HISTOLOGY AND HISTOPATHOLOGY OF THE NASAL MUCOSA

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THE HISTOLOGY OF THE OLFACTORY MUCOSA

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With the sense of smell we have to do with a peripheral receptive area made up of the olfactory mucosa with the specific olfactory cells, on the one side, and a central or cortical area made up of the olfactory bulb, on the other side. Here we will only deal with the structural details of the olfactory mucosa and of the olfactory nerves connecting both areas of the olfactory system.

The olfactory mucosa, situated in the narrowest parts of both nasal passages, the olfactory slits (1—2 mm wide), extends about the superior concha and the part of the nasal septum opposite to it. The olfactory area varies, according to several authors, from 2,5 to 5 cm^2. Macroscopically the olfactory mucosa is distinguished from the respiratory mucosa of the nasal passage by a yellowish colour resulting from the presence of a yellow pigment.

Histologically the olfactory mucosa can be characterised as an pseudostratified epithelium with a thick lamina propria containing the mixed seromucous glands of Bowman. In the epithelium the nuclei of the cells are arranged in three horizontal rows. The most superficial row is taken up by the nuclei of the supporting cells, the central row by those of the sensory cells, the bottommost row by the nuclei of the basal cells. The sensory cells are the specific elements of the epithelium. Their number in man is estimated at 2×10^7.

The olfactory cells.

This is a slender bipolar nerve cell, with a short peripheral or dendritic portion and a long, very thin central process or axon, which leaves the epithelium. The dendritic portion is the most interesting part from a structural and functional point of view. This part is rich in organelles. At its end it forms a more or less spherical protuberance, the olfactory vesicle or rod, from which olfactory hairs or cilia protrude at right angles to the surface. These hairs rise above the external limiting membrane of the epithelium and are lying in the mucus that covers the epithelium. The invidual authors vary very much in their estimates of the number (6—40) of these olfactory hairs on each olfactory vesicle. The structure of these olfactory hairs resembles that of cilia which are found elsewhere in the body (Bloom 1954, Fawcet and Porter, 1954). Characteristic of these cilia are their fibrils. Of these fibrils, each of which is made up to two filaments, nine are situated marginally and two centrally.

Unlike the marginal fibrils the central ones continue as far as into the olfactory vesicle, where they terminate in a small basal body. The basal bodies are mutually connected. Le Gros Clark (1956, 1957) is of the opinion that the cilia may take up various positions and that the position of these cilia may change under the influence of olfactory stimuli. From his light microscopic investigations on normal as well as on experimental material, this author also concluded that there are not only structural differences between the olfactory cells, but also differences in reaction on removal of the olfactory bulb, suggesting the existence of at least two categories of olfactory cells, those which disappear after removal of the bulb and those which persist after removal of the bulb. Thus far electron-microscopic investigations have not produced any arguments for the existence of structural differences between the specific olfactory cells. This is an interesting point, because in physiological studies there is talk of twenty or more different receptor-types (Stuiver, 1958). The possibility that differences in enzyme-contents play a part in the specificity is not out of the question, but enzymo-histological research, however, has not yet produced very much (Bourne and Baradi 1953/1959, Burkhardt and Ehrmantraut 1955).

The supporting cell.

The nuclei of supporting or sustentacular cells are lying more superficially than those of the olfactory cells. Their protoplasma is very rich in organelles, notably on the basal part. Of great importance is the relation of these supporting cells with the olfactory cells.

Van Scherpenberg (1958) is of the opinion that the olfactory cells lie enclosed between the walls of two adjacent supporting cells, which in cross-section have a more or less hexagonal shape. De Lorenzo (1957), on the other hand, is of the opinion that the supporting cells invest the olfactory cells much more intensively. The plasma-membrane of the supporting cell reflects around the olfactory cells in a fashion that in many respects is analogous to the mesaxon formed by a Schwann-cell around an unmyelinated axon (Gasser, 1958). From this may be concluded that the supporting cells are of greater functional significance than only to provide for mechanical support to the olfactory cells (Brettschneider, 1958). All authors who have studied the olfactory mucosa electronmicroscopically are agreed that the basal cells are ensheathing the axons that leave the epithelium.

The glands of Bowman.

There are tubulo-acinous glands with serous as well as mucous cells. The excretory duct is narrow and not separated by a basal membrane from the epithelium, through which it runs. An important functional role is ascribed to the excretion of these glands, since it functions as a solvent for the smell substances. These glands also form the yellow pigment mentioned above. The properties and the significance of this pigment, which is found in the glands of Bowman and in the excretion on the epithelium as well as in the olfactory epithelium itself, is still not clear. Jackson (1960) arrives chromatographically at the conclusion that the pigment is mainly formed by lecithine or the oxidation products of this phospholipid. Of significance is that this author makes a firm stand against the wide-spread view that there is a close relation

between the degree of pigmentation of the olfactory mucosa and the acuity to odors. There are differences in pigmentation, however not only between different species but also within one and the same species. Moreover, the degree of pigmentation proves to be very much dependent on the contact with the air and the attendant oxidation. According to this author the pigment is not primarily concerned with the process of olfaction. The pigment as an unsatiated fatty acid has, in his opinion, rather a bactericide or fungicide activity.

On the regeneration of the olfactory cells.

In most handbooks it is said that olfactory cells cannot be substituted and that for this reason the number of olfactory cells diminished with advancing years. Contrary to this, however, are the findings of Van Scherpenberg (1958), who, as far as we know, has been the only one who has studied experimentally the regeneration by means of electron-microscopy. In the regeneration of the olfactory mucosa the glands of Bowman play an important part. For it is from these glands that basal cells develop, which, according to this author, may differentiate not only into supporting cells but also into olfactory cells. This hypothesis, however, deserves further confirmation.

The olfactory nerves.

These are formed by aggregation of the axonal extensions of the olfactory cells in the submucosa. These axons are extremely small (average diameter: 0,2 μ, Gasser) and unmyelinated. Their velocity of conduction is the slowest ever come across with nerve fibres (Gasser 1958). From electron-microscopic investigations it has appeared that these axons are ensheated by Schwann-cells in rather complex mesaxons. In such a mesaxon several axons are lying very close to each other (mutual distance: 100—150 A, De Lorenzo), what might have some important functional implications. Grouped into larger fascicles the olfactory fibres pass through the lamina cribosa of the ethmoid to reach the olfactory bulb as the filia olfactoria. At its surface they form a dense network of fibers, the stratum fibrorum of the olfactory bulb. This bulb forms the primary cortical area of the sense of smell. We cannot go further here into the histological details of the olfactory bulb. For an extensive discussion of these details and of the connexions of the olfactory bulb with other parts of the brain, especially those referred to as the rhinencephalon and the limbic system, we may refer to Brodal (1947), Allison (1953), Pribam and Kruger (1954) and Gastaut and Lammers (1961).

L'HISTOLOGIE DE LA MUQUEUSE OLFACTIVE

A l'aide des données récentes, notamment des données de la microscopie électronique, les détails structuraux de la muqueuse olfactive et des nerfs olfactifs sont décrits. L'épithelium de la muqueuse contient des cellules sensorielles et des cellules de soutien superficielles et basales. Le prolongement périphérique ou dendritique forme au point de vue structual et fonctionnel la partie la plus intéressante de la cellule sensorielle. Il se termine dans une vésicule olfactive dont la paroi est parsemée de cils olfactifs. La

structure de ces cils est identique à celle des cils non sensoriels en d'autres endroits. Les cellules de soutien n'ont pas seulement un rôle statique, mais également très probablement un rôle dynamique. Elles enveloppent très intimement les cellules sensorielles comme une cellule de Schwann enveloppe une fibre nerveuse amyélinique. En dessous de l'épithelium les prolongements axonaux extrèmement minces se groupent en petits faisceaux, qui sont enveloppés dans un mesaxon commun et très complexe d'une cellule de Schwann. Groupés en faisceaux d'épaisseur variable, ils arrivent à la surface du bulbe olfactif, dont ils forment le stratum fibrosum. En relation avec l'épithelium l'on trouve les glandes séro-muqueuses de Bowman, qui secrètent également le pigment jaune caractéristique de la muqueuse olfactive. Le rôle de ce pigment dans la fonction olfactive est discuté ainsi que le rôle de ces glandes dans la régénération de la muqueuse olfactive, notamment des cellules sensorielles.

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