UNSOLVED PROBLEMS OF CAROTID BODY TISSUES

by

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It gives me great pleasure to accept an invitation to contribute an article to the special issue of *Acta Biologia Szegediensis*, to celebrate Professor AMBRUS ÁBRAHÁM's 70 th birthday.

Although well acquainted with Prof. ÁBRAHÁM's work, it was not until his recent visit to this country that I became thoroughly familiar with the outstanding quality — and quantity — of his work.

In an excellent and comprehensive lecture, given at this University, Prof. ÁBRAHÁM was able to guide the audience, of which many were by no means specialists in Prof. ÁBRAHÁM's field of the fine innervation, especially of the cardio-vascular system, to a fuller appreciation of this important field. His lecture gave many the rare and valuable pleasure of hearing a master in his subject summarising his life's work. He demonstrated in an endless number of excellent photographs that the finest nerve supply to the cardiovascular system is of astonishing complexity and intensity and it gave those working in the field of nerve staining a new stimulus of what can be achieved.

Prof. ÁBRAHÁM had also brought with him his own histological preparations of carotid body tissue and these I had the pleasure to study in great detail at my own leisure. They were by far the most beautiful preparations I had ever seen, with even the finest fibres standing out with unsurpassed crispness and clarity. And, as it so often happens, when stimulated by a perfect preparation frech thoughts on the subject come to mind, and with it a new zest for further research.

The carotid body is usually situated as a minute swelling at the bifurcation of the common carotid artery. This tissue has so far been found in all investigated mammals and birds (DE KOCK, 1959). In all cases, it is characterised by the presence of a sinusoidal vascular bed with an intensive nerve supply and the presence of typical cells (DE KOCK, 1954). Its function is generally believed to be chemosensory, testing, as it were, the quality of the circulating blood, especially regards its oxygen content, and sending informative impulses to the respiratory and vasoregulatory centres of the brain (HEYMANS & NEIL, 1958). The true nature of the typical cells is still under discussion, so are the details of innervation. Using the lightmicroscope it became apparent that the typical cells fell into two distinct types, the one a large, rounded cell, with interlocking cytoplasmic extensions towards other cells of its own type (type I cell, DE KOCK, 1954). The comparatively clear cytoplasm, of this cell carries a round, vesicular *nucleus* with one to two *nucleoli*, and marked cytoplasmic inclusions, such as conspicuous *mitochondria*, endoplasmic *reticuli*, excretory vesicles and osmiophilic granules. The other cell (type II cell) has irregular cytoplasmic outlines, whereby most of the cytoplasm sprawls between type I cells. The cell

is densely granular and carries on oblong nucleolated *nucleus* and *mitochondria.* Its cytoplasm ensheathes fine nerve fibres.

With the introduction of the electron microscope (E. M.) it was hoped to solve final questions of innervation, and especially the place of synaptic transmission between either type of cell and the nerve supply; a problem which has already been solved for the other known chemoreceptors of the tongue and nose, as well as for a number of invertebrate chemoreceptors (DE LORENZO, 1958; TRUJILLO-CENOZ, 1957; ENGSTÖM, 1953; SCHANZ, 1953; BLOOM, 1954, and DETHIER, 1955).

However, it appears that the carotid body tissue represents an especially complex problem aggravated by the fact that it is not like other chemoreceptors orientated towards one surface, but lies enmeshed in a twisted sinusoidal system.

So far, previous workers have been able to confirm the presence of two cell types, using the E. M. and the view was developed that type I cell represents the true *receptor* cell, although direct evidence of synapses were rather scanty. Type II cell, consequently was considered a sustenticular or supporting cell (TANGE, 1959; GARNER et al. 1958; ROSS, 1959).

These findings are at present under review by the author, using the light- and electron-microscopes.

Two approaches are open:

(i) That the structure and *stimulus* transmission of carotid body tissue falls in line with the basic structures and *stimulus* transmission of the other known chemoreceptive organs — which as will be shown below — are indeed all following the common principle of a *receptor* cell accompanied by a second type of cell.

(ii) That the chemoreceptive pathway in the carotid body may be based on entirely different principles and that its basic structure is not comparable to other chemoreceptors.

(i) In discussing the first argument the work of DE LORENZO comes to mind in which he describes the E.M. picture of the rabbit's tongue *papillae foliate:* „two cytological different cells, the gustatory *receptor* cell and the sustenticular cell, can be clearly distinguished" (DE LORENZO, 1958). In the same paper he gives a description of these two cells. It is interesting to note that his description of the *receptor* cell does in no way agree with the description of the carotid body's alleged *receptor* cell (type I), but would rather refer to type II cells, the alleged supporting or sustenticular cell. DE LORENZO continues: „They" (the *receptor* cells) „are characterised by a basally located, elongated *nuscleus* in which a *nucleolus* is usually present. The karyoplasm is uniformly dense, following OsO_4 and $KMNO_4$ fixation. This is to be contrasted with the large, round and less dense *nucleus* of the supporting cell" (DE LORENZO, 1958).

ENGSTRÖM, in a description of the olfactory cells also mentions two distinct cell types, whereby the olfactory cell is again, as in the tongue, the cell with the dense *nucleus,* surrounded by scanty cytoplasm which is divided into many distal processes (dendrites), while the supporting cell is bulky, with a large, vesiculated *nucleus* and a cytoplasm rich in intracellular inclusions (ENGSTRÖM, 1953).

Even insect chemosensory units appear to adhere to the two cell type arrangement, with the supporting cell represented by the bulky, highly active

cell. In the blowfly *labella* the chemoreceptive unit consists of a *receptor* or nerve cell with dense cytoplasm, small nucles and accompanying bulky trochogen and tormogen cells with large, vesicular *nuclei* and relatively clear cytoplasm (HOGSON, 1956).

If, thus these general rules of structure in other chemoreceptors are applied to those suggested for carotid body tissues, it becomes evident that the agreement is not very satisfactory. This is further aggravated by the fact that in all other chemoreceptors a cutting of their nerve supply causes a degeneration of the *receptor* cells. This is not the case in the carotid body, where the alleged *receptor* cells (type I) do not degenerate under these circumstances (MEIJLING, 1938).

There is thus a possibility that in the carotid body the type I cell, generally considered to be the *receptor* cell, is either entirely different in structure to other chemoreceptors and that, in this case a biochemically different mechanism may be at work, compared with the one of other *chemoreceptor* units, or that it is not the *receptor* cell or at least not a *chemoreceptor* cell in the usual sense. The same would apply to type II cell, the alleged supporting cell, which in the carotid body would lack all the earmarks of the other supporting cells, which are all highly active, obviously biochemically complementary cells to their *receptor* cells.

(ii) The second line of approach to the histology and cytology of the carotid body is to detect in its structure any evidence which may throw light on the existence of a non-typical mode of reception, when compared with the chemosensory units of taste and smell.

Such an approach may be necessary when the discrepancies, outlined above, are considered.

In search of any obvious differences between carotid body tissue and other chemoreceptors the mode of the nerve supply comes to mind. While the nerve fibres supplying the taste buds and the olfactory *epithelium* follow a more or less straight course, this is not so in the carotid body. As was so well demonstrated in the excellent preparations of human carotid body tissue by Prof. ÁBRAHÁM, the fibres, on entering the sinusoidal region, begin to spiral in ever-increasing coils, encircling groups of type I and type II cells. The E. M. pictures, taken so far by the author, confirm that even the finest fibres continue to spiral round single type I and II cells without obvious synaptic terminations.

It could also be observed that the type I cell is not only ensheathed by type II cells (Ross, 1959) (hence the presumption that it is the supporting cell), but that type I cell, in turn, sends pseudopodia-like extensions of its cytoplasm into the cell body of type II cell.

Further, in all cases so far seen, type I cell is separated from the nearest blood vessel by a thin cytoplasmic layer of type II cell, which would thus be is closer contact with the blood supply than type I cell.

The significance of these structural specialisations — none of which have so far been taken into consideration — are at present under detailed investigation. It is hoped that their results throw new light on the problems of chemoreception in the carotid body.

May I conclude this article with my sincerest thanks to Prof. ÁBRAHÁM for the stimulation I received from his work, and wish for many fruitful years to come.

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