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Drogi nerwowe w mózgu pszczoły biegnące od organów zmysłów wzroku i organów zmysłów antenalnych*

Нервные пути у пчелы (*Apis melliiica*) соединяющие мозг с органами чувств

Nerve Tracts in Bee (*Apis melliiica*) Running from the Light and Antennal Organs to the Brain

One of the first, more accurate investigations of the internal structure of the brain of *Hymenoptera* were conducted by Viallanes, who studied the brain of *Vespa crabro*. Later Kenyon studied the brain of the bee. The external and internal structure of the brain was also described by Ionescu. The most accurate of those investigations are undoubtedly the studies of Kenyon. However, the works were conducted about 50 years ago, at the time when the microscopical technique was not as advanced as it is nowadays. My own studies conducted in 1934 and 1948 were concerned only with certain portions of the bee's brain, or only dealt with the brain of *Hymenoptera* partly. Recently, 1956, in an extensive work on the anatomy and physiology of the bee, Snodgrass described also the brain of the bee. Vowles (1955) has published an interesting paper on all connections of *corpora pedunculata* with various parts of the brain and with the suboesophageal ganglion. Vowles used new methods of investigation by means of high frequency radio waves. Special attention should be also paid to the latest paper by Panov (1957) concerning the postembryonic development of the brain in *Hymenoptera*.

Although numerous studies on the brain of the bee have been published, we still lack exhaustive information on its structure. There are also some contradictory statements which should be confronted and rectified.

The present studies were conducted mainly on worker bees and queens. It was the purpose to describe first of all the association conspicuous tracts, which run from the sensory organs in question. As already mentioned in my previous works, I have not used any special methods to soften the chitin,

* Praca subsydiowana przez Polską Akademię Nauk.

but I have removed the whole brain from the chitin case. In my investigations were used exclusively imagos, not larval stadia. The objects were fixed in 96% alcohol and two methods of staining were employed: iron haematoxylin and Cajal's impregnation. The brain was cut in various planes to illustrate on many sections the course of the tracts connecting the sensory organs with this organ. These tracts are shown in the enclosed schemes and are also visible, at least partly in the numerous photographs. The photographs in the text are not always given in the succession of numbers. Describing the various parts of the brain it is difficult to coordinate the separate photographs of one series with a file of photographs of another series or with the succession of the same series.

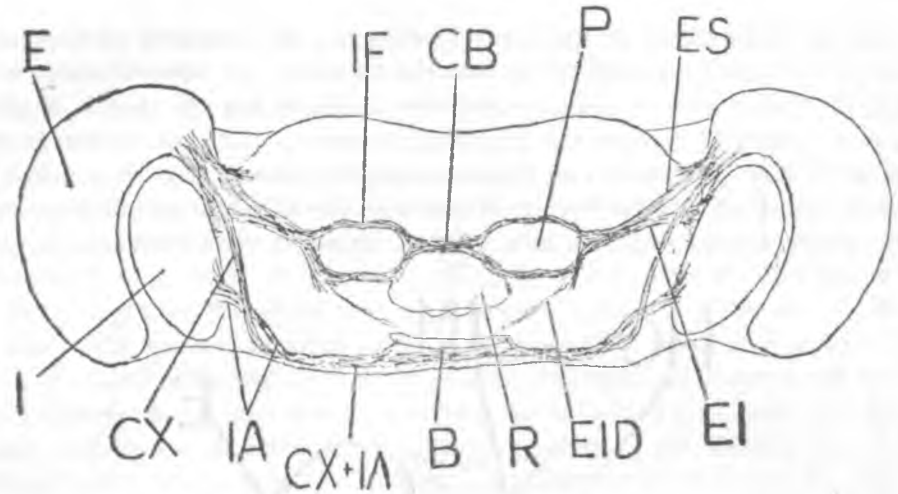
TRACTS CONNECTING *MEDULLA EXTERNA* WITH *PROTOCEREBRUM*

The commissure CX of the decussating fibers, which connect the right and left *medulla externa,* takes origin in the anterior portion of the *medulla externa.* Initially it passes posteriorly in direct closeness of *medulla interna.* (Fig. 1). Further on it changes its direction and runs across the *protocerebrum* (Fig. 2), sending a part of the fibers to the pons. This tract in the transverse course of the *protocerebrum* is indeed closely united with another tract, which runs from the *medulla interna* and is described below. In the enclosed (Fig. 1) in the central part of the brain the fibers from the *medulla externa* prevail. The scheme (1) shows the entire course of this tract jointly with the part united with the tract of *medulla interna.* In the frontal or approximately frontal sections of the brain there is seen a part of the tract of *medulla externa* in transverse sections, which runs along the *medulla interna* (Fig. 5, 6, 14, 11, 24). Kenyon did not find this tract, at least he did not show it in his schemes. Viallanes describes this tract as „faisceau supero-posterieur".

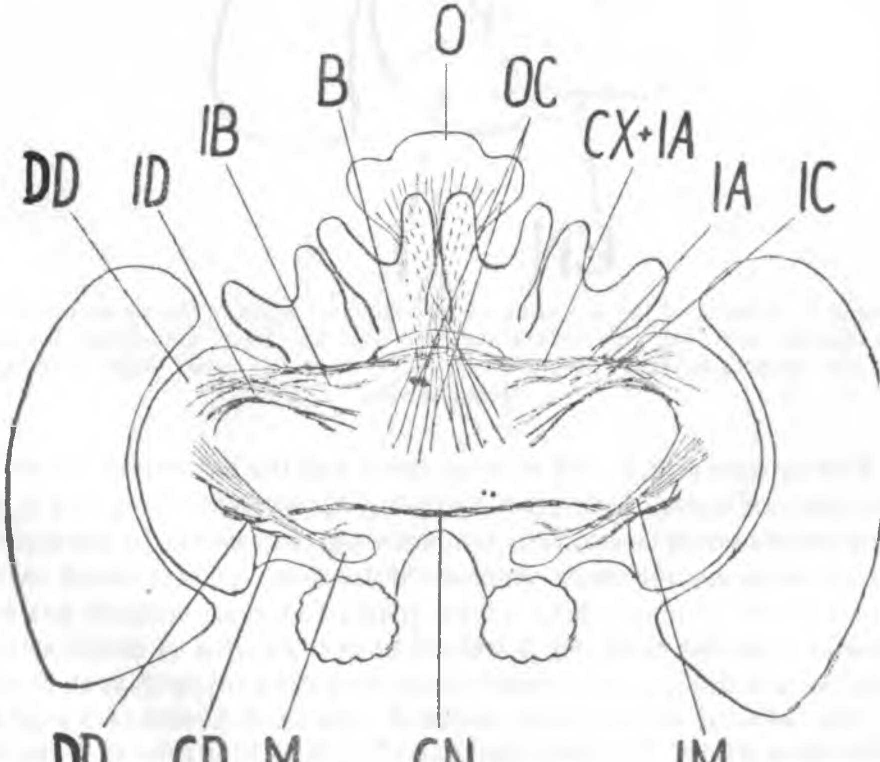
Jointly with the commissure which connects the right and left *medulla externa* takes origin another tract which passes to the *corpora pedunculata.* This tract will be described below. A portion of fibers of this tract is dispersed already in the *protocerebrum.*

TRACTS CONNECTING *MEDULLA INTERNA* WITH *PROTOCEREBRUM*

The scheme of these tracts is given in the scheme (2). Numerous tracts take origin from the *medulla interna.* The tract IM associates the *medulla interna* with the *tuberculum opticum* (scheme 2 and 3). In Fig. 18 there are seen places of origin of this tract from the *medulla interna.* This is the broadest tract running from *medulla externa* and *interna.* This tract in *Hymenoptera* has been described by several authors.

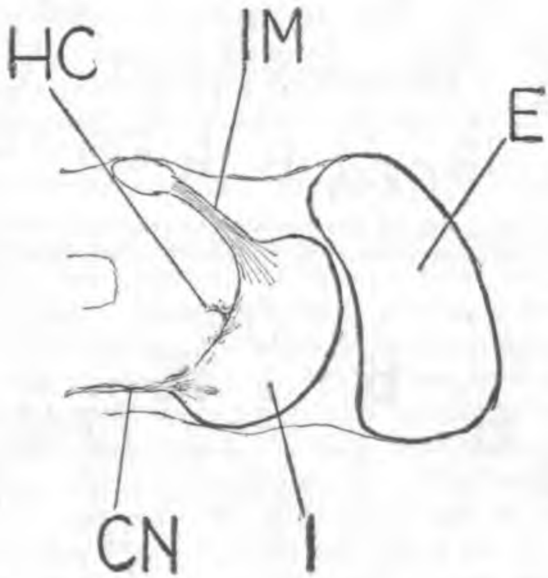


Scheme 1. Scheme of tracts of the *medulla externa* and *medulla interna* in the horizontal plane or most approximately horizontal in the upper part of the brain.



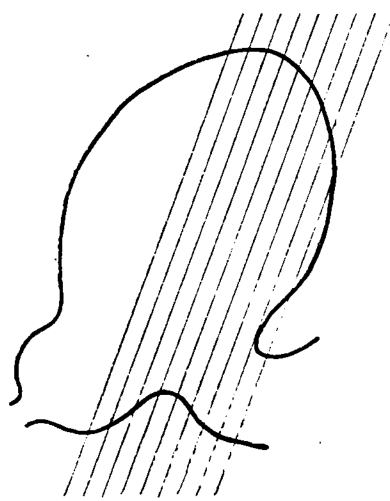
Scheme 2. Scheme of tracts in *protocerebrum* running from *medulla interna* in places where their greatest number leaves *medulla interna*, and scheme of ocellar tracts. Plane approximately frontal.

As to other tracts of the *medulla interna*, the majority of them are grouped into two concentrations DD, the superior and inferior (scheme 2) (Fig. 9). This is not an accurate determination of the site, but it enables us most easily to discern the two concentrations of tracts, closer to the posterior side of the brain on frontal or approximately frontal sections. In the enclosed scheme for better distinctness the superior and inferior concentrations are more separated one from the other, than they actually are.



Scheme 3. Scheme of the arrangement in horizontal plane of the tracts connecting the medulla with the *tuberculum opticum* and the tract connecting the right and left *medulla interna*. Place of origin of the tract HC shown. Right half of the brain shown.

Photographs (Fig. 3—10) of those tracts and the concentrations are taken from one series of microtomic sections. Approximate directions of sections of this series is shown in the drawing (scheme 4). In the superior concentration several tracts composed of decussating fibers which emerge from portions of the *medulla interna* situated at some distance one from other can be discerned. All the tracts have their sites of origin at close distance, and the closest are those of the first three tracts (Fig. 4). Further on the course of all the tracts becomes somewhat diverse and they disperse their fibers. The broad tract IA (Fig. 3, 4, 5, 6) runs in close vicinity of the commissure, which unites the right and left *medulla externa*, therefore it is not possible to separate it from the latter along the whole distance, as I have mentioned. Most likely the fibers of the tract IA pass partly into the pons. They seem to run further to the *medulla interna* of the opposite side, as Kenyon marks it in his drawing. The tract IB (Fig. 2, 3 and 4) runs initially horizontally and somewhat downwards, bends wave-like and its fibers disperse in the area of the ocellar tracts. The tract IC (Fig. 5 and 6) breaks up into two branches already close to the *medulla interna*. The branch which runs downwards is more conspicuous and visible on a longer distance (Fig. 5). The branch which runs anteriorly and more horizontally (Fig. 6) is less visible, because after a short distance it breaks into a number of smaller branches. Close to those tracts and a little anteriorly there is the tract ID (Fig. 7 and 8). This tract is more conspicuous than the above described. It takes a somewhat downwards course and breaks into two tracts, which run most frequently near each other. Besides, all the tracts, as already mentioned, are at the site of issue lying near one another, and their branches near the site of issue can be regarded also as smaller tracts.



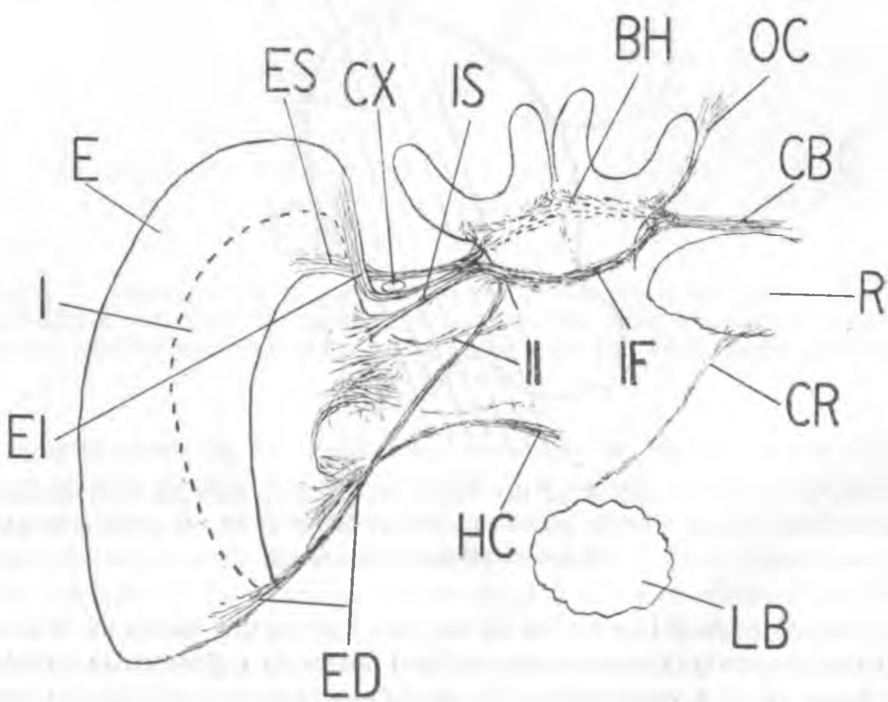
Scheme 4. A lateral outline of the brain of the bee. Straight lines denote the approximate direction of the series of sections. In fig. 3—10 are given photographs of some sections of this series.

Attention should be called to the fact that in the region of the tract ID the neuropile is more condensed and possesses a glomerular structure. In figure (7) this condensation OP can be observed although in this photograph it is slightly visible. This is probably a structure analogous, although considerably smaller, to „*corpus opticum*" described by Hanstrom in the *Petrobius*. I have also found neuropiles of dotted structure in my preparations of some species of the genus *Periplaneta* and *Saltato-*

ria. In the mentioned species this organ is considerably larger than in the bee.

In the second, lower concentration (scheme 2 and 3, Fig. 10) two main tracts can be differentiated. One of them, the commissure CN is composed of decussating fibers which unite the right and left *medulla interna.* The second tract CD runs initially almost parallelly to the first one and further on it turns to the peripharyngeal commissure. It is possible that there are also fibers carrying motoric stimuli. The two tracts were already noted by Kenyon and Viallanes. The commissure which joins the right and left *medulla interna* recorded by Viallanes in *Vespa crabro* is termed „Cordon comissural du nerf optique". The second, however, only partly known, is termed by the mentioned author as „Faisceau optique infero-posterieur". It appears that according to Ionescu those tracts are branches of the „hintere Bündel".

The tracts originating from the described concentrations of fibers and naturally the tracts which run towards the *tuberculum opticum* are most



Scheme 5. Scheme of tracts connecting the *medulla interna, medulla externa* with the *corpora pedunculata* and of the supposed tract connecting the antennal organs with the central body, as well as of some fibers running from *medulla interna* towards *protocerebrum.* The plane approximately frontal. Left half of the brain shown.

conspicuous. Anteriorly to those concentrations of fibers there is still one concentration of connections of the *medulla interna* with the *protocerebrum* (scheme 5). The fibers which are present there have the character of a neuropile. They partly disperse and partly form connections as e. g. with the *corpora pedunculata*, to be described below. There appears only one conspicuous tract HC (Fig. 11 and 14), although I am not sure if this tract is exclusively composed of fibers derived from this concentration of fibers. This tract bends semicircularly downwards. It is visible in frontal and approximately frontal sections. It would be difficult to compare it with any of the tracts described by other authors. Judging Kenyon's drawings the tract HC described by me is at least in its initial part corresponding to the tract „Posterior optic tract".

At present it is difficult to compare these optic tracts and their course in the brain of the bee with such tracts in individuals of other orders of insects, although some of them, such as commissure, which unite the right and left *medulla interna* and the tract which connects the *tuberculum opticum* were found in many insects. The more recent, detailed works of Pflugfelder on *Rhynchoten* and Ehnbom on *Trichoptera* and *Lepidoptera* give a detailed description of connections of fibers of tracts with the optic lobes, but they pay less attention to the course of those tracts in the brain.

One of the relatively recent works, which deals with the course of tracts of compound eyes in the brain is the work by Power. Power studies the brain of *Drosophila melanogaster*. On the basis of the description and of the enclosed scheme of those tracts it bears a certain analogy with my description of tracts in the bee. If the course of all the tracts is not the same, the sites of their emergence from the *medulla externa* and a number of tracts from the *medulla interna* are very similar. Taking into consideration Power's scheme it should be stressed that the *medulla interna (glomerulus* Power) in the *Drosophila* is composed of two parts while in the bee and *Hymenoptera* they form one entity.

I should stress that terminal branchings of the described tracts may extend farther than the enclosed schemes or photographs permit to conclude; they may form connections not described in this work.

TRACTS CARRYING VISUAL STIMULI FROM THE OCELLI TO THE BRAIN

These tracts were described by me already in 1948. The ocellar fibers OC are very conspicuous. They are thick, and disperse fan-like in the brain (scheme 2) (Fig. 13). A part of them decussate to the opposite side (Fig. 6) Some of them carry motoric stimuli and pass to the *lobus olfactorius*, surround it posteriorly and enter the antenna in the direct vicinity of sensory fibers, which leave the antenna towards the *lobus olfactorius*. It should be noted that in the bee these motoric fibers are much less conspicuous than in the wasp. The ocellar fibers have no connection with the *pons*. They only run along its two sides, most numerously, however, on the posterior side. In their further course they appear also on the posterior side of the central body and do not unite with it.

TRACTS CONNECTING *MEDULLA EXTERNA*, *MEDULLA INTERNA* AND *OCELLI* WITH *CORPORA PEDUNCULATA*

A certain differentiation of the *calyx* is already seen in the photographs presented by Kenyon. He reported also that two kinds of fibers of various thickness enter the *calyx*. In my work published in 1934 I divided the *calyx* into three parts and I termed them I, II and III layer. In the various species of *Hymenoptera* the layers can be more or less separated or united with each other. There can appear also differences in the internal structure of each layer. In the bee, in spite of a partial union of the upper layers, a certain structural difference can be also observed, although they are milder expressed than in other species of *Hymenoptera*. (I intend to publish a separate paper devoted to the differences of structure of the layers of the *calyx* in various species of *Hymenoptera)*.

In the schemes of the present work I am presenting only a contour of the *calyx*.

Towards the *corpora pedunculata* run tracts from the *medulla externa* and *medulla interna* (scheme 5). Ionescu was the first to observe that these tracts run from the upper and lower portions of the *medulla externa*. These tracts, however, have not yet been accurately described. The course of these tracts is difficult to trace and represent in schemes.

The upper tract is composed of fibers which form two main branches ES and EI. It takes origin, at least one of its branches ES (Fig. 1, 15, 18) jointly with the tract already described which unites the right and left *medulla externa*. This branch lies somewhat higher than the branch EI. In Fig. 16 there are visible fibers of the branch ES along the whole EE of the upper tract of the *medulla externa*. The branch EI passes under the tract connecting the right and left *medulla externa* (Fig. 11, 15, scheme 5), which has here almost a vertical course to the branch EI. The fibers of the latter branch run initially so close to the *medulla interna* that they seem to take origin from it. The fibers of both branches partly interlace themselves at the *medulla interna* and near the peduncles they are already very close one to another and are difficult to distinguish. The lower tract of the *medulla externa* ED (Fig. 12) originates in the lower portions of this *medulla* and runs initially close to the *medulla interna* together with the tract HC originating from the *medulla interna* as previously described.

In the *medulla interna* there take origin also two tracts, which run to the *corpora pedunculata*. One of them IS is more conspicuous (Fig. 19). The second one, II, however, is more receded into the interior of the neuropile and is composed of fibers which are more dispersed. (Fig. 14 and 24). The tract IS is apparently closer to the upper tract of the *medulla externa* and most likely its fibers unite with the lower branch of the *medulla externa*. All the named tracts come close together in the vicinity of the *calyx (scheme 5)*. It is also most likely that all partly enter into the *calyces*, there they ramify posteriorly (BH, Fig. 20) and partly they follow their course and surround the peduncles anteriorly (IF, Fig. 18) somewhat lower. In these surrounding tracts and in the fibers which enter into the *calyces* the most conspicuous are the fibers of the upper tract of the *medulla externa* and the first tract of the *medulla interna*. (To these tracts other fibers also join, probably conveying other impulses. Besides the tracts surrounding the *calyces* FP, BH, there is still the branch EID (scheme 5), which runs outside the *calyces* and does not unite with them.

The connections at the *calyces* as well as the connections within the same are complicated and require further studies.

On the medial side of the internal peduncle the surrounding tracts unite again and form a broad tract OB, which runs to the opposite side (Fig. 17) and was observed also by K e n y o n and other investigators. In this tract fibers are seen which decussate to the opposite side.

Besides the tracts which connect the *corpora pedunculata* with the *medulla externa* or *interna* there are also tracts, less conspicuous, which connect this organ with the *ocelli*.

The above described tracts which run to the *calyx* are not basically different from connections described by V o w l e s. Thus connections marked by him with the figures V and IV may be considered as the superior and inferior branch of the superior tract. It is also probable that the *medulla interna* has more connections than given by V o w l e s. My investigations show that the *calyces* have connections with the *ocelli*. Particularly interesting are V o w l e s' s data concerning connections between the frontal and medial root, „lobe a" and „lobe b", as they are called by the author, and the sensory and motoric fibers respectively. V o w l e s describes a series of connections between the lobe „a" and the compound eyes; it is possible that such connections do exist. The lobe „a" is surrounded by a mass of fibers which enter into it. I did not investigate these connections in a more detailed way because I did not observe there very distinct tracts. Nevertheless I am of the opinion that all connections described by V o w l e s are ramifications of the above described tracts.

P a n o v is right connecting the structure of the *calyx* and the whole *corpora pedunculata* with some definite cells. He investigated the *corpora pedunculata* not only in the bee, but also in other *Hymenoptera*, and found a differentiation of the *calyx* not only in the species described by me, but in many other as well. P a n o v ascribed the greatest importance to the third layer. In my opinion, the explanation of the activity of the brain or of the *corpora pedunculata* largely depends on all kinds of structural differences between layers, irrespectively of the cells from which they originate. Impulses may be transmitted omitting the cells, and all differences of the structure of the neuropile must have an influence on the functions of the brain.

V o w l e s found a differentiation of the cells in the *calyx* of the bee: in the centre of the *calyx* cells are smaller than the surrounding ones. In the ant, on the other hand, he could find no such differentiation. There are, however, data (J a w ł o w s k i, 1934) pointing to the existence of such differentiation not only in the bee, but also in the ant, which is fully confirmed by P a n o v's detailed studies.

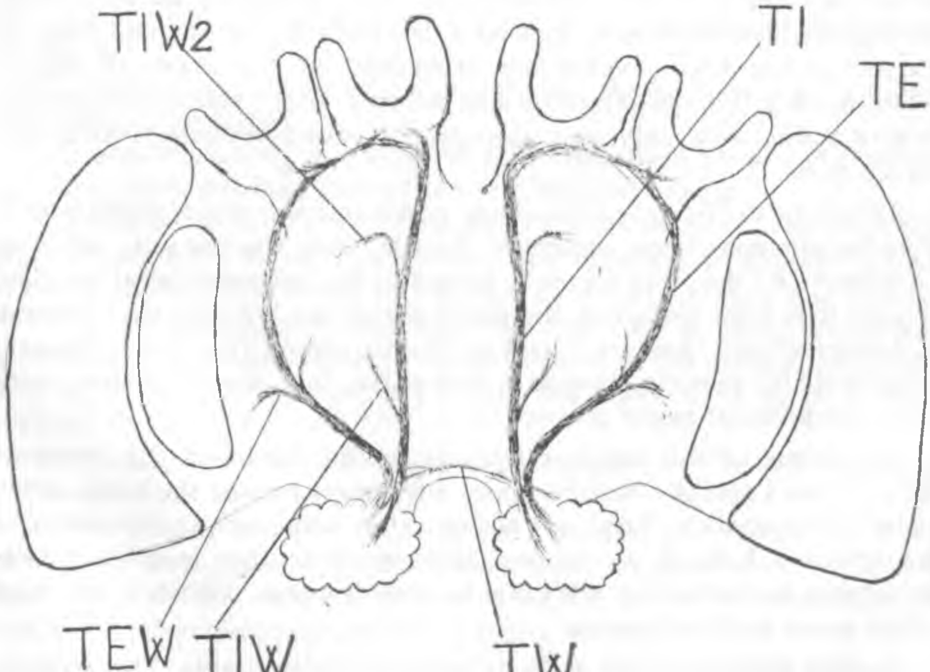
My present studies do not confirm the existence of a special tract which connects the *lamina ganglionaris* or the *medulla externa* with the suboesophageal ganglion. It cannot be excluded, however, that such connections exist in other insects. Z a w a r z i n in his work presents in drawings structures of eyes of insects, fibers leaving the *lamina ganglionaris* and passing to the *protocerebrum*, but their further course is at present unknown. According to P o w e r, one of the tracts connecting compound eyes sends a branch to the suboesophageal ganglion.

The tract which runs in the optic lobes NS (Fig. 21) does not unite with the *medulla externa* and *lamina ganglionaris*. As might be supposed this is undoubtedly the root of the nerve termed as the „salivary nerve". There are, however, differences between the descriptions of this nerve NS, and especially its site of issue, given by K e n y o n, and I o n e s c u represents in every one of his three drawings a somewhat different site of the emergence from the brain. It appears that this nerve may really leave the brain at the site of the optic lobe as illustrated in Fig. 21. I have found in my preparations certain individual fluctuations as to the point of leaving the brain by this nerve. It is most likely that the fluctuations may be still larger as regards races of bees. The root of the described nerve always leaves the suboesophageal ganglion. In this case I o n e s c u's supposition that this nerve is in bees homologous to *tegumentarius-tegumentalis* in other insects seems to me to be correct.

I did not find conspicuous tracts connecting the compound eyes with the central body. Neither K e n y o n shows such tracts in his drawings. May be that there pass some branches or dispersed fibers of the above described tracts. P f l u g f e l d e r does not record any direct tracts in *Rhynchota* connecting the compound eyes with the central body.

ANTENNAL TRACTS

The antennal tracts in *Hymenoptera* were described by me already in 1948. In the mentioned work a scheme of those tracts in *Vespa germanica* was presented, whereby it was stressed that in other *Hymenoptera* no fundamental differences were found. Now I am presenting a similar scheme in the bee (scheme 6). The antenno-globular tracts are joined, similarly as in *Saltatoria* by scanty fibers from the suboesophageal ganglion. The antenno-globular medial tracts TI jointly with their branches are partly visible in Fig. 22 and 23, the external one TE in Fig. 18 and 24. In a number of sections, as for instance in Fig. 11, 15 and 16 this tract is also visible in the transverse plane. I should add that in certain sections of the brain there are seen in the lateral tract branches which appear to be turned to the interior of the brain. Probably they are fibers which only join this tract, but do not convey stimuli from antennal organs.



Scheme 6. Scheme of the antenno-globular tracts and their branches. The plane approximately frontal.

In 1954 I wrote that the fibers of the antennal tracts decussate to the opposite side, but that in some insects the number of fibers is numerous, in others not. In *Hymenoptera* it is difficult to observe the fibers of the antenno-globular tracts which decussate to the other side of the brain. More conspicuous is the decussation of the fibers of the medial and lateral tract in each half of the brain near the *calyces*.

The tracts between the right and left *lobus olfactorius* in the bee TW (scheme 6) are not as conspicuous as the antennal tracts.

Towards the central body runs a thin tract CR (Fig. 25), which originates from small cells situated near the *lobus olfactorius*, possibly it connects the central body with the organs of senses. Anyway, this tract is considerably smaller than those leaving the *lobus olfactorius* towards the corpora pedunculata. As may be supposed from Kenyon's data there is no special tract connecting the *glomeruli* with the central body.

As may be judged from descriptions and schemes of the antennal tracts and the tracts leaving the organs of vision, the latter ones are more numerous. The antennal tracts are only somewhat thicker than the majority of the optic tracts. In the *protocerebrum* the majority is constituted by tracts leaving the organs of vision, from the antennal organs are derived only branches of the antenno-globular tracts. As regards *deutocerebrum* it would be difficult to suppose that it is a part of the brain exclusively dependent on the antennal organs. Fibers leaving the *lobi olfactorii* and directed to the *protocerebrum* and *corpora pedunculata* only pass through the *deutocerebrum* and do not ramify there.

According to Vowles and some other authors, *deutocerebrum* contains the antenno-motor centre. It results from the research work by Jawłowski that this centre is placed in the suboesophageal ganglion because it is from there that the motor fibers run towards the antenna. In *deutocerebrum* they are joined by fibers running from the *ocelli* carrying probably motoric stimuli. It is possible that *deutocerebrum* contains an additional motor centre.

The brain of the queen differs from the brain of the workers. Hitherto were actually observed only differences in size, the brain of the queen being smaller. There can appear also some small differences of the structure. I am of the opinion, however, that they may be of some importance in connection with factors, which cause different activities of the queen and the workers.

Further studies on the brain of bees are indispensable. The arrangement of the *calyces* in the queen does not differ from that in the worker. However, the brain of the drone is not only smaller than the brain of the worker or the queen but the arrangement of the *calyces* is also different. These *calyces* may be termed anterior and posterior, whereas in the queens and workers they deserve to be termed as lateral and central, as already reported by Jawłowski in 1934, (my investigations did not confirm the data given by Ionescu as to the similarity between the arrangement of *calyces* in the queen and the drone) Describing the size of the brain I do not take into consideration the optic lobes which are the largest in the drone.

The *lobus olfactorius* in the drone differs from the analogous organ in the queen or the worker, as reported by me in 1948. Now I am enclosing a more accurate photograph of the *lobus olfactorius* of the drone (Fig. 26), which differs by larger *glomeruli* from the same organ in the worker or the queen (Fig. 27). Exact investigations of the brain of the drone will perhaps permit to demonstrate further differences.

RESULTS

1. Schemes of tracts from compound eyes and *ocelli* to the *protocerebrum* and also to *corpora pedunculata* are described and illustrated.

2. Tracts from the *medulla interna* are more numerous than those from the *medulla externa*. From the *medulla externa* to the *protocerebrum* there runs one tract only. The tract unites the right and left *medulla externa*.

3. A description and scheme of tracts from the antennal organs (*lobus olfactorius)* is presented.

4. Tracts originating in compound eyes *(medulla externa* and *interna)* are more numerous than tracts from the antennal organs.

5. No conspicuous tracts running directly from organs of senses to the central body were found. It is possible that branches or dispersed fibres of the tracts described above, or the tract shown in scheme 5 enter there.

6. The most important difference between the brain of the worker and that of the queen lies not in the difference of the internal structure, as it is the case in the drone, but in that the brain of the queen is little smaller.

7. The salivary nerve leaves the brain not only in the direct vicinity of the optic lobe, but also through it.

8. The present studies do not confirm the existence in *Hymenoptera* of a special tract connecting the suboesophageal ganglion with the *lamina ganglionaria* or the *medulla externa*. Possible is only a connection by branches of tracts originating from *medulla interna*.

EXPLANATION OF TABLES

x ca. 130, x ca. 250.

Fig. 1. Section of a part of the brain and the optic lobe. The plane aproximately horizontal.

Fig. 2. Frontal section of the posterior part of the brain.

Fig. 3—10. Sections of one series of the posterior part of the brain. The plane is in the scheme 4, approximately frontal. The sections are successive, but at different distances.

Fig. 11—12. Successive sections of one series conducted through one half of the brain and the optic lobe. Frontal plane.

Fig. 13. Section of the posterior part of the brain. The plane approximately frontal. ,

Fig. 14. Section of the external *calyx*, *pedunculus*, and part of the optic lobe.

Fig. 15—17. Sections of a part of the brain and a part of the optic lobe. Successive sections but not at uniform distances. The plane approximately, horizontal.

Fig. 18. Section of one half of the brain and part of the optic lobe. The plane approximately frontal.

Fig. 19. Section of a part of the optic lobe and a part of the brain with the two *calyces*. The plane approximately frontal.

Fig. 20. Section of the major part of the brain and the optic lobe.

Fig. 21. Section of the optic lobe and the suboesophageal ganglion.

Fig. 22. Section of a part of the brain showing the medial antenno-globular tract.

Fig. 23. Section of a part of the brain showing the whole medial antenno-globular tract with its branches.

Fig. 24. Section of one half of the brain and the optic lobe. Frontal plane.

Fig. 25. Section of the lower part of the brain. The plane approximately frontal.

Fig. 26. Transverse section of the *lobus olfactorius* and a part of the brain of the drone.

Fig. 27. Transverse section of the *lobus olfactorius* and part of the brain of the worker.

ABBREVIATIONS

B	—	*pons*
BH	—	fibers and branches posteriorly to *calyces*
CB	—	tract between *corpora pedunculata* of right and left side of the brain.
CD	—	tract in lower concentration of fibers running towards peripharyngeal commissures.
CE	—	external *calyx*
CN	—	tract commissure connecting the right and left *medulla interna*
CR	—	tract towards central body
CX	—	tract (commissure) connecting the right and left *medulla externa*.
DD	—	upper and lower concentrations of fibers from *medulla interna*
E	—	*medulla externa*.
ED	—	lower tract of *medulla externa* to *corpora pedunculata*.
EE	—	upper tract of *medulla externa* to *corpora pedunculata*.

EI	—	branch of upper tract of *medulla externa* passing under the tract connecting the right and left *medulla externa*.
EID	—	branch of tracts passing to *corpora pedunculata* but not uniting with them.
ES	—	branch of upper tract of *medulla externa* to *corpora pedunculata* taking origin jointly with the tract connecting the right and left *medulla externa*.
FP	—	anterior root of *pedunculum*.
HC	—	tract of medulla *interna* bending semicircularly.
I	—	*medulla interna*.
IA, IB, IC	—	tracts of upper concentration of fibers of *medulla interna* at the site of issue lying most closely one to another.
ID	—	the most conspicuous tract of upper concentration of fibers.
IF	—	fibers passing anteriorly around *pedunculi*.
II	—	shorter tract of *medulla interna* running inside the neuropile to *corpora pedunculata*.
IM	—	tract from *medulla interna* to *tuberculum opticum*.
IS	—	longer tract of *medulla interna* running between neuropile and a layer of cells.
LB	—	*lobus olfactorius*.
M	—	*tuberculum opticum*.
NS	—	salivary nerve.
O	—	*ocelli*.
OC	—	ocellar tracts.
OP	—	condensation of neuropile.
P	—	*pedunculus*.
R	—	central body.
TE	—	lateral antenno-globular (olfactory) tract.
TEW	—	branch of this tract.
TI	—	medial antenno-globular (olfactory) tract.
TIW	—	first branch of this tract.
TIW²	—	second branch of this tract.
TW	—	tract (commissure) connecting the right and left *lobus olfactorius*.

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Microphotographs made by Cyprian.

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STRESZCZENIE

1. Opisano i zilustrowano schematy szlaków prowadzących od złożonych oczu i *ocell*, do *protocerebrum* i *corpora pedunculata* mózgu pszczoły.

2. Szlaki biegnące od *medulla interna* są liczniejsze od szlaków *medulla externa*. Od *medulla externa* ku *protocerebrum* biegnie jeden szlak. Szlak ten łączy prawą i lewą *medulla externa*.

3. Podano opis i schemat szlaków biegnących od organów antenalnych.

4. Szlaki wychodzące od złożonych oczu *(medulla externa* i *medulla interna)* są liczniejsze niż szlaki wychodzące z organów antenalnych.

5. Nie stwierdzono wyraźnych większych szlaków biegnących bezpośrednio od organów zmysłów ku ciału centralnemu. Być może, że wchodzą tam rozgałęzienia lub rozproszone włókna opisanych powyżej szlaków lub też szlak załączony na schemacie 5.

6. Najistotniejsza różnica między mózgiem pszczoły robotnicy i matki polega na tym, że mózg matki jest mniejszy. Mózg trutnia zaś ma nieco inną budowę.

7. Nerw ślinowy opuszcza mózg w bezpośredniej bliskości płatu ocznego lub przez sam płat.

8. Obecne moje badania nie potwierdzają istnienia u błonkówek specjalnego wyraźnego szlaku łączącego zwój podprzełykowy z *lamina ganglionaris* lub *medulla externa*. Możliwe są tylko połączenia od rozgałęzień dróg wychodzących z *medulla interna*.

РЕЗЮМЕ

1. Описаны и представлены на рисунках схемы путей отходящих от сложных глаз и *ocelli* к *protocerebrum* и *corpora pedunculata.*

2. Пути идущие от *medulla interna* многочисленнее чем пути идущие от *medulla externa.* От *medulla externa* к *protocerebrum* идет лишь один путь. Этот путь связывает правую и левую часть *medulla externa.*

3. Представлены описание и схема путей отходящих от антеннальных органов.

4. Пути отходящие от сложных глаз (*medulla externa* и *medulla interna*) более многочисленны, чем пути выходящие из антеннальных органов.

5. Не обнаружены ясно выраженные пути отходящие от органов чувств к центральному телу. Быть может, входят там разветвления или рассеянные волокна описанных выше путей или путь представленный на рисунке 5.

6. Наибольшее отличие между мозгом рабочей пчелы и матки заключается в том, что мозг матки относительно меньше мозга рабочей пчелы. Мозг трутня построен несколько иначе.

7. Слюнный нерв выходит из мозга поблизости глазной доли или даже через неё.

8. Произведенные автором исследования не подтверждают существования у перпончатокрылых особого нервного пути, связывающего подглоточный ганглий с *lamina ganglionaris* или *medulla externa.* Возможна только связь от разветвлений нервных путей выходящих от *medulla interna.*

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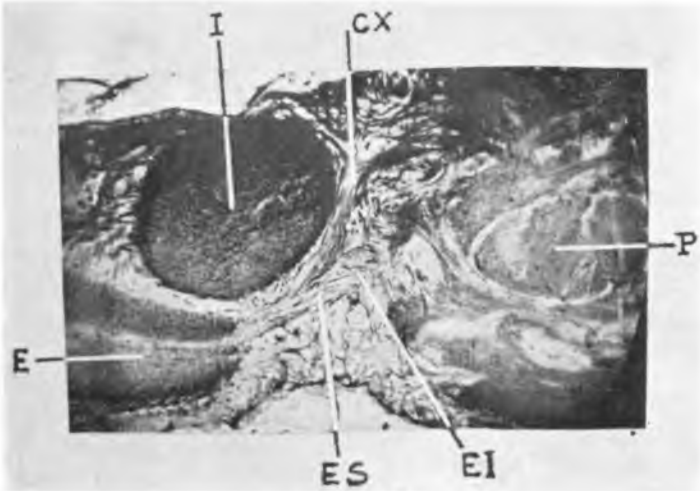

Fig. 1.

Fig. 2.

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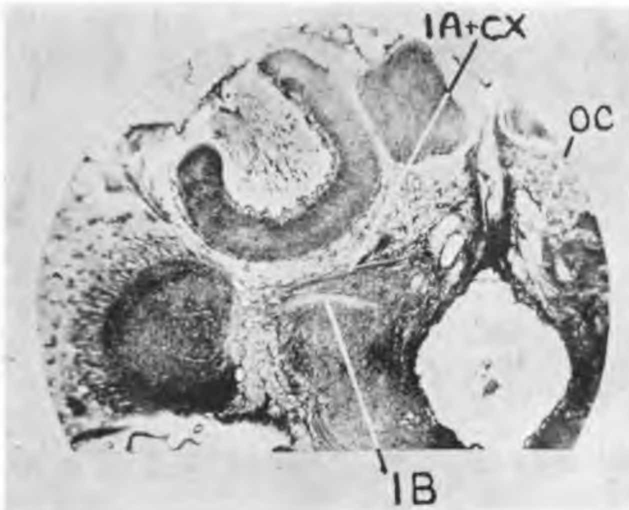

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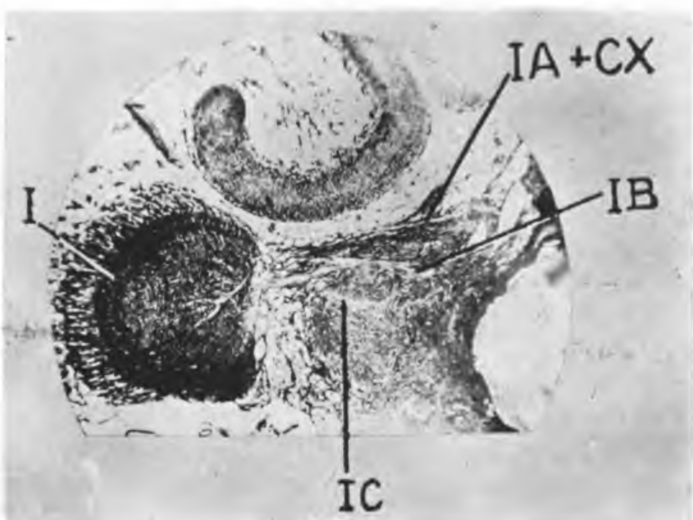

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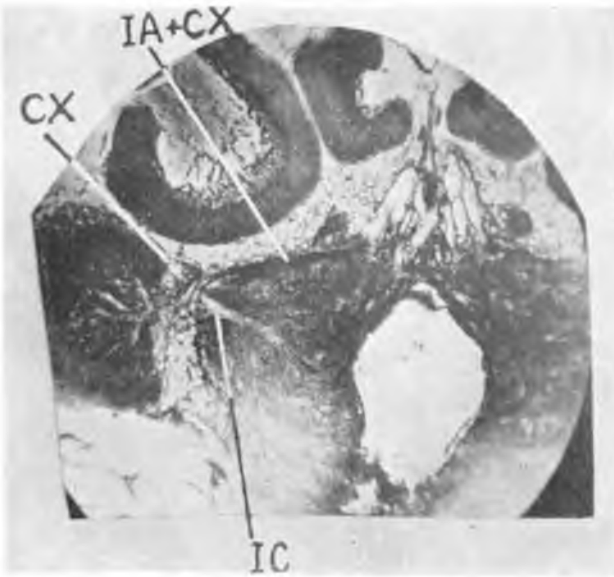

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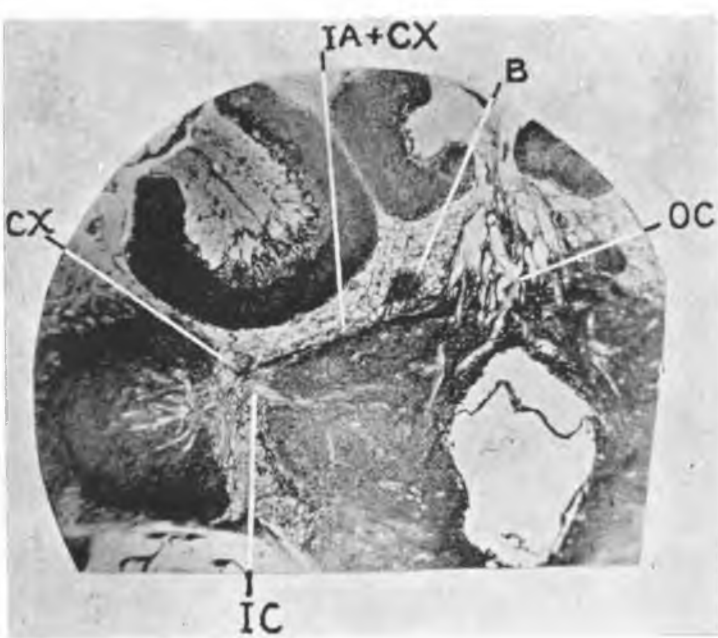

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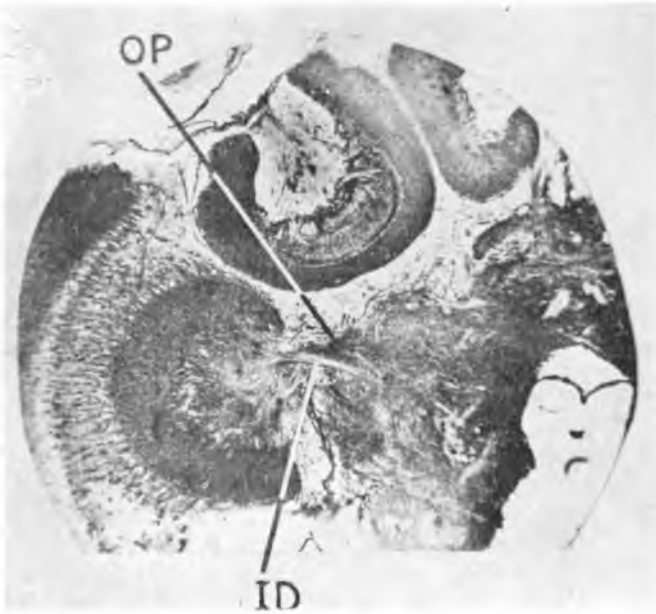

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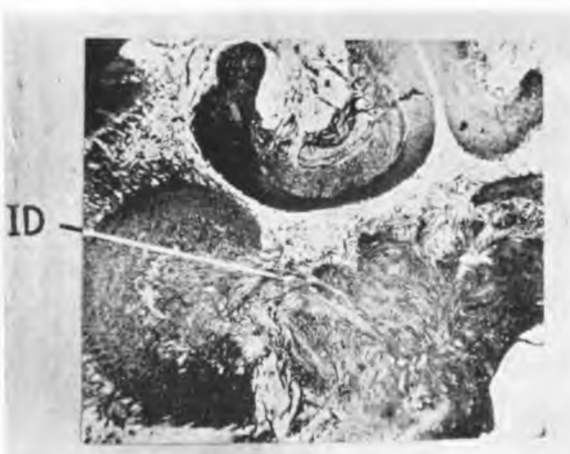

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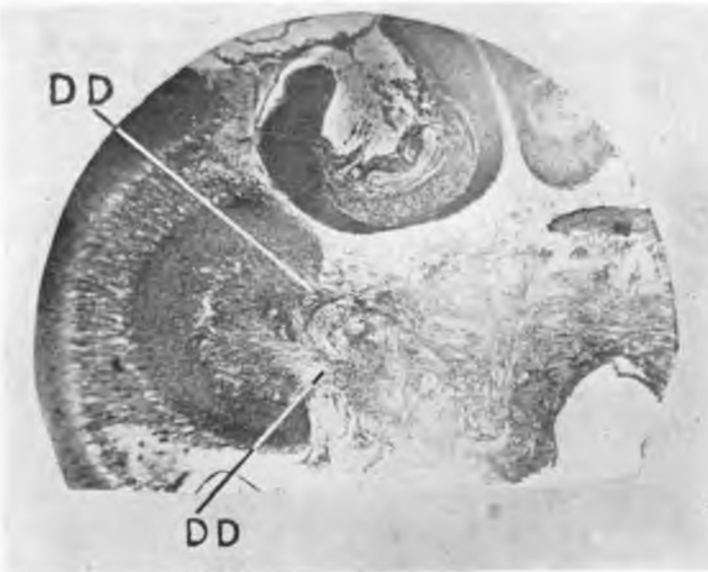

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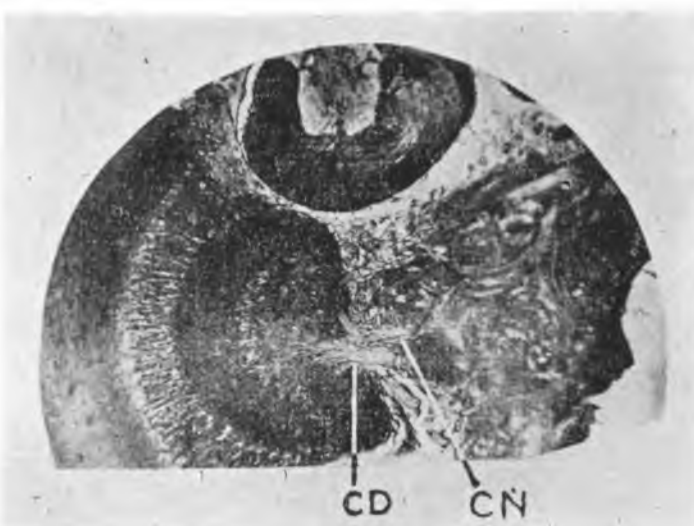

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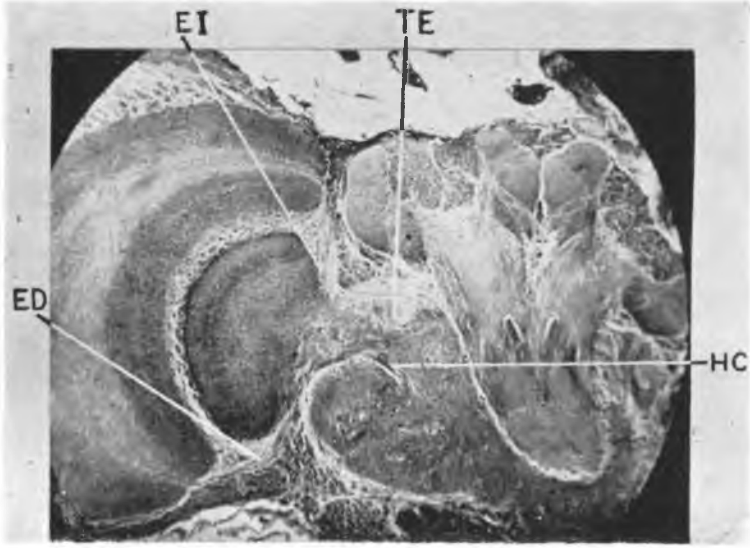

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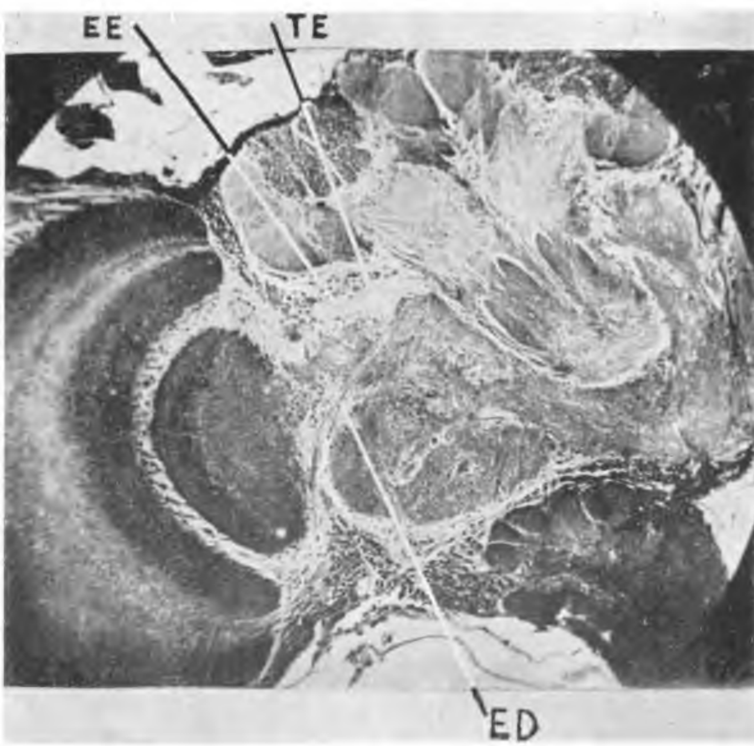

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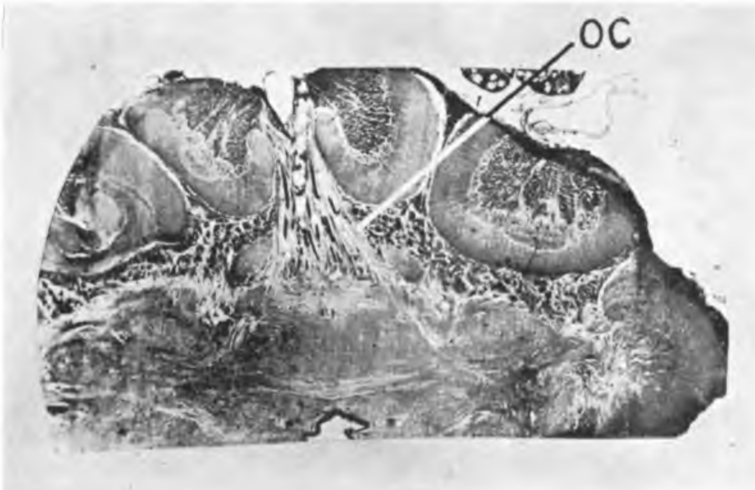

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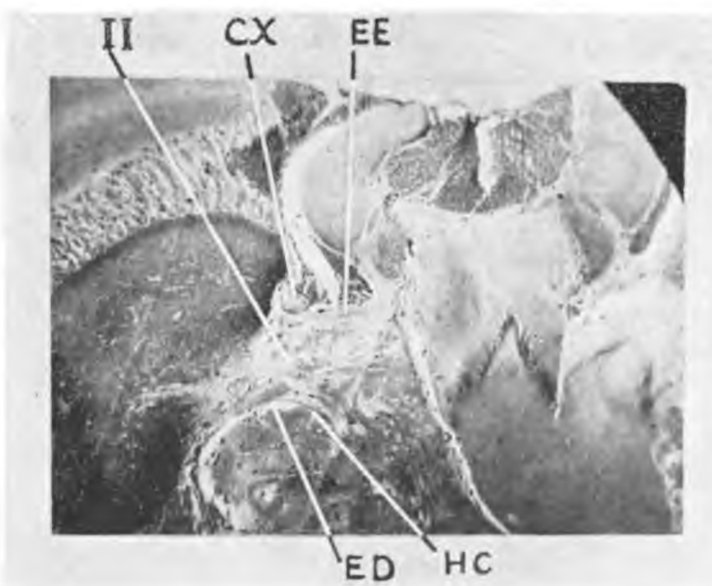

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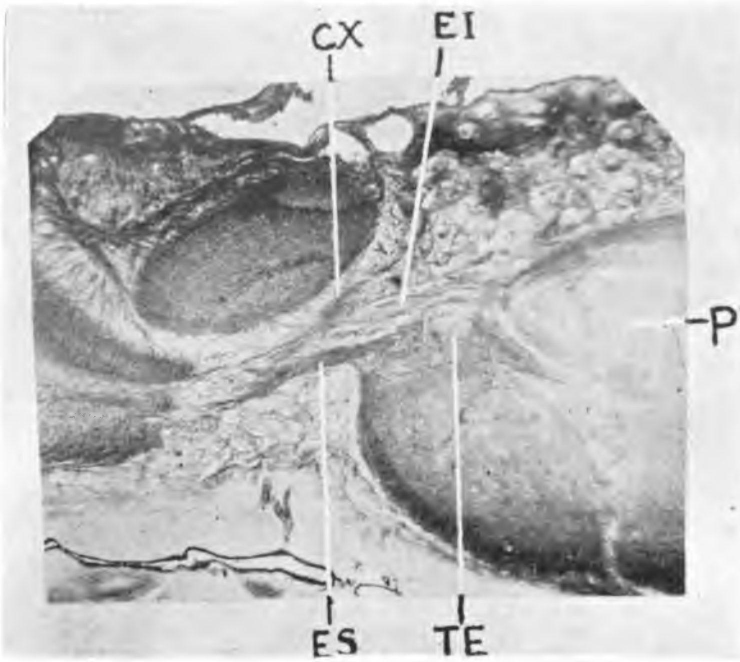

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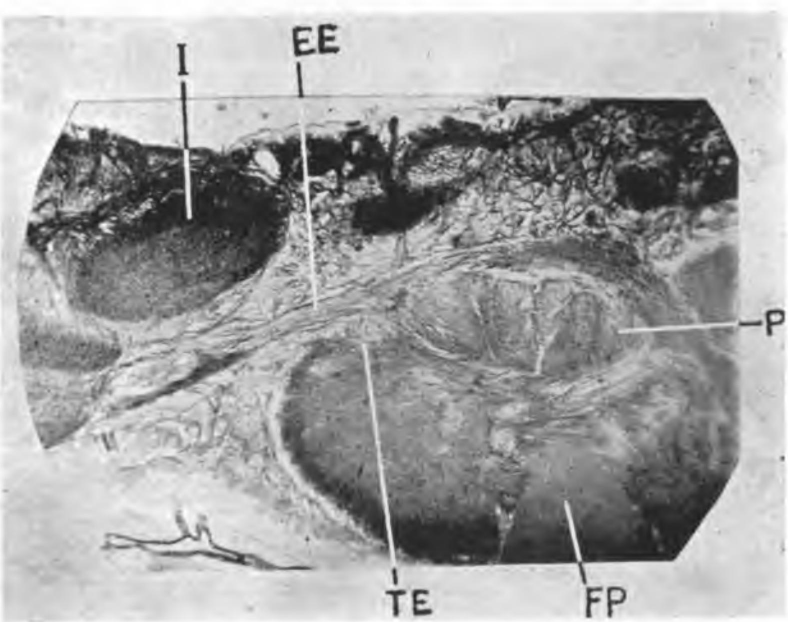

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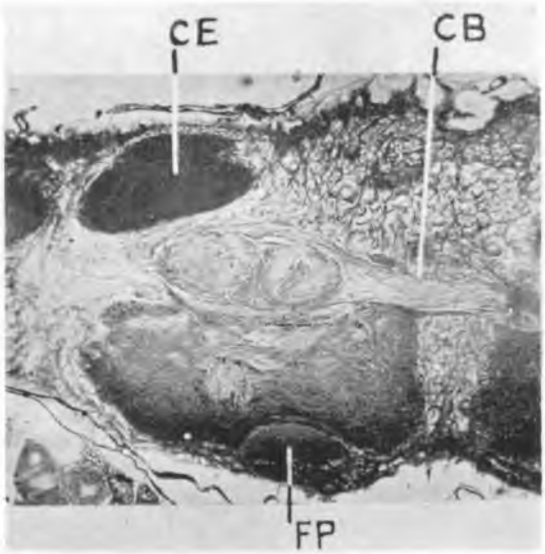

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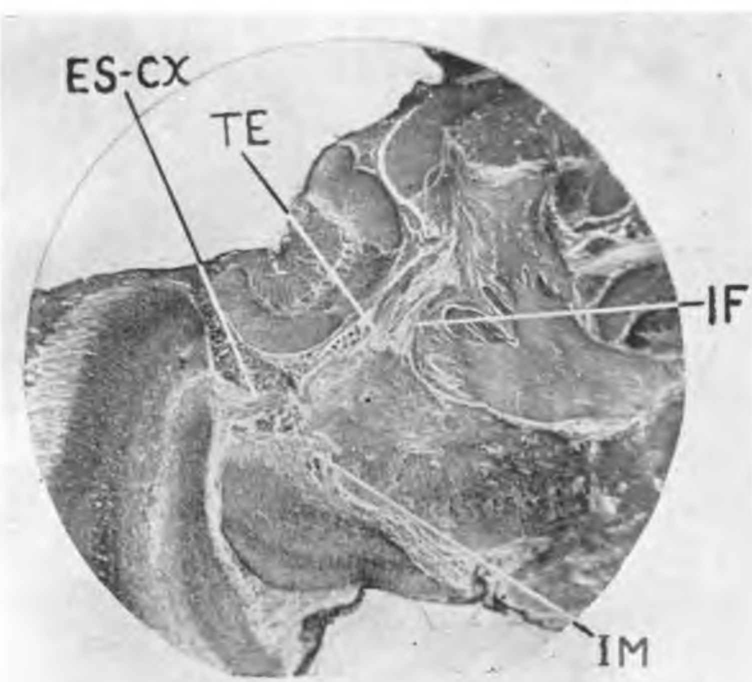
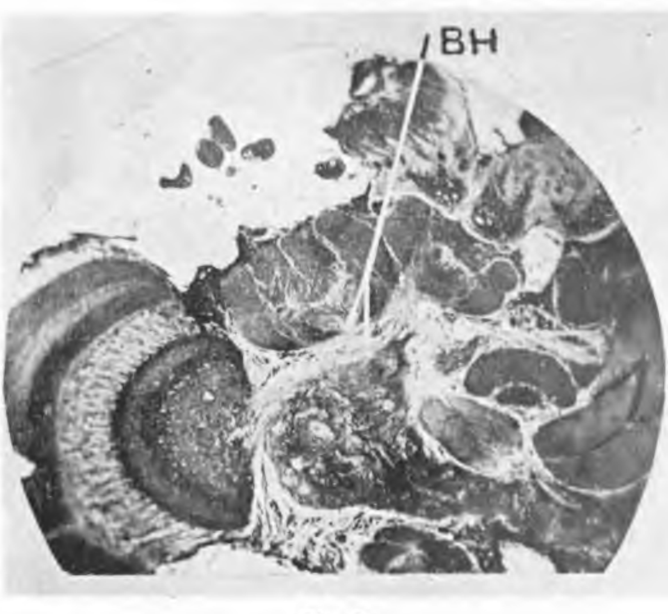


Fig. 18.

Fig. 19.



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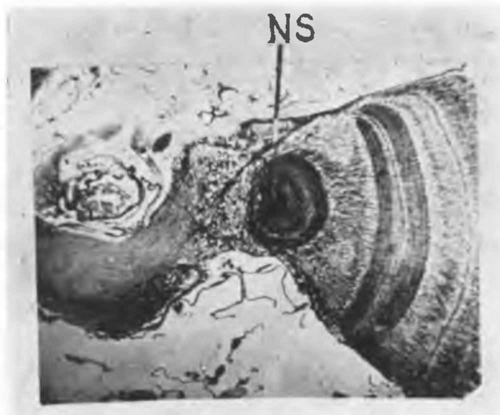

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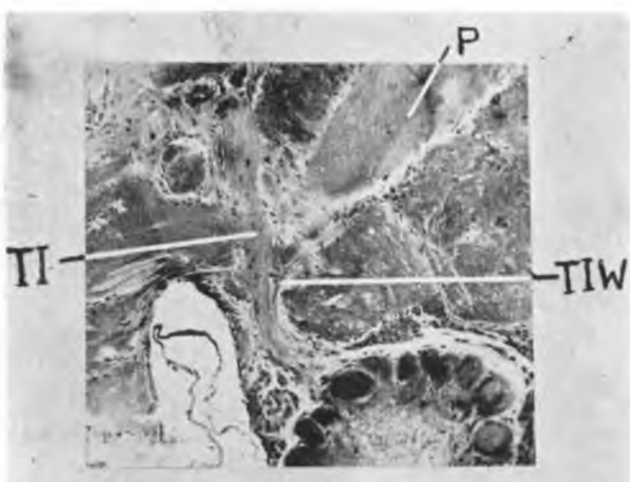

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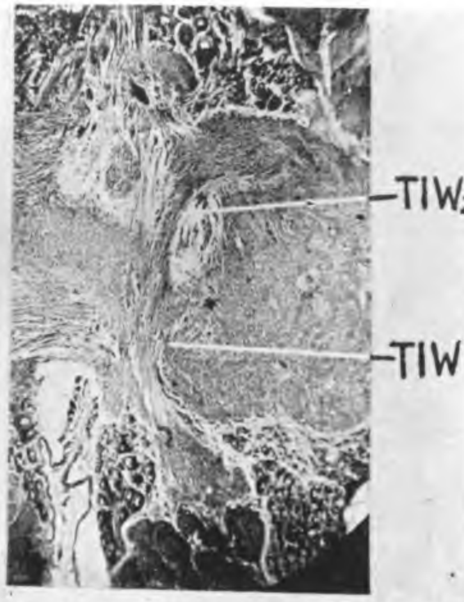

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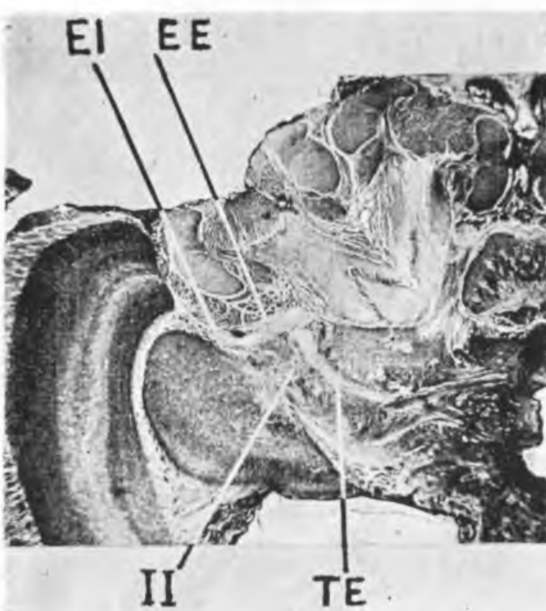

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Hieronim Jawłowski

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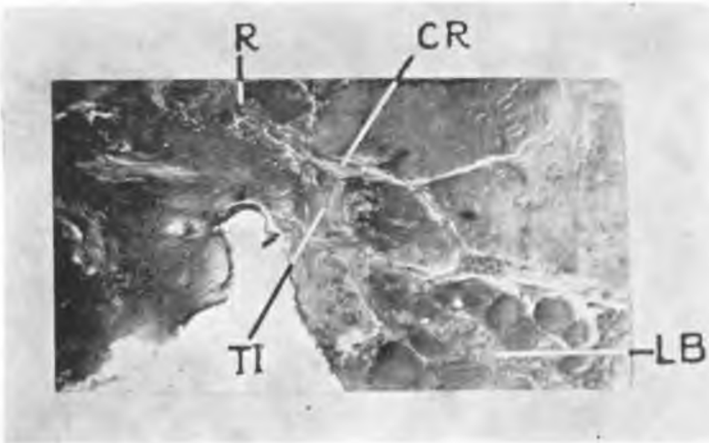

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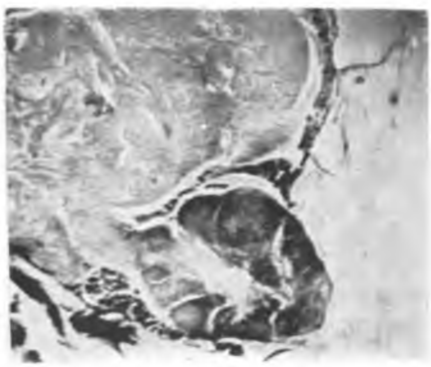

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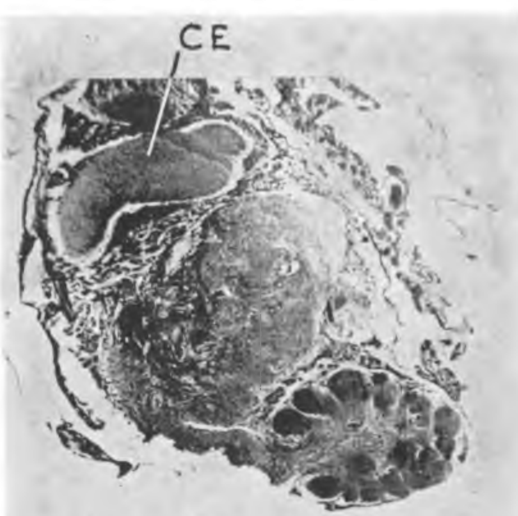

Fig. 27.

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