.

With the exception of the second lateral group of globuli cells which extends from the brain down in the dorsal region of the lateral sides of the suboesophageal ganglion, the cellular suboesophageal cortical layer is formed of a mixture of sensory, motor and association cells. However, the concentration of the motor cells is relatively great around the pedipalpal nerve tract while the concentration of the sensory cells are relatively great around the pectinal nerve tract.

Behind the suboesphageal ganglion, a pair of longitudinal connectives connects the successive body segmental ganglia. The lateral components of that paired connectives are medially in contact with each other, but they are not fused, up to their region lying between the second and third segmental body ganglia. Behind that region, the connectives are slightly separated from each other and they are slightly dorso-ventrally compressed. The outer appearance of the segmental body ganglia shows as if they are a median single structure, but the serial transverse sections in any of those segmental body nerve ganglia show that each pair of ganglia in a segment are fused only in a middle region of their median surfaces. A

median dorsal and longitudinal artery, the supraneural artery runs on the dorsal surface of the central nervous system behind the suboesophageal ganglion. A ventral similar but smaller artery, the subneural artery, is found on the ventral surface of the central nervous system behing the suboesophageal ganglion. Both arteries are vertically connected together in the anterior and posterior regions of each pair of segmental body ganglia, where they are not fused together, and in the places when the two longitudinal connectives are separated from each other, behind the third body segmental ganglion. The anterior three mesosomatic ganglia are evidently smaller in size than the posterior metasomatic ganglia. However, the last or fourth metasomatic ganglion is the largest in size of all the body segmental ganglia.

Histologically, the material of the longitudinal connectives consists of longitudinally extending nerve fibres, each of those fibres is surrounded by its sheath. The greatest majority of those longitudinglly running nerve fibres are of the small sensory type, (BULLOOK and HORRIDGE 1965), while the minority of those fibres are of the giant motor type (Fig. 13).

The material of the segmental pairs of body ganglia is composed of neuropile substance that contains several blood sinusoids. The paired nature of each segmental structure is evident, except in the middle region where the lateral pair of ganglia are fused together and the two lateral neuropile masses are continuous with each other. Further, in that region of fusion between the lateral components, a dorsal and ventral transverse commissures could be identified (Fig. 14). Peripheral extra-cellular spaces surround the central neuropile material of the segmental ganglion. A cellular mass which is composed of sensory, motor and association cells is located on the lateral and ventro-lateral sides of the neuropile mass of each segmental ganglion. The size of that mass of cells is relative to the size of the ganglion.

Generally speaking the association cells are by far more numerous than any of the other types of cells. One must remind the reader, in this respect that the motor nerve cells are always greater in number than sensory cells, since a single sensory cell could communicate to one or more of the motor cells via the association cells.

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EXPLANATION OF FIGURES

Fig. (1): Photomicrographs of transverse section of the central nervous system of the scorpion Buthus quinquestriatus, showing neural lamella and perineurium (X 1000).

Fig. (2): Transverse section of the anterior region of the brain and subeesophageal ganglion. (X 40).

Fig. (3): Transverse section of the anterior region of the brain and suboesophageal ganglion, showing the rostral mass, the optic masses I, II and the cheliceral ganglion (X 100).

Fig. (4) Transverse section of the anterior region of the brain and suboesophageal ganglion, showing the anterior cellular septum and the tritocerebral commissure. (X 40).

Fig. (5): Horizontal section of the dorsal region of the brain, showing the two protocerebral lobes (X 40).

Fig. (6): Horizontal section of the dorsal region of the protocerebral lobes (X 40).

Fig. (7): Horizontal section of the middle region of the protocerebrum, showing first and second group of globuli cells and the central body (X 40).

Fig. (8): Enlarged part of horizontal section of the ventral region of the protocerebrum, showing calyces, protocerebral commissure, mushroom body and the central body (X 100).

Fig. (9): Horizontal section of the protocerebrum of the scorpion Buthus quinquestriatus, showing the optical masses and the optical tract.

Fig. (10): Horizontal section of the dorsal region of the tritocerebral central body, first and second group of globuli cells and blood sinusoids (X 40).

Fig. (11): Horizontal section of the dorsal region of the suboesophageal ganglion (pedipalpal ganglion), showing the second group of globuli cells. (X 40).

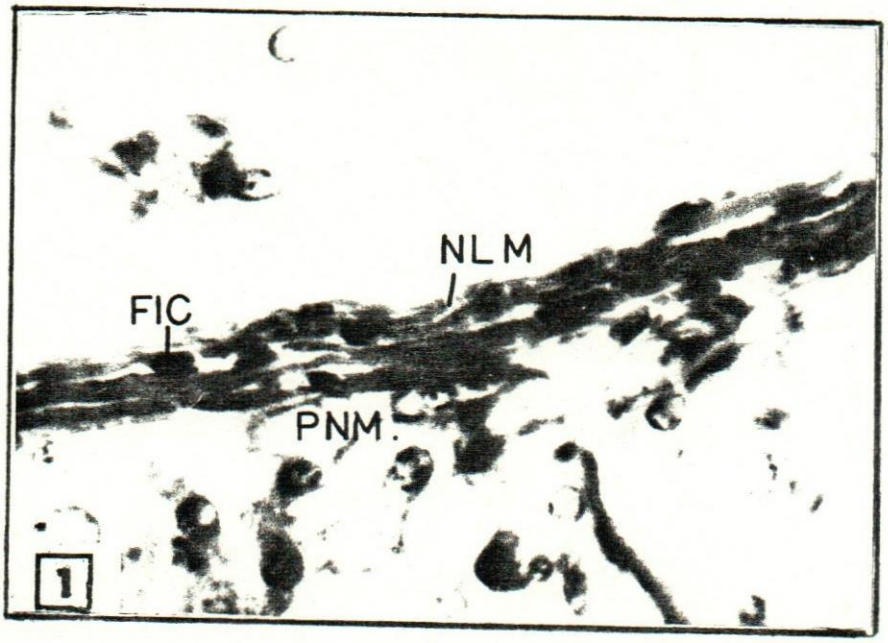
Fig. (12): Horizontal section of the suboesophageal ganglion, showing the transverse commissures, the vertically successive blood vessels and longitudinal connective tract (X 40).

Fig. (13): Enlarged part of transverse section in the mesosomatic longitudinal connective, showing small and giant nerve fibers and their sheathes. (X 400).

Fig. (14): Transverse section of the middle region of a mesosomatic ganglion, showing dorsal and ventral transverse commissures (X 100).

KEY TO LETTERING OF FIGURES

Ass.= Association cells. b.= Type B of neurosecretory cells. Br.= brain. Bls.= blood sinusoids B.V.= blood vessel CA.= clayx CB.= central body. CHG.= cheliceral ganglion CP.= cellular septum D= Type D of neuroseoretory cells DTCO.= dorsal transverse commissure, EXCSP.= extra cellular space, FC.= fatt body cells FIC.= fibroblast cells, Gl.= globuli cells., Gl.I.= first group of globuli cells, Gl.II= second group of globuli cells, GNF.=giant nerve fiber, M.= Motor cell, MB.= mushroom body, N.L M.= neural lamella, NP.= neuropile mass, Oes.= oesophagus, OP.M.= optic mass, OP.M.I= first optic mass, OP.M.II= second optic mass, OP.M.III= third optic mass, OP.M.IV= fourth optic mass, OP.M.V= fifth optic mass, OP.T.= optic tract, PN.M.= perineurium, PR.L= Protocerebral lobe, PR.Co.= protocerebral commissure, RBV.= rostral blood vessel, RM.= rostral mass, SH.= sheath of nerve fiber. S.N.A.= supra neural artery, So.g.= suboesophageul ganglion, T.CO.= Transverse commissure, TR.CB.= tritocerebral central body, Tr.Co.= tritocerebral commissure, Tru.= trunk, WL.T= Walking leg tract, V.T.CO.= ventral transvese commissure.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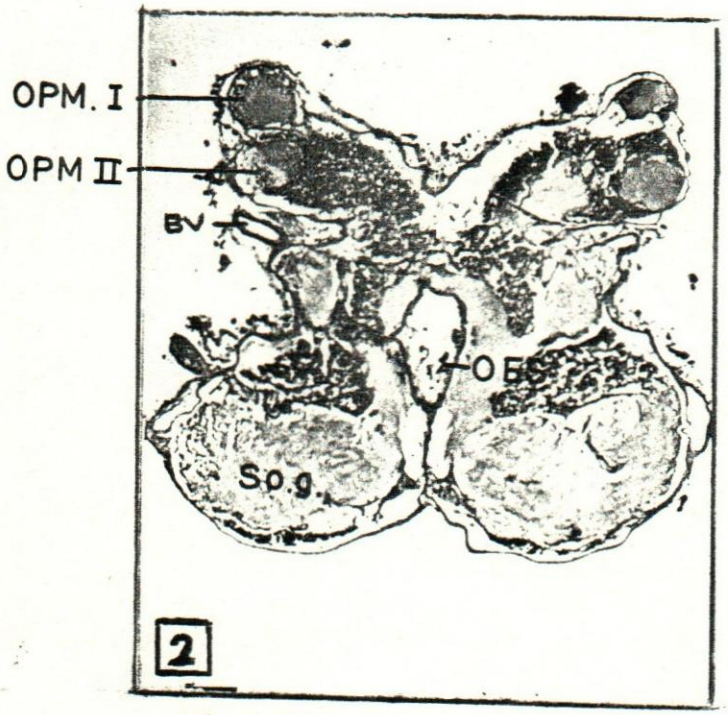
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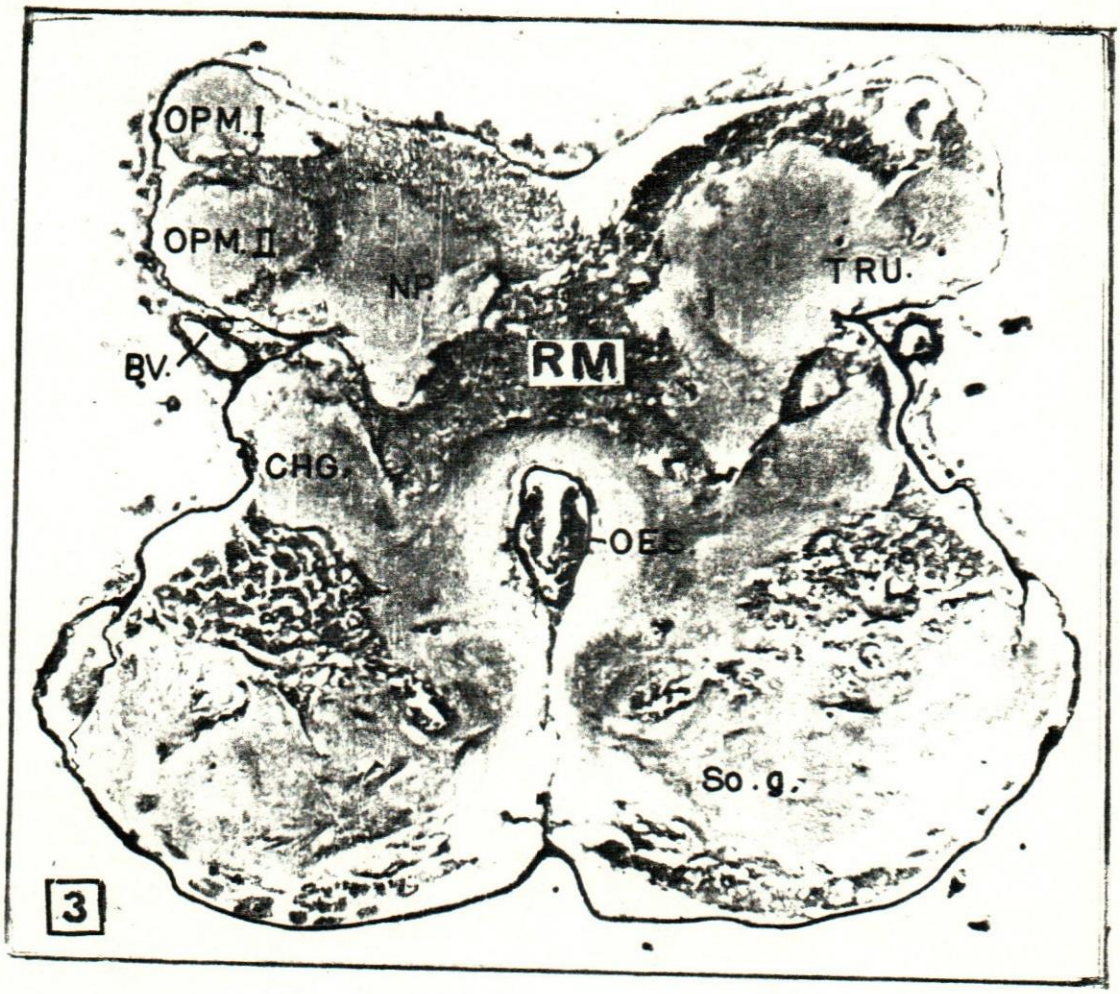
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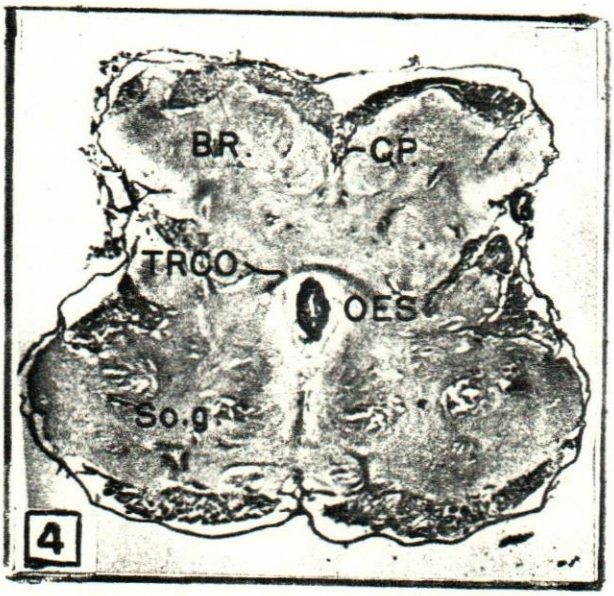
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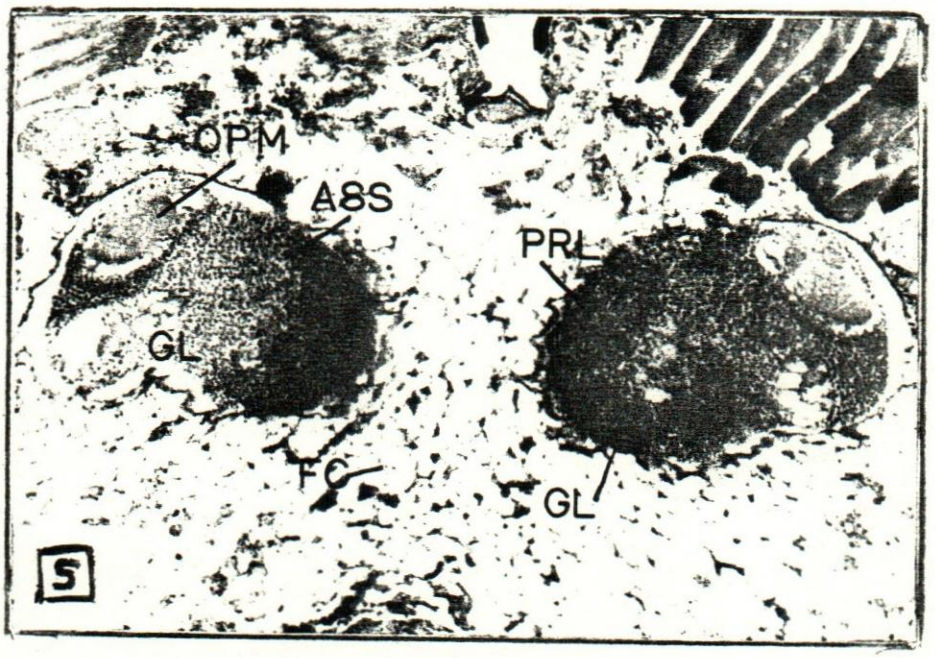
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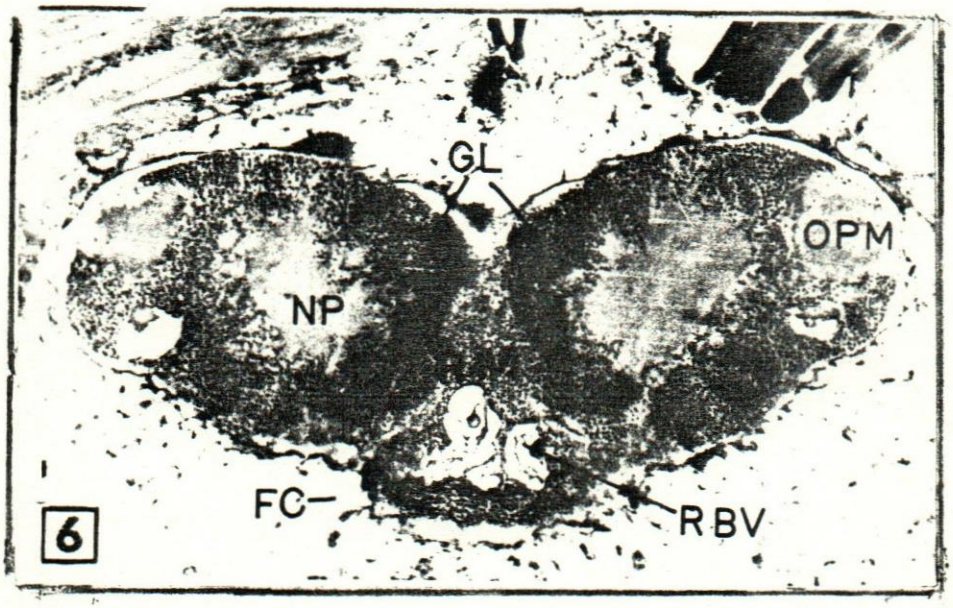
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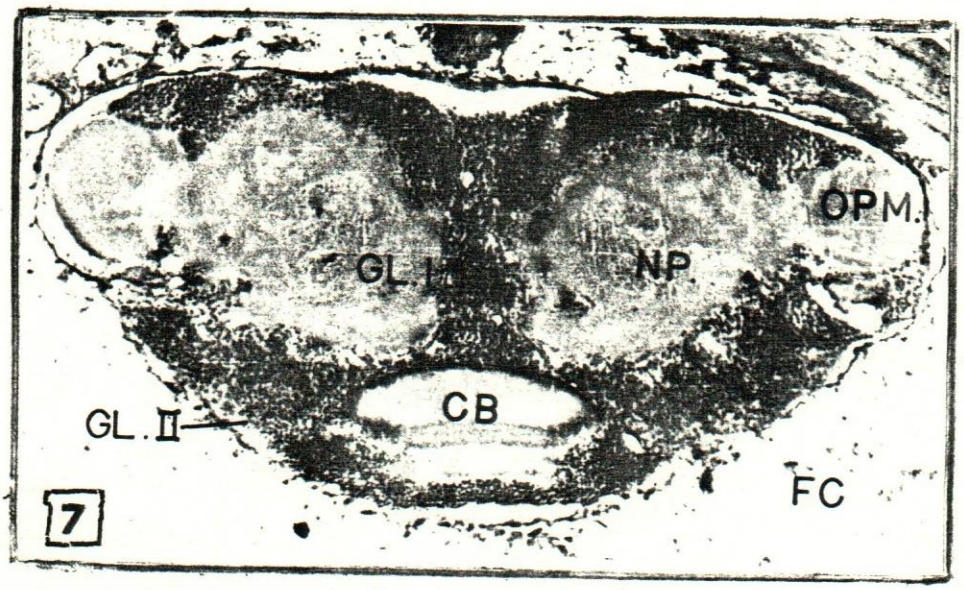
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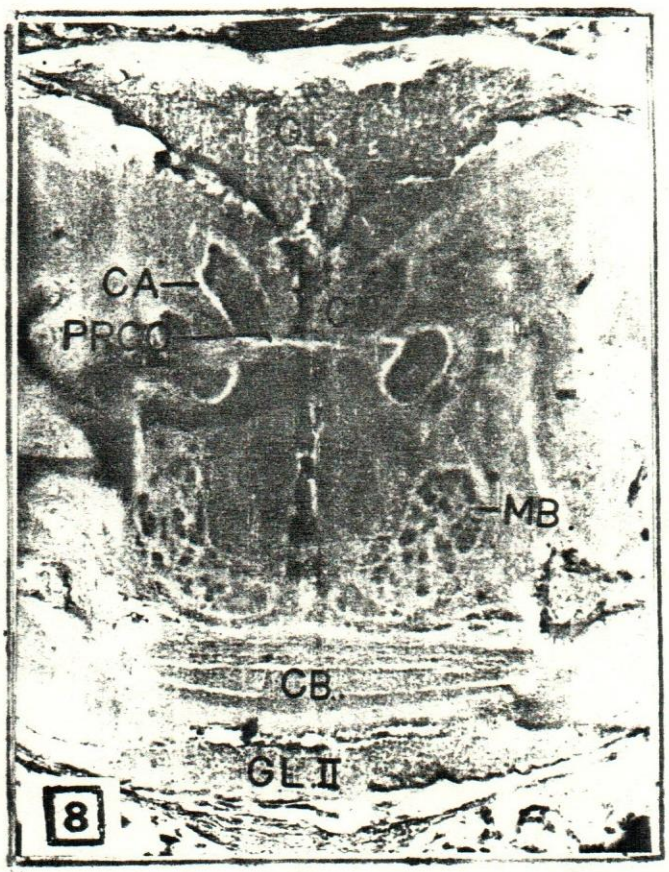
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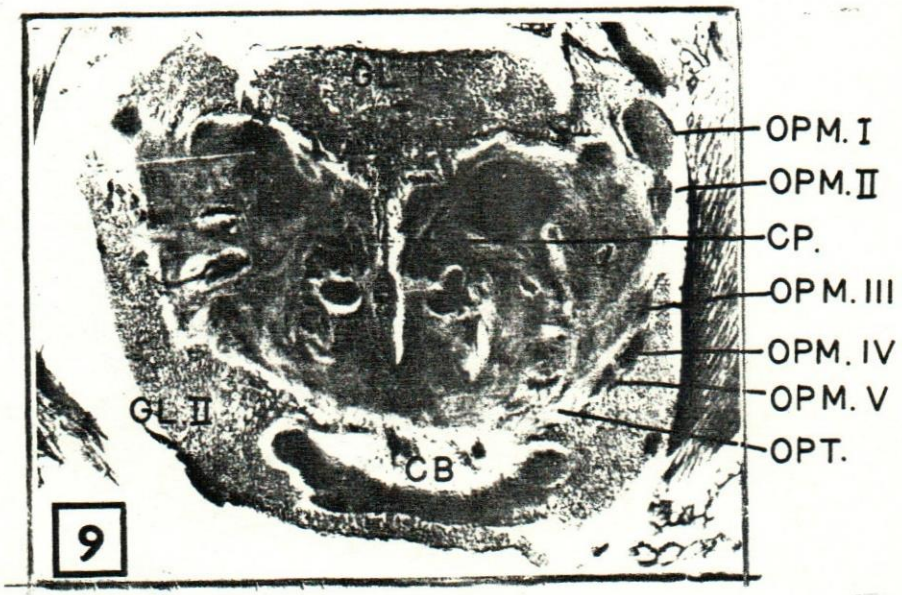
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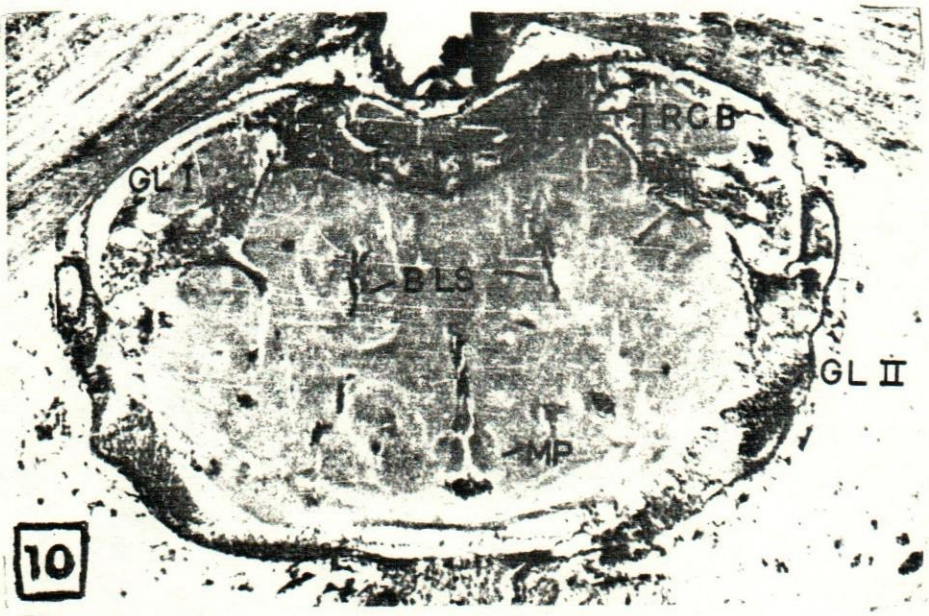
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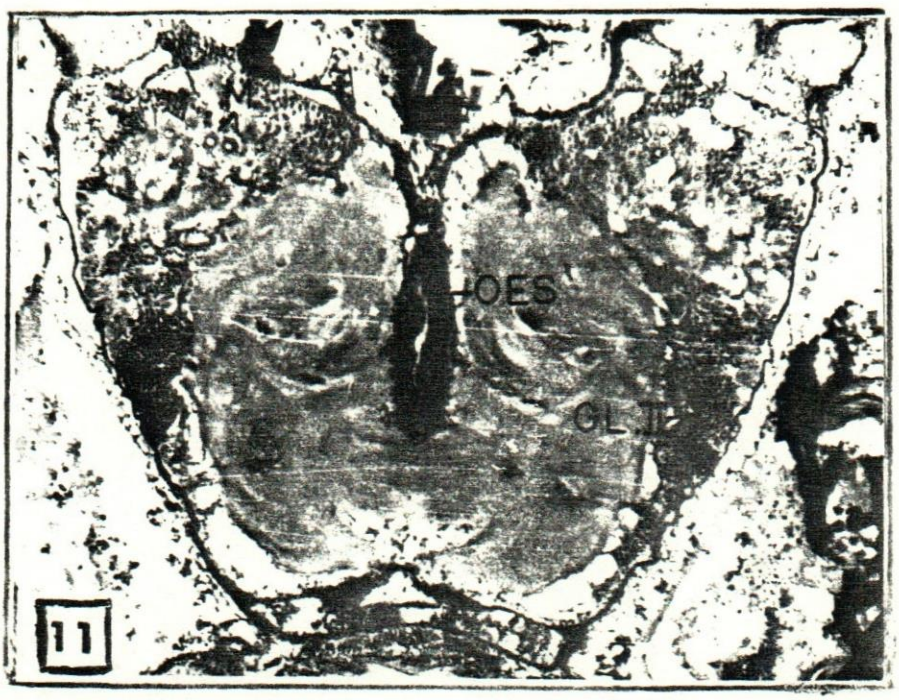
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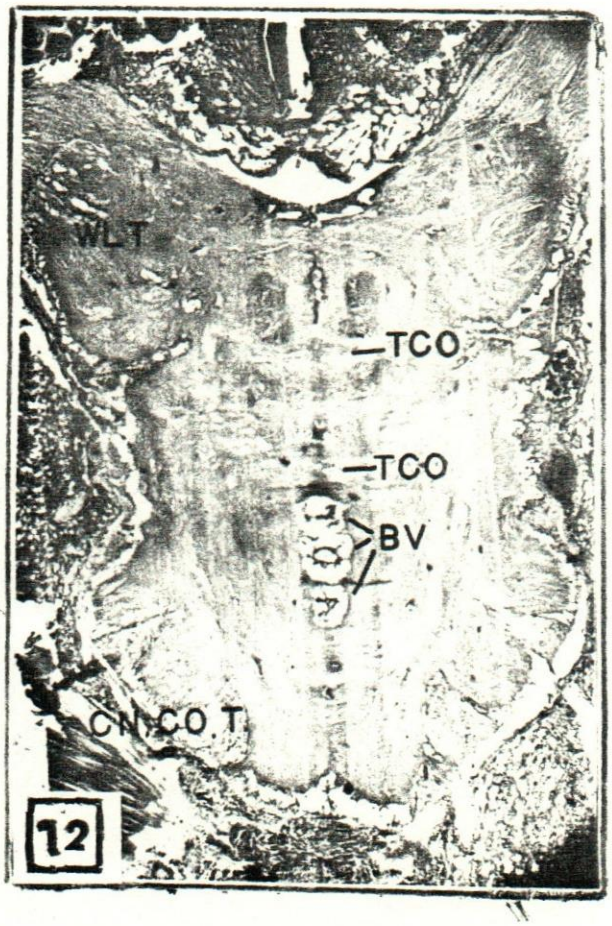
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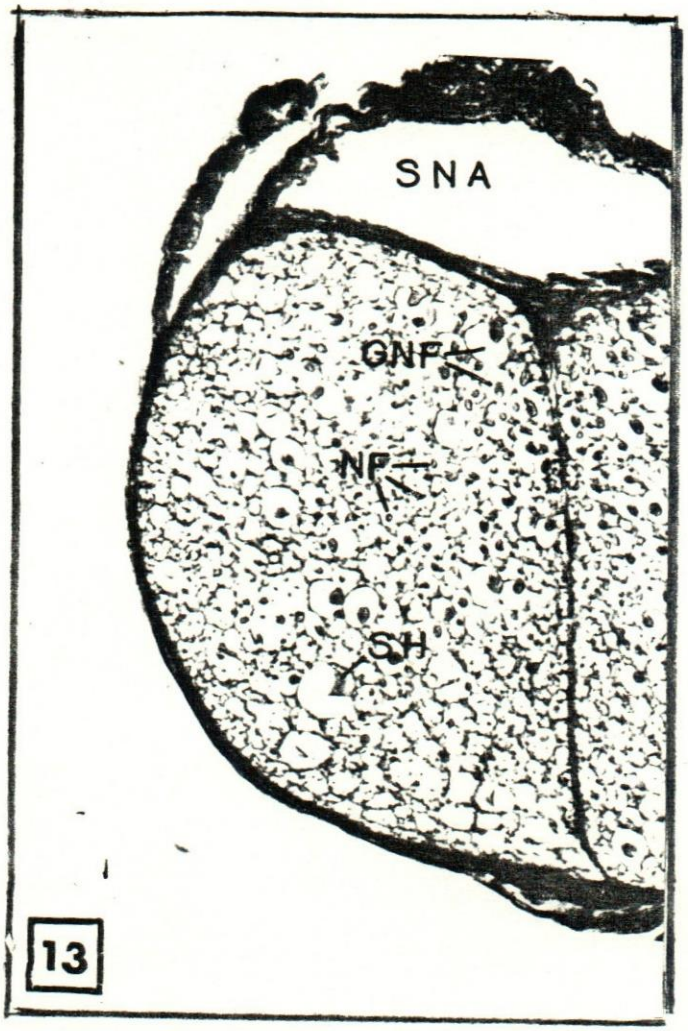
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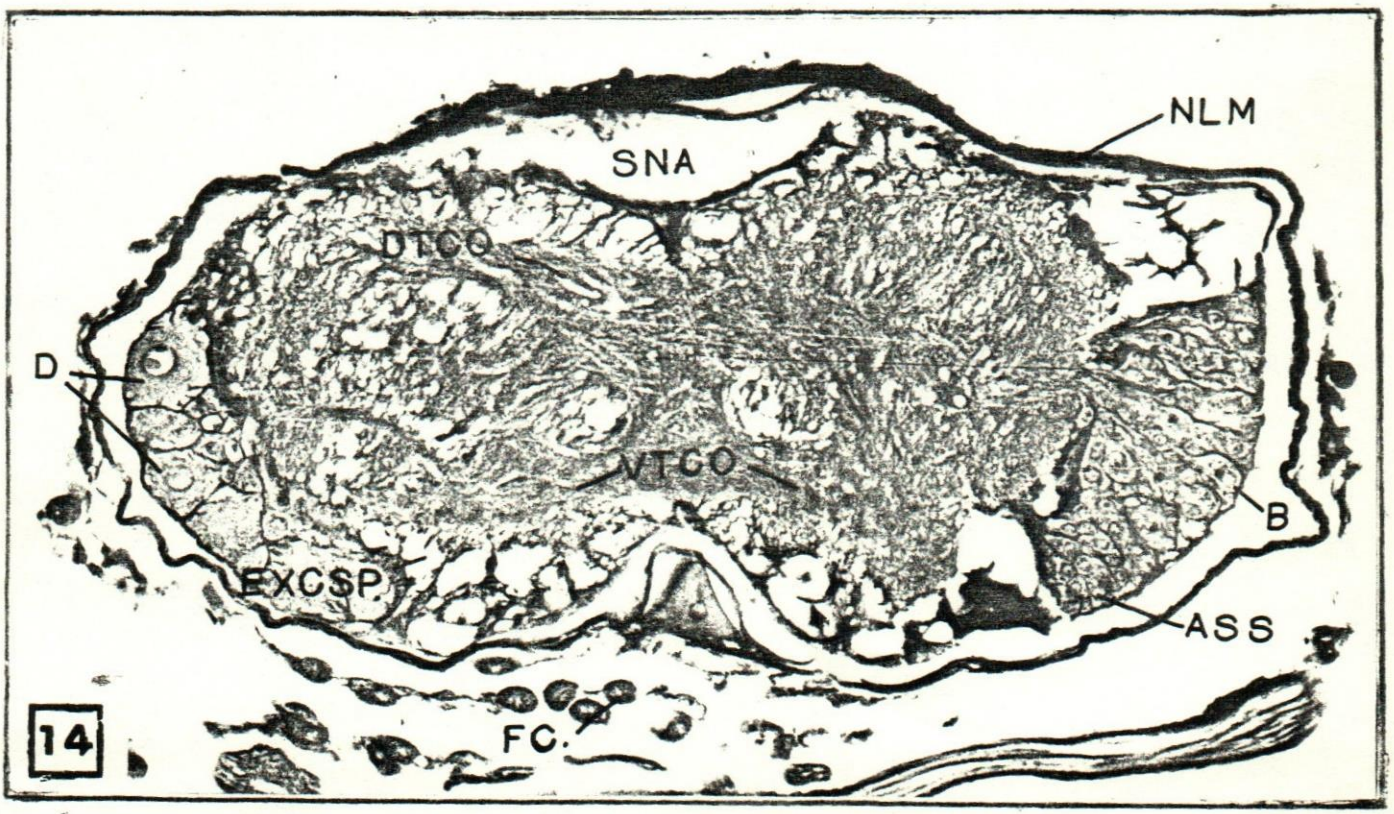
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