THE ANTERIOR NASAL GLANDS

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The nasal mucosa is divided into regions according to function and to type of epithelium. Each of these regions is provided with caracteristic glands. Thus in the olfactory region we find the Bowman glands, in the respiratory region serous and mucous glands as well as goblet cells and in the vestibule sebaceous glands.

Using a whole mount method combined with ordinary histological sections we have examined the topography of the glands of the respiratory region and have shown the existence of anterior nasal glands in rats and in some other mammals including man. Anterior nasal glands are previous described in rodents by Broman [1]).

The aim of the whole mount technique is to obtain a three-dimensional view of the topography of certain structures in a tissue block. This is accomplished by selective staining of the structures under investigation followed by a clearing procedure of the sample by which it is made transparent, though it be several millimeters thick. Viewed in a stereo microscope the stained structures will then stand out distinctly in the tissue block. The stain used in this work is osmium tetroxide, which stains nerves and epithelial elements.

The materal consisted of the nasal mucosa from 10 young and adult rats, 2 rabbits, 1 monkey and 10 adult human beings. Moreover, the vestibules and the internal ostia of a number of patients have been examined with a stereo microscope. For further details regarding technique and material see Bojsen-Møller [2] + [3]).

Results

A. Rat.

The serous acini of the rat septum are situated in the lamina propria of the middle part of the respiratory region and are provided with 4 or 5 long excretory ducts which all proceed anteriorly to open in the vestibule. The longest of these ducts forms a spiral-shaped (fig. 1 + 2) or an S-shaped coil before it proceeds forward. In the anterior third the ducts receive no tributaries, while in the posterior two-thirds they receive branches in right angles (monopodic branching). These branches arise in the acini which are situated as small clusters along the main excretory ducts. Posteriorly they are densely arranged, while more anteriorly they decrease in number as well as in size. Histological

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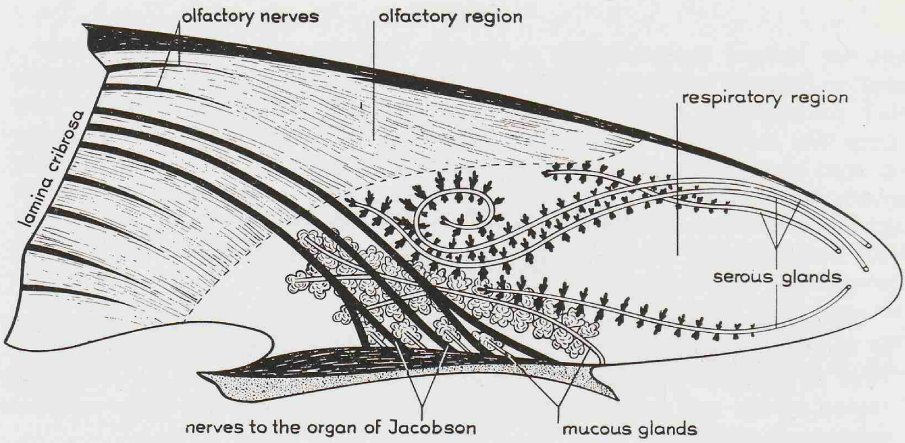

Fig. 1. Diagram of the right side of the rat nasal septum. The serous acini are provided with long excretory ducts which open in the vestibule of the nose. The mucous glands empty themselves into Jacobsons organ which is situated along the lower margin of the septum (the organ is not shown in the diagram).

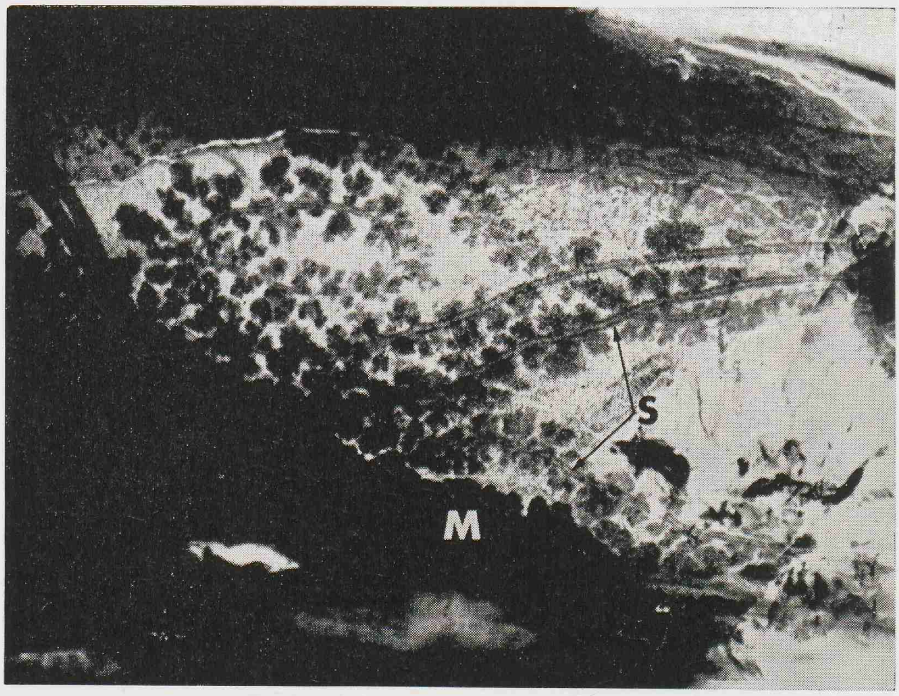

Fig. 2. Part of the rat nasal septum viewed from the right. Two-week old rat. Osmium tetroxide stained whole mount. S: serous glands, M: mucous glands in the respiratory region. Note the acini situated as clusters along the excretory ducts one of which forms a spiral-shaped coil. Compare with fig. 1. x 23.

sections showed that the glands in question are serous and that no mixed glands exist. The ducts measure 30—40 microns in diameter. The study did not reveal any acini opening directly on the surface in the respiratory region.

The serous acini of the lateral wall of the nasal cavity are situated both in the lamina propria of the middle meatus and around the maxillary sinus ostium. The former empty into 10—12 long ducts, coursing forward in the middle meatus to the vestibule. Shortly before reaching the vestibule, a number of the ducts curve, either cranially or caudally, until they reach the roots of the nasoturbinal and the maxilloturbinal respectively from which they continue to open on the sides or on the free edges of the turbinals (fig. 3). The remaining ducts open anteriorly in the meatus.

The acini situated around the maxillary sinus ostium are called the lateral nasal gland of Steno, as they were described by Steno, the Danish anatomist, in a sheep and a dog in 1662 [4]. The gland extends into the medial and anterior wall of the maxillary sinus and is drained by a single duct, which curves upwards and then forward in the middle meatus, opening at the nostril just anterior to the nasoturbinal (fig. 3). In the whole mounts this duct stands out darker and thicker than the others and is, consequently, easy to trace. In the sections it shows a pseudostratified epithelium with two rows of cuboidal cells unlike the other excretory ducts which predominantly have a simple epithelium. Its diameter is about 60 microns, those of the others 30-40 microns.

B. Rabbit.

A similar system of anterior nasal glands exists in the rabbit. Here we have found 20 septal and 30 lateral excretory ducts proceeding forward from acini

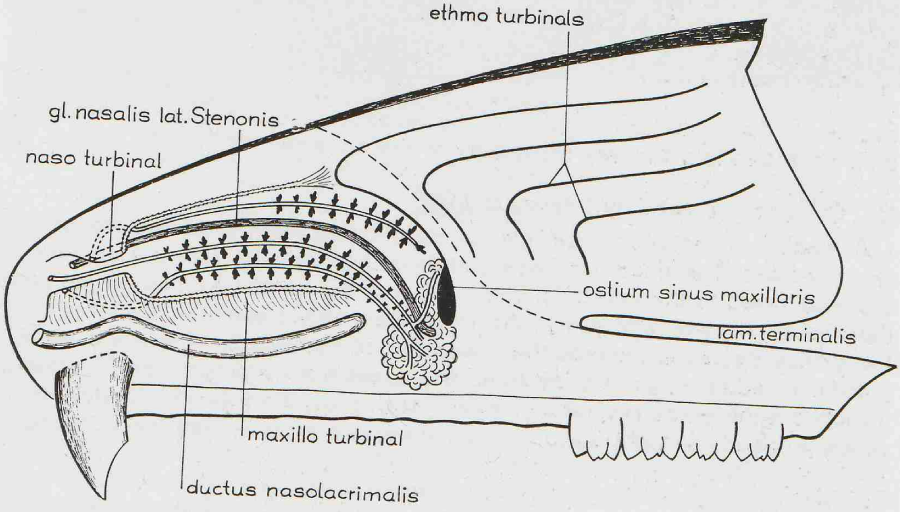

Fig. 3. Diagram showing the topography of the glands on the lateral wall of the nasal cavity in the rat. The posterior parts of the nasoturbinal and the maxilloturbinal have been removed so that the course of the glandular ducts in the middle meatus may be traced. Only a few of the ducts are demonstrated.

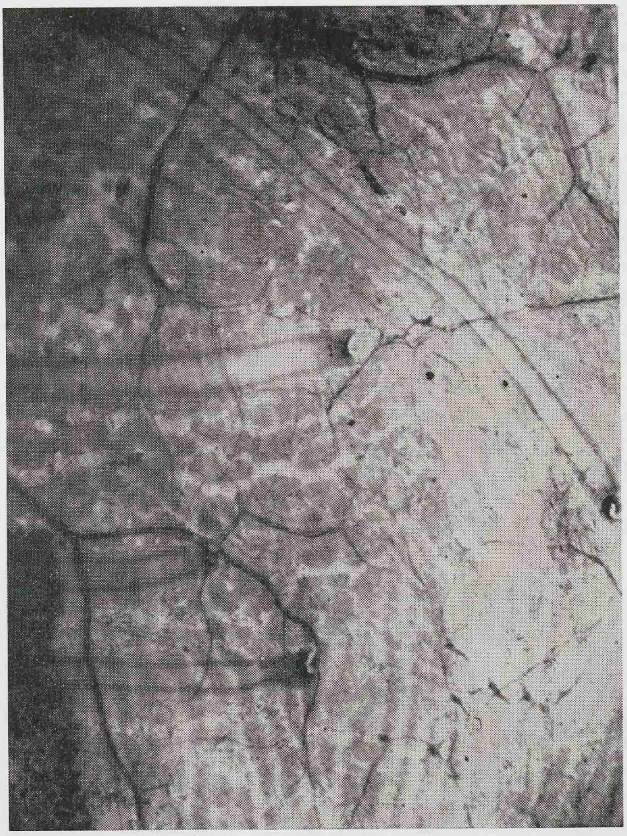

Fig. 4.
Vestibule in an adult rabbit; septum viewed from the right. Osmium tetroxide stained whole mount. 4 ducts and their openings are visible. x 45.

situated in the posterior two thirds of the respiratory region. They all discharge their secretion into the internal ostium of the nose (fig. 4).

C. Cynomolgus Monkey (macacus irus).

A number of anterior nasal glands is found in the septal mucosa of the monkey nose. The ducts of these glands course parallel with the dorsum of the nose down to the vestibule. The longest of the ducts take their origin near the olfactory region and run in the upper part of the septum. The lengths of the glands decrease towards the lower part of the septum. There are 15—20 glands. In addition, groups of acini, the nasal glands proper, are scattered throughout the entire respiratory region, each provided with an excretory duct which proceeds straight up to the surface where it penetrates the epithelium.

D. Man.

In man, as in the monkey, the glands of the lamina propria of the respiratory region can be divided into two groups; larger ones, which open into crypts in the region of the internal ostium i.e. anterior nasal glands, and smaller ones, which are scattered throughout the entire region. The former can be

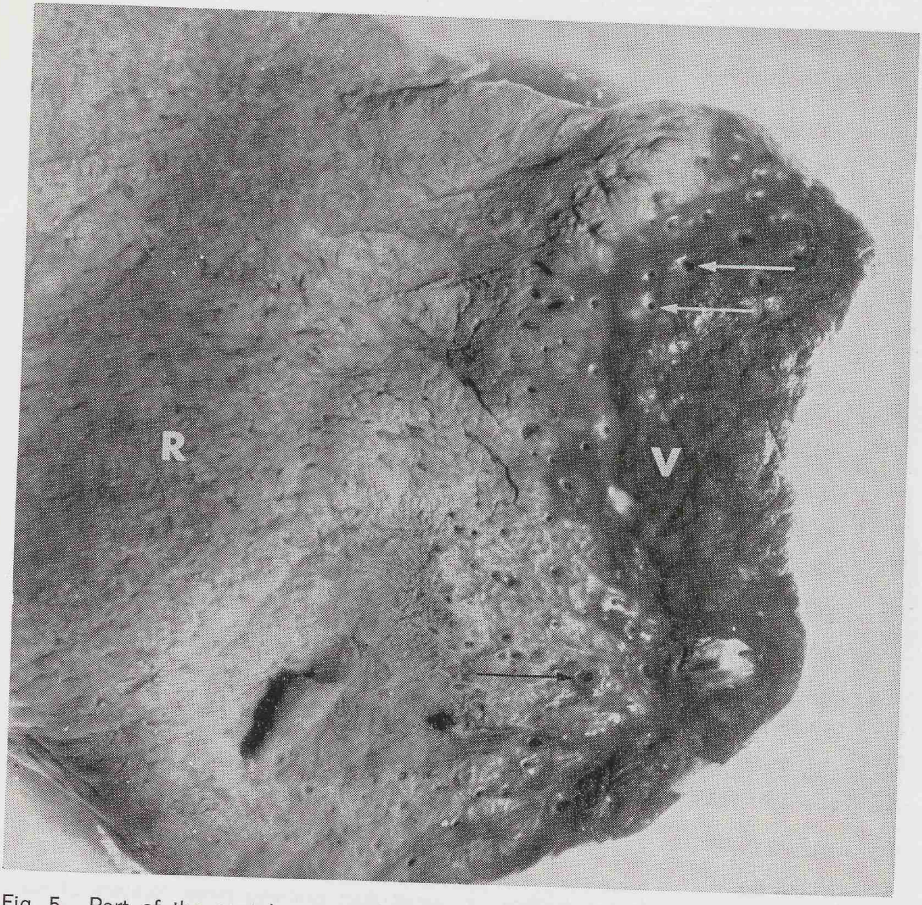

Fig. 5. Part of the septal mucosa from the right side of the nose. Adult man. Fixed and stained with osmium tetroxide. The vestibule (V) and the anterior part of the respiratory region (R) are shown. In the posterior part of the vestibule about 70 crypts are visible (arrows) each leading on to an excretory duct of the anterior nasal glands. x 6.

divided into a medial or septal group and a lateral group called glandulae nasales anteriores mediales et laterales respectively. As is evident from figure 5 50—80 crypts are found on the septum, most densely in the upper part of the internal ostium. On the lateral wall along the limen another 50—80 crypts are present. The crypts, some of which are surrounded by a slight elevation, measure from 100—400 microns in diameter. The whole mounts show that these crypts continue into excretory ducts which are running backwards from the internal ostium. The excretory ducts are 3—20 mm in length and are especially densely placed in the upper part of the septum where they run parallel with the dorsum nasi, whereas those in the lower part run parallel with the floor. The longest of the ducts drain the acini which are accumulated

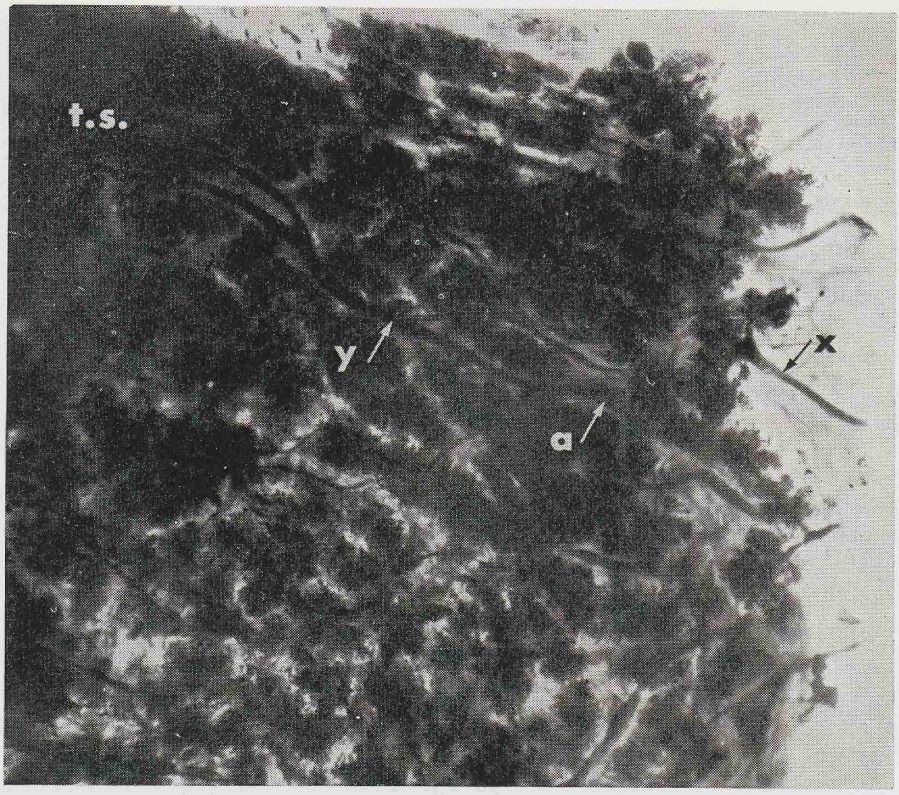

Fig. 6. Part of the septal mucosa from the right side of the nose. Adult man. Osmium tetroxide stained whole mount. y: large duct draining acini in the region of the tuberculum septi (t.s.). The duct is provided with an ampulla (a) just before it bends towards the surface. x: small duct draining three clusters of acini situated in the region of the internal ostium. In this cleared preparation the ducts of the anterior nasal glands are visible in the lamina propria surrounded by numerous acini. The ducts are larger and more numerous in the upper part of the nose. x 10.

in the tuberculum septi (fig. 6). The ducts are 150—400 microns in diameter and appear slightly sinuous in the deep part of the lamina propria. In the posterior part they have a few ramifications and the acini are here particularly numerous, whereas only a few acini are scattered along the course of the ducts. Some ducts have all their acini situated in the lamina propria of the internal ostium, consequently the ducts are shorter. Often the ducts are provided with an ampulla 0.8—1.5 mm in diameter before they bend towards the surface and empty themselves into the bottom of the crypts. On the limen nasi are seen similar ducts which are, however, only 3—10 mm in length. Thus many of their acini lie embedded in the firm connective tissue of the alae nasi, which tissue may be conceived to exert pressure on the acini when the nostrils are dilated on inspiration.

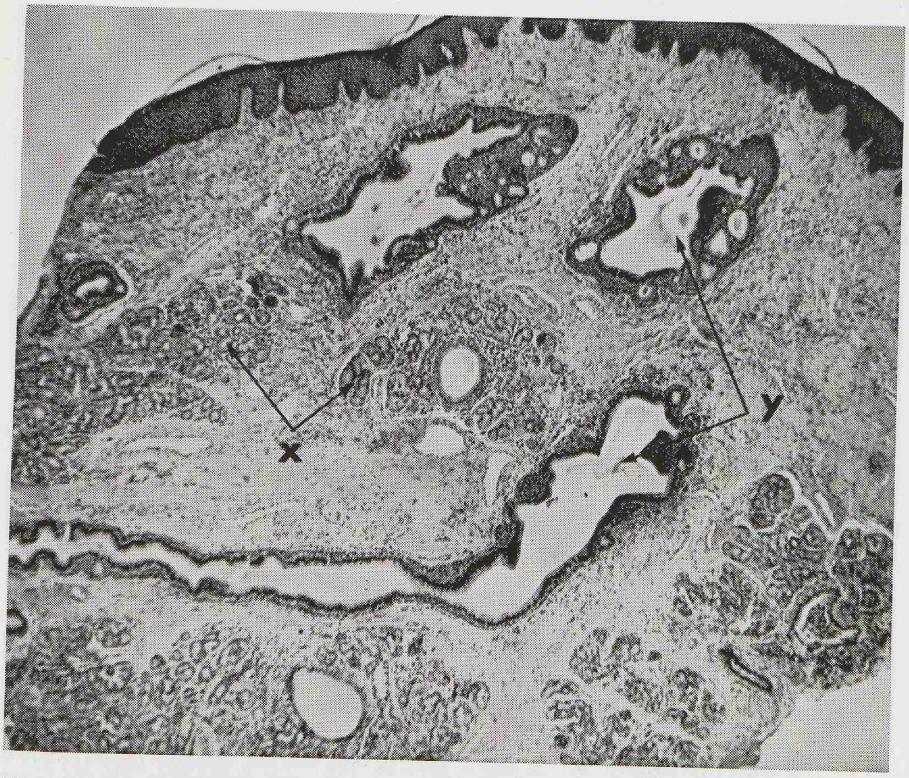

Fig. 7. Histological section from the vestibular part of the septal mucosa. Adult man. Stained with hematoxylineosin. y: duct from anterior nasal gland bending towards the surface. x: mixed glands in the region of the internal ostium. x 45.

Besides the anterior nasal glands smaller glands are scattered throughout the entire respiratory region. Their acini are placed in groups in the superficial part of the lamina propria and from each group a small excretory duct proceeds straight up to the surface where it penetrates the epithelium.

Histological sections of the vestibule and the anterior part of the respiratory region show that compound glands of the mixed type in which the PAS-positive acini predominate exists in the lamina propria. Excretory ducts of two sizes are discernible: 70—80 micron ducts draining the superficial acini and 200—400 micron ducts which drain the more deeply situated acini. The small ducts proceed more or less obliquely to the surface where they discharge their secretion into small pits. The larger ducts deep in the lamina propria are only seen to open in the region lined with stratified squamous epithelium (fig. 7). These ducts are lined with simple or pseudostratified columnar epithelium, but before reaching the opening they assume the nature of the surface epithelium, viz. stratified squamous epithelium.

By anterior rhinoscopy numerous duct openings are visible even to the naked eye in the region of the internal ostium, both on the septum (fig. 8) and

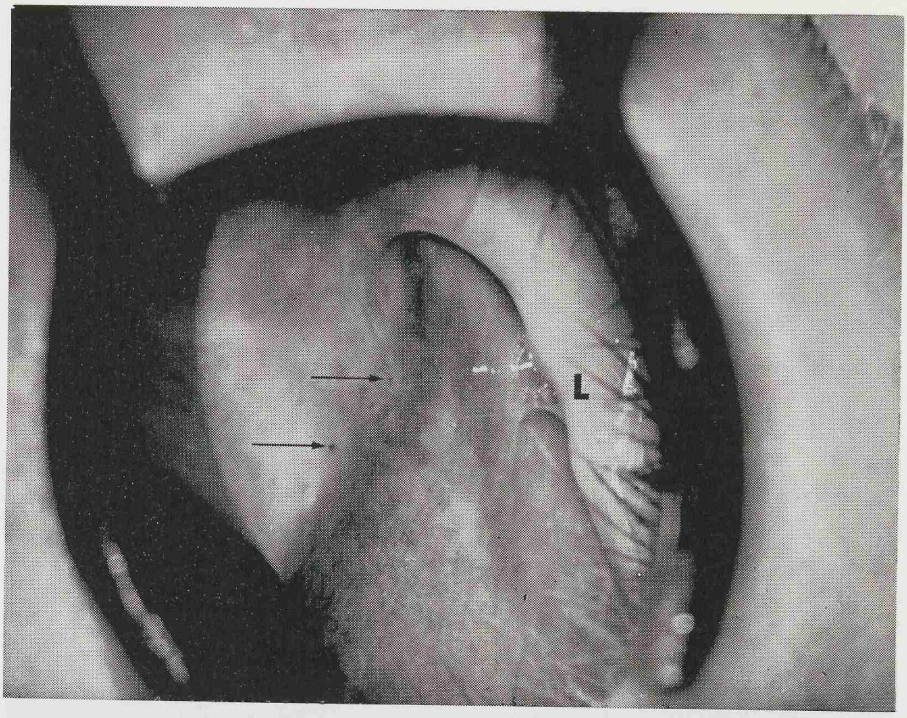

Fig. 8. Vestibule and internal ostium of the left side of a human nose as seen by anterior rhinoscopy. In the upper part of the internal ostium a small amount of fluid is distended between the limen nasi (L) and the septum. On the latter numerous duct openings of the anterior nasal glands are seen (arrows). x 6.

along the limen. Each duct opening is covered by a droplet of a clear serous fluid. After applying a mechanical stimulus to the vestibule one can observe the droplets increase in size initial to the sneezing reflex. Furthermore, in a few cases the droplets can be observed to increase during inspiration and decrease during expiration; this is probably caused by the changes of pressure. These phenomena are only seen, however, if the speculum be inserted in the vestibule which care. The internal ostium is rounded caudally, whereas rostrally or apically it tapers off to a point as the limen nasi converges towards the septum. This acute angle is filled with a small amount of a clear serous or slightly ropy secretion (fig. 8). During quiet breathing it is seen to fluctuate parallel to the tidal air. Previous to a forced inspiration or a sniff, the acute angle of the internal ostium is widened because of the function of the alar muscle, and the fluid is distended between the septum and the limen. During the forced inspiration the fluid is atomized and blown into the nasal chamber. Presently it is re-formed.

Discussion

It is remarkable that all mammals examined including man are provided with anterior nasal glands opening into the region of the internal ostium which

is the most constricted point of the nasal airway. This is particularly striking in rodents in which all the serous glands of the nose discharge their secretion here. This secretion cannot be removed by ciliary action either in rodents whose cilia in the anterior part of the nose beat towards the nares or in man who has no ciliary action in the anterior third of the nose. However, during an inspiration the stream of air is particularly accelerated at the internal ostium because of this constriction; moreover, the pressure over the duct openings is low. It is, therefore, tempting to speculate that the glandular discharge in the internal ostium during this phase of respiration is atomized and blown into the nasal chamber. Indeed, if a speculum is inserted into the human vestibule with care, it can be observed that during a forced inspiration or a sniff the small quantity of fluid which accumulates in the upper acute angle of the internal ostium and which probably originates from the anterior nasal glands, atomizes and disappears into the nasal cavity.

Negus [5]) points out that it must not be presumed that the resources of the nose are necessarily designed for the benefit of the lower respiratory passages; it may be nearer the truth to consider them as provided for purposes of olfaction, or for the facilitation of ciliary action.

If the droplets of the atomized secretion are more than 10 microns in diameter nearly 100 % will be retained in the upper respiratory passages (Hatch [6]) and thus spray the nasal mucosa. This could be of importance for the ciliary function by supplementing the transudation to maintain the viscosity of the mucous blanket. Since the internal ostium in man acts as a nozzle directing the inspired air almost vertically to the top of the chamber (Proetz [7]) it is possible that during a sniff the olfactory region too is sprayed with this glandular discharge. This would provide the liberal supply of water vapour which, according to Negus [5]), is essential if the olfactory sense is to be maintained at a high degree of efficiency, and it is also possible that the atomized fluid may entrap olfactory molecules and carry them to the olfactory region. Foreign particles and bacteria may also be entrapped and thus be dispersed over the nasal mucosa. Finally, the process of humidification is favoured by the greatly enlarged fluid surface induced by atomization.

Postscript.

As this lecture, in which attension is called to Steno's gland, was given in Leiden it might be of interest to note that Steno's original paper on the lateral nasal gland was called De narium vasis and appeared in his Observationes anatomicae [4]) as an appendix to De glandulis oculorum. They were dated Leyden in Holland 1661 on Dec. 6th and were dedicated to "the famous and outstanding men" Dr. Simon Paulli, Dr. Jørgen Ejlersen and Dr. Ole Borch professors at The Royal University of Copenhagen and the following professors of "the exellent University of Leyden in Holland" Dr. Frants De Le Boe Sylvius, Dr. Johannes van Horne and Dr. Jacob Golius, all of them "renowned professors and my highly estimated teachers who ought to be honoured for ever".

RÉSUMÉ

La topographie glandulaire de la zone respiratoire du nez a été examinée chez le rat, le lapin, le singe et l'homme. A cet effet on a employé en partie des sections histologiques en partie des pièces entières teintes par de l'osmiumtetroxyde. Ceci est combiné avec une rhinoscopie antérieure sur plusieurs personnes.

Dans la muqueuse nasale de beaucoup d'animaux, il y a une système de glandes séreuses dont les acini se trouvent dans la partie postérieure de la zone respiratoire aussi bien de la cloison que de la paroi externe. Les conduits d'excrétion de ces acini sont longs et se dirigent tous en avant pour déboucher dans le vestibule. On appelle ces glandes: glandulae nasales anteriores mediales et laterales. Chez le rat, nous avons trouvé 4 à 5 glandes médiales et 10 à 12 glandes latérales, et chez le lapin 20 glandes médiales et 30 glandes latérales.

Chez l'homme, il existe partout dans la zone respiratoire de la cloison des glandes mixtes dont les canaux excréteurs traversent la muquèse perpendiculairement ou obliquement à sa surface. Leurs conduits d'excrétion ont un diamètre de 70 à 80 microns. En plus il existe un système de glandes mixtes dont les acini sont plus profonds dans l'antérieur tiers de la zone respiratoire de la cloison. Les canaux excréteurs de ces acini glandulairs traversent la muqueuse nasale paralellement au dos du nez et débouchent dans 50 à 80 entonnoirs dans l'ostium internum. Les canaux ont une longueur de 3 à 20 millimètres et un diamètre de 200 à 400 microns. Sur la paroi externe, il existe un pareil nombre de glandes qui débouchent le long du limen nasi. Les conduits d'excrétion de ces glandes ont une longueur de 3 à 10 millimètres. Le lumen a un diamètre de 300 à 400 microns à l'embouchure et l'on peut le voir à vue simple.

La sécrétion de ces glandes nasales antérieures se présente donc dans l'ostium internum et remplit probablement une fonction pour l'humidification de l'air courant. Comme c'est ici le passage le plus étroit du nez on forme la hypothèse que la sécrétion séreuse se nébulise et se projette véritablement dans le fossé nasal pendant l'inspiration. En faisant ceci, elle ne participe non seulement à l'humidification de l'air mais elle sert aussi à l'odorat en dissolvant les molécules olfactives dans les petites gouttes et en les «douchant» sur la zone olfactive pendant une respiration forte. On peut également s'imaginer que la sécrétion nébulisée joue un certain rôle pour la purification de l'air en absorbant des particules de poussière et des microbes.

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