Innervation of Pharynx in Hedgehog.

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Only two studies have been reported hitherto on the innervation of the mucous membrane of the pharynx, the one by SATO (1952) on human pharynx published recently, and the other a former work by SABUSSOW (1913) on the pharynges of some mammals. The staining methods at the command of the latter, by methylene blue and the GOLGI's method, were both inadequate to assure dependable results.

I was recently given the opportunity to follow up the studies of the above pioneers in this field with hedgehogs as my subject. The materials were fixed for a long time in 10% neutral formol and cut into 40 µ transverse and sagittal frozen sections, which were stained with SETO's silver method. The large series of preparations thus obtained I subjected to minute microscopic examinations and arrived at the results described hereunder. In this report, I will give only my observations on the oral and the laryngeal parts of the pharynx and leave the study on the innervation of the palatum molle and the tonsilla palatina to the next report.

I. Individual Observations.

The epithelium of the laryngeal and oral parts of the hedgehog pharynx is in general composed of non-cornified stratified flat epithelium but at the vicinity of the orifices of the ducts of the pharyngeal glands lined with ciliated epithelium, the surface epithelium is also often ciliated. The pharyngeal stratified flat epithelium is tallest at the transitional parts to the radix linguae and the palatum molle, next on the lateral walls, where it decreases in height as the dorsal wall is approached and especially low on the dorsal wall just below the nasal part, seemingly due to the sudden transition of the thinner ciliated epithelium of the nasal part into the stratified flat epithelium of the pharynx. The ventral wall of the pharynx, especially the dorsal wall of the larynx and the special mucous folds described below have thick stratified flat epithelium.

The existence of taste-buds in the epithelium covering the pharynx of human embryos and new-borns has been reported by PONZO (1907), PATZELT (1904) and SCHUMACHER (1925), and has been beautifully
confirmed by the recent study of SATO (1952), who ascertained their existence also in human adult pharynx. In my specimens from adult hedgehogs I observed the existence of taste-buds in various parts of the pharyngeal epithelium, and that in not a small quantity, either solitarily or in groups of threes and fours. The location of these taste-buds was similar to those observed by SATO (1952) in human 10th month embryo, that is, in the ventral wall of the laryngeal part, especially at the dorsal wall of the larynx and its lateral walls, the lateral walls of the oral part, and also on the special mucous structure detailed below.

As also in the hedgehog pharynx the development of the papillae is in proportion to the height of the epithelium, the papillae are worst developed in the dorsal wall where the epithelium is lowest, while in the ventral wall of the oral part where the pharynx approaches the radix linguae, in the dorsal wall of the larynx and also in the special mucous fold mentioned below, they are in comparatively good development. As the development of sensory nerve fibres in its turn is dependent on the development of the papillae, it may be readily presumed that the mucous membrane in the hedgehog pharynx is generally rather poor in sensory innervation.

The tela submucosa in the pharynx is particularly ill-developed, being altogether absent in many places, where its place is taken by a longitudinal layer of elastic fibres. This layer is very strongly developed at the laryngeal part of the pharynx but becomes thinner in the upper levels, just as in adult human throats described by SATO (1952). In human pharynx, mixed glands are seen only in the ciliated epithelium at the nasal part, but in hedgehogs, they are found also in the oral part, especially in a large number in the dorsal wall in the upper oral part. But in hedgehogs also the majority of the glands in the mouth and the pharynx is represented by mucous glands, which are particularly well developed in the dorsal side of the larynx.

The lymphatic tissue is poor in the hedgehog pharynx, but it is somewhat better developed than in its radix linguae. In the pharynx, we find some lymph nodules, lymphocyte infiltrations and aggregations, though in sporadic existence. Only the ventral wall of the pharynx, especially, the dorsal wall of larynx is exceptional in that it contains comparatively numerous lymph nodules and lymphocyte aggregations.

The nerves supplying the walls of the pharynx originate in the plexus pharyngicus composed of all the pharyngeal rami from the n. vagus, the n. glossopharyngicus and the truncus sympatheticus cervicalis, of which the sensory and the motor as well as the parasympathetic nerves are derived from the n. vagus and the n. glossopharyngicus, and the sympathetic nerves from the cervical sympathetic trunk. The plexus
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pharyngicus is formed around the muscular layer of the pharynx, and minute branches run out of it into the submucosa or the propria through the intermuscular connective tissue, but the motor fibres among them spread out in the muscular layer. The nerve elements penetrating into the propria take part in forming the proprial plexus. This plexus is generally very ill-developed in the pars oralis and the pars laryngica of pharynx, except in the dorsal wall of the larynx and the special mucous fold mentioned below. The plexus is composed of thick medullated sensory fibres and thin unmedullated vegetative nerve fibres, but as the distribution and termination of the vegetative nerve fibres are quite similar in the pharynx as in the radix linguæ of this animal reported previously, I will avoid repeating the description in this report.

The sensory fibres supplying the pharynx of a hedgehog generally run into the propria of the mucous membrane and form terminations there, but the development of these elements is generally very poor in proportion to the poor development of mucous papillae as was the case in the radix linguæ, though in some parts, the development is rather remarkable. E.g., the ventral wall of the pharynx adjacent to the radix linguæ and the dorsal wall of the larynx are comparatively rich in sensory fibres, while the ventral wall of the pars laryngica is also rather well provided. Besides, well developed sensory elements are found also beneath the taste-buds found in various parts of the pharynx.

The sensory terminations, generally speaking, may be classified into the unbranched, the simple branched and the simple plexus-like terminations, but many interesting observations were besides obtained according to the locally very peculiar structures of the pharynx. In the oral part of the pharynx, the epithelium over the transitional part from the epiglottis to the radix linguæ and the palatum molle is thick and provided with comparatively well developed papillae, so that it is rich in sensory nerve fibres, which are generally rather thick and form their terminations in the papillae in most cases, but often they come to end in the propria outside the papillae and in the lymphatic tissue. The terminal formation is either unbranched or branched simply into a few rami. The terminal branches end mostly in sharp points (Fig. 1), sometimes, however, run glomerular courses and not rarely, several sensory fibres run together to end in a plexus-like arrangement.

In the dorsal and lateral walls of the pharynx abutting on the nasal part, ciliated epithelium is found sporadically in the stratified flat epithelium which is thin and poor in papillary formation. The broad propria is rich in mucous glands but the sensory fibres are few and thin, only a very small minority of them being represented by thick fibres. The terminations are either unbranched or simple branched ones,
but under the taste-buds found in this part, the sensory fibres are somewhat better developed, as mentioned below.

The ventral wall of the pars laryngica, that is the dorsal wall of the larynx, is very rich in sensory fibres, especially in its upper part, as is the case with the human throat. In this part, the development of the papillae is fully advanced and the epithelium is rich in taste-buds, so that the proprial plexus is also well developed and contains many sensory fibres, which run out in terminations of various forms. Beside the common unbranched and the simple and more complex branched terminations (Figs. 2 and 3), there are also found simple glomerular terminations here. Many of the terminations are formed in the papillae but not a few of them are found in the propria, as the glomerular termination formed in the connective tissue of the propria shown in Fig. 4. Lymphatic tissue is also well developed in this part and sensory fibres of various sizes are found running into the lymph nodules here (Fig. 3). SATO (1952) has reported on uncapsulated complex
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glomerular terminations and intraepithelial fibres in the dorsal wall of human larynx, but no such terminations were found in the hedgehog pharynx. Therefore, it may be said that the development of sensory terminations in this part in hedgehog stands somewhat in arrear in comparison with that in man.

In the dorsal wall of the pars laryngica in hedgehog, there is a very interesting appendage to the mucous membrane that has no parallel in man, dog nor cat. This is a discus-shaped mucous fold resembling the epiglottis attached to the median part of the dorsal wall on the level of the entrance of the laryngeal part and protruding bilaterally and cranially. This fold has an epithelium even thicker than that of the dorsal side of the larynx and proportionally well-developed papillae. Consequently, the development of sensory fibres here is also very remarkable. The epithelium and the papillae at the wall where this

Fig. 3. Proprial plexus and unbranched and simple branched sensory terminations seen directly beneath the epithelium of the dorsal wall of larynx of a hedgehog. 1 lymphocyte aggregation. Same staining. ×320, reduced to 1/2.

Fig. 4. A simple glomerular termination found in the propria of posterior wall of larynx of a hedgehog. Same staining. ×400, reduced to 4/5.
appendage is attached, are rather tall, so that the sensory fibres are here rather large in number, but as the distance grows laterally, the height of the epithelium and the papillae decreases and the sensory fibres grow naturally weaker.

This peculiar appendage is a mucous fold devoid of any muscle fibre and provided with papillae and taste-buds very much resembling the special gemmal papillae found in human soft palate by SAKAI (1944) (Fig. 5), and with a large quantity of sensory fibres as mentioned above, so I am led to believe that this peculiar attachment is a receptor organ of stimuli accompanying food ingestion, next in importance to the oral mucous membrane.

The numerous sensory fibres originating in the well-developed proprial plexus in this appendage and the part of the wall where it is attached are mostly stout and their terminal formation is represented by the unbranched and the simple branched terminations, and often also by the complex branched and the simple ansal or glomerular terminations. The taste-buds in the fold are provided with especially stout sensory fibres terminating after running a peculiar winding course. In the other parts of the dorsal wall of the larynx, however, where no such an appendage is found, the sensory fibres as well as the proprial plexus grow much less pronounced, especially, as the lower levels are reached.

It is of interest the taste-buds are much more numerous in a hedgehog than in man in the mucous membrane of the pharynx and are not less in number than those in the radix linguæ already reported and in the palatum molle of this animal as will be described in my next report. From this fact, it may be assumed that not only the special mucous fold described above but also the entire pharynx in itself is a receptor organ next to the oral cavity in sensitivity. The parts most well provided with taste-buds are the mucous epithelium opposing the lateral edges of
the epiglottis, the upper end of the special mucous appendage and the lateral sides of the pars oralis of pharynx.

According to SATO (1952), the taste-buds in human pharynx show that they are already in a degenerative stage and are very small in number, the sensory fibres supplying them being also very ill-developed. On the contrary, in a hedgehog, the taste-buds in this part are far from degeneration and the sensory fibres running to them are also in good development. These are composed of numerous
stout fibres, often assembled in plexus form beneath the taste-buds (Fig. 6), and ending in simple glomerular or ansal terminations after a peculiar meandering course (Figs. 6 and 7). In some cases these fibres penetrate into the taste-buds or the epithelium around them. Such intragemmal fibres almost always end without branching.

Thus it may be seen, from their structure and their sensory innervation, that the taste-buds in the mucous membrane of the pharynx of a hedgehog are nothing inferior to those in its oral cavity, clearly enjoying active physiological functions and are not degenerative remnants in any sense as those in the human pharynx.

II. Summary.

The epithelium of the oral and laryngeal parts of the pharynx in hedgehog is composed of stratified flat epithelium and its height is tallest at the transitional part to the radix linguæ and the palatum molle, growing lower as we pass over the lateral walls to the dorsal wall. Tall epithelium is also found on the dorsal side of the larynx and the undermentioned special mucous appendage. In the pharyngeal epithelium are found rather numerous taste-buds, especially in the ventral and the lateral walls of the laryngeal part and the lateral walls of the oral part as well as in the special mucous appendage.

The formation of papillae into the epithelium is generally in ratio with the height of the epithelium, and the development of the sensory nerve fibres is abreast with that of the papillae. It follows that the mucous membrane of the hedgehog pharynx is never rich in sensory innervation. The sensory terminations found here are in their majority either of unbranched or of simple branched and simple plexus-like ones, but in the parts showing special structures some interesting endings are observed.

As the transitional part of the epiglottis into the radix linguæ and the palatum molle is provided with well-developed epithelium and papillae, so the sensory fibres are also abundant here. These are stout fibres forming subepithelially, especially in the papillae and sometimes in the lymph tissue their terminations, among which are often found simple glomerular or plexus-like terminations. In the dorsal and lateral walls of the oral part abutting on the nasal part, however, the papillae as well as the epithelium are weak in development, so that the sensory fibres are small in number and their terminations are also limited to unbranched or simple branched endings of thin fibres.

In the dorsal side of the larynx, especially at its upper levels, in parallel with the good development of the papillae and the taste-buds
sensory fibres are abundant and their terminations include also many complex branched, and simple glomerular endings, though no intraepithelial fibres are detected.

On the dorsal wall of the laryngeal part is found a mucous appendage peculiar to this animal, consisting of a discus-like mucous fold attached to the median line of the dorsal wall at the level of the entrance of the pars laryngica. Its epithelium and papillae are extremely well-developed containing taste-buds here and there. Consequently, the sensory fibres therein are also very remarkable. It is thought that this appendage constitutes one of the receptor organs active at food ingestion. The sensory fibres are stout and frequently end in complex branched, ansal or glomerular terminations.

The taste-buds found in various parts of the mucous membrane of the hedgehog pharynx are large in number and show no degenerative status as those in human pharynx. The sensory fibres in connection with them are always stout and powerful, ending in simple glomerular or ansal terminations beneath the taste-buds which further, not rarely, pass over into intra- or extragemmal fibres. Thus, these taste-buds seem to be on equal footing with those in the oral cavity, showing that they are active organs enjoying full physiological functions.
する知覚線維の発達も甚だ顕著。そこで本器官は食物摂取に関する1感受器官であろうと想像される。知覚線維は太い線維から成り、尾々複雑な分歧終末、係秘状終末及び糸状状終末に移行する。

咽頭粘膜に発見される多数の味蕾は何等退化状態を示さず、之に対する知覚線維の発達も良好、味蕾基底部に単純性糸状終末及び係秘終末を見、又尾々管内及び管外線維の存在も認められる。斯くして之等味蕾も活動的生理作用を営むものと思考される。

References.