

A CONTRIBUTION TO THE KNOWLEDGE OF THE DEVELOPMENT OF THE SUBMAXILLARY AND SUBLINGUAL SALIVARY GLANDS IN HUMAN EMBRYOS

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Although the stomatologist is well aware of the importance of the salivary glands, both in regard to their physiological function and to the influence of their secretion on the condition of the teeth, he has given little or no attention to the development of these organs. Of the anatomists, very few have made a detached study of this subject and the number of human embryos which have been studied for this purpose is too limited to comprise the basis for a comprehensive knowledge.

Chievitz of Copenhagen published, in 1885, an admirable work, "Beiträge zur Entwicklungsgeschichte der Speicheldrüsen," upon which most of our present knowledge is based. He describes detailed observations on embryos of six, eight, ten and twelve weeks, and some findings in two older specimens. Bujard of Geneva published, in 1911, an article, "Reconstructions plastiques des glandes salivaires d'un fœtus humain de 10 semaines environ." His excellent observations are all based upon a 35 mm. embryo (tête siége). The fourth volume of "Studies in Cancer and Allied Subjects," issued by Columbia University, contains the result of a careful study, by Schulte, of the human salivary glands of three embryos. The embryos are nos. 229, 325 and 3 of the Columbia collection and measure 7.5 mm., 20 mm. and 22 mm., respectively. Besides these there are a few short remarks of importance found in articles by His, 1885 (embryos 12.5, 13.8 and 18.5 mm. in length), Hammar, 1901, Stöhr, 1905, and Paulet, 1911 (embryo, 14.7 mm. in length).

CONSIDERATION OF THE GROSS ANATOMY

Most anatomists have given but a very inaccurate description of the submaxillary and sublingual salivary glands. The former is usually said to be a body of irregular form with a duct leading to the caruncula sublingualis; the latter, a much smaller gland separated from the submaxillary by the mylohyoid muscle, with from 8 to 20 excretory ducts of which one may be of larger size opening near the submaxillary duct in the sublingual papilla. Carmalt has given us, in the fourth volume of "Studies in Cancer and Allied Subjects," the result of his careful dissection of injected specimens, which show that the submaxillary gland is quite frequently of complicated structure, while the so-called sublingual gland is in fact made up of one large sublingual gland, which is not constant, and a number of smaller ones. This fact had already been observed by Chievitz, who calls the latter glandulae alveololinguales. Carmalt gives a great many beautiful reproductions of prepared human specimens illustrating the following facts.

The *submaxillary gland* varies in form not only in different individuals but also in the two sides of the same person. It consists of a main gland which is placed dorsocaudal to the free border of the mylohyoid muscle, around which the duct turns to reach the floor of the mouth. It is usually divided into three or four large lobes by incisures which penetrate to the hilus. Frequently there are one or more smaller glands varying greatly in position and arrangement. They are, for the most part, placed above the mylohyoid muscle, draining from the dorsal as well as the ventral side into the main submaxillary duct. These are called accessory glands. Occasionally a ventral gland is developed more independently and placed more anteriorly, so that it comes in close relation to the sublingual glands. Its duct, which opens into the main duct further forward, also has a characteristic appearance, being longer than the ducts of the ordinary accessory glands. To such a gland, Carmalt gives the name of secondary gland. A ventral accessory submaxillary gland was also found by Bujard in his 35 mm. embryo.

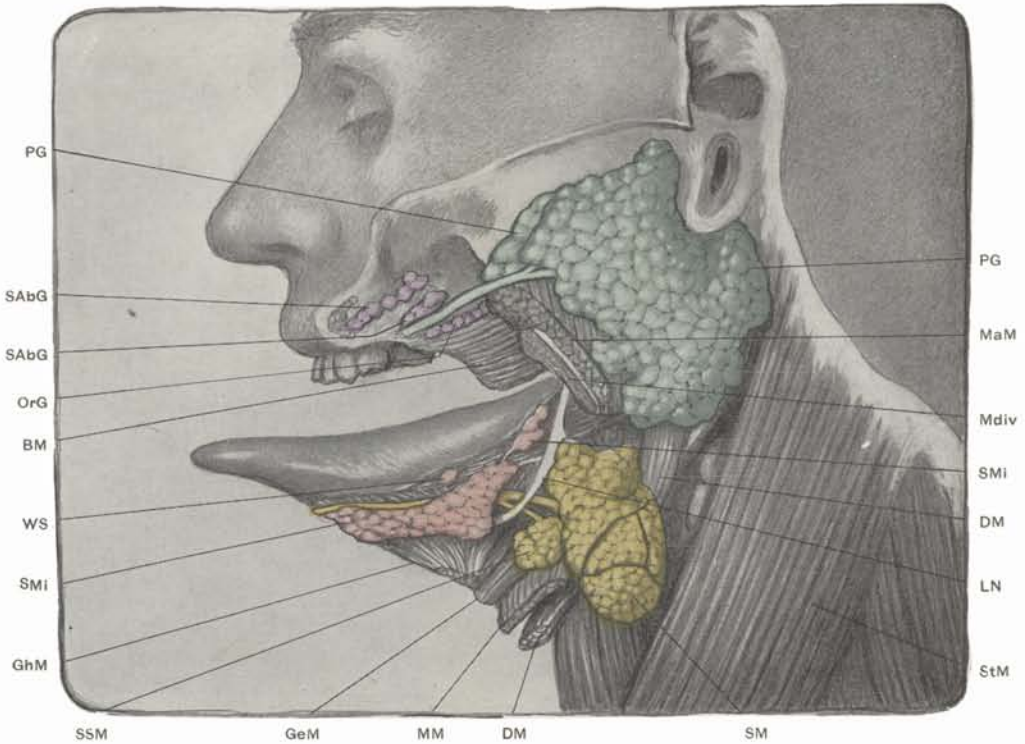


FIG. 1. DEEP DISSECTION OF ADULT HUMAN SALIVARY GLANDS OF THE LEFT SIDE, COLUMBIA UNIVERSITY MORPHOLOGICAL MUSEUM, No. 2305 (CARMALT)

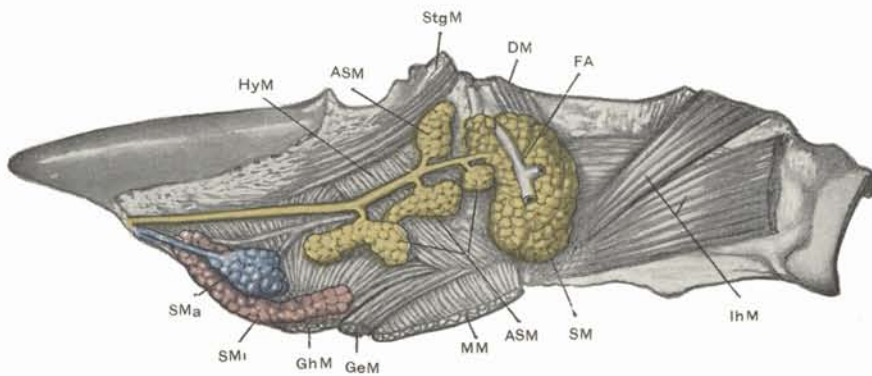


FIG. 2. DEEP DISSECTION OF ADULT HUMAN SALIVARY GLANDS OF THE LEFT SIDE, COLUMBIA UNIVERSITY MORPHOLOGICAL MUSEUM, No. 1980 (CARMALT)

The *larger sublingual (Bartholinian) gland* (sublingualis major) is not constantly found in man. It sometimes develops on one side and is absent on the other. If present it is usually situated medially to the lesser sublingual glands. Its duct extends forward and upward toward the floor of the mouth directed toward the median line, where it either joins the terminal part of the submaxillary duct or opens independently on the parafrenular papilla.

The *lesser sublingual (Rivinian) glands* (sublinguales minores) are a group of smaller glands, each provided with a small duct opening on the plica sublingualis (ducts of Rivini). If the larger sublingual gland is present, these lesser glands become reduced in size and extent, while on the other hand they develop to much greater size if the sublingualis major is absent.

For better orientation let us briefly review the location and nomenclature of the various sulci of the floor of the mouth (*figs. 3 and 4*).

An explanation of "leaders for all illustrations" is summarized on page 143.

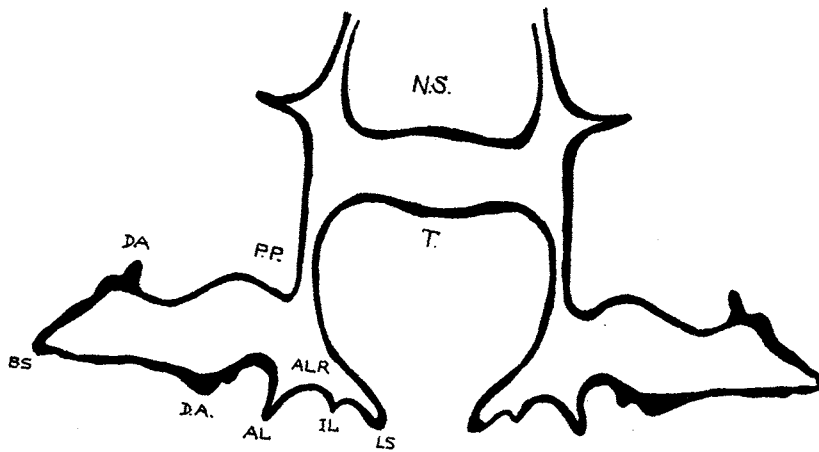


FIG. 3. CAMERA LUCIDA OUTLINE OF THE ORAL EPITHELIUM OF A 20 MM. EMBRYO IN FRONTAL SECTION (SCHULTE)

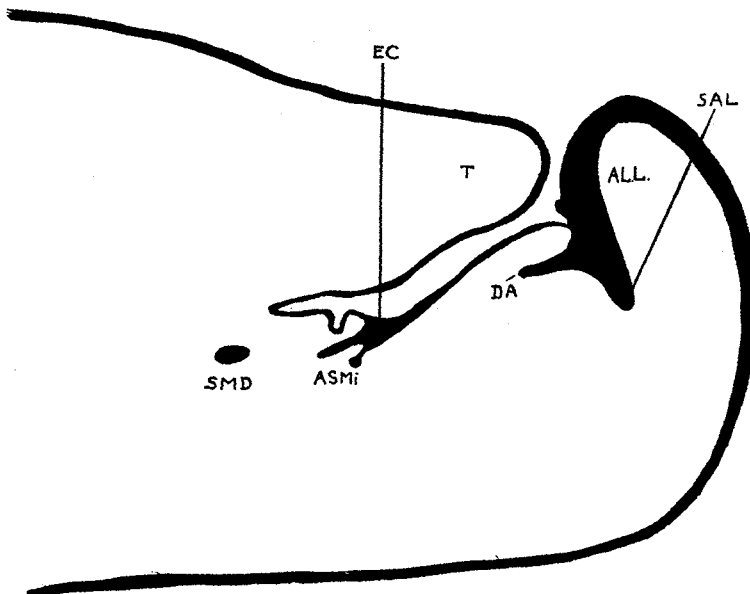


FIG. 4. CAMERA LUCIDA OUTLINE OF THE ORAL EPITHELIUM OF A 31 MM. EMBRYO IN SAGITTAL SECTION

TABLE 1
Data on embryos examined by the author

SIZE	PROBABLE AGE. (KEIBEL & MALL)	EMBRYO-SERIES NUMBER	SECTIONS ILLU- STRATED—NUM- BER	DIRECTION OF SECTIONS THROUGH HEAD	STAINING METHOD	REMARKS
<i>mm.</i>	<i>days</i>					
10.0	40	1000	251	Transverse frontal	Borax, carmine and Lyons blue	Harvard Embry- logical Collec- tion
10.2	40	736	125	Sagittal	Borax, carmine and Lyons blue	
11.0	42	2036	None	Transverse frontal		
11.5	43	189	None	Transverse frontal		
11.7	43	1605	None	Transverse frontal		
12.0	44	816	259	Transverse frontal	Borax, carmine and Lyons blue	
13.6	45	839	265	Transverse frontal	Borax, carmine and Lyons blue	
18.1	50	1129	227	Sagittal	Borax, carmine and eosin	
20.0	52	2037	339	Sagittal	Cochineal and Orange G.	
22.0	54	851	248	Sagittal	Borax, carmine and Lyons blue	
			279			Specially pre- pared sections through head
			289			
			295			
28.8	59	1598	276	Sagittal	Borax, carmine and Orange G.	
			233			
31.0	61	1706	332	Sagittal	Cochineal and Orange G.	
			341			
			343			
			362			
32.0	63	290	None	Sagittal		
47.0	73	4	46	Sagittal	Hematoxylin and eosin	
			62			
			73			
			80			
			83			
			93			
			98			
			102			
			154			
			163			
			249			
			278			

TABLE 1—*Continued*

SIZE		PROBABLE AGE. (KEIBEL & MALL)	EMBRYO—SERIES NUMBER	SECTIONS ILLU- STRATED—NUM- BER	DIRECTION OF SECTIONS THROUGH HEAD	STAINING METHOD	REMARKS
<i>mm.</i>	<i>days</i>						
52.0	76		2	172	Transverse frontal	Hematoxylin and eosin	Specially pre- pared sections through head
				20			
62.0	90?		5	32	Sagittal	Hematoxylin and eosin	
				39			
				46			
				82			
				157			
230.0	182		6	52	Sagittal	Hematoxylin and eosin	Only anterior part of mouth
				58			
				79			

THE WRITER'S OBSERVATIONS

The various authors who have studied the development of the salivary glands, in human embryos, used for the purpose frontal sections through the head. In the opinion of the writer serial sections in the sagittal plane should prove of greater advantage. They give a clearer idea of the direction of the developing glands, their ramification and relation to adjoining structures of the mouth. I was fortunate enough to have at my disposal a large number of specimens (serial sections), from the Harvard Embryological Collection cut in the sagittal plane, but I had to prepare specially the heads of a few embryos in more advanced stages. The further purpose of my study was to furnish more complete data concerning the time of development of the anlagen of the submaxillary, sublingual minor and major, the anterior lingual and the labial glands. I gave special attention to the place from which the development of the anterior lingual gland starts, as Schulte found in *embryo* 325 of the Columbia collection a sprout mesad from the submaxillary anlage, which he thinks may form the anterior or apical gland of the tongue (Nuhn-Blandin). The time, location and frequency of the development of accessory and secondary lobes of the submaxillary gland promised another interesting study, to which sagittal sections are specially well adapted.

A great deal more time than was at my disposal could be spent in observing the changes in the epithelial growth and the reaction produced in the surrounding mesenchyma.

DESCRIPTION OF THE DEVELOPMENT OF THE SALIVARY GLANDS IN THE
EMBRYOS EXAMINED

Embryo 1000 of the Harvard collection—length, 10 mm.

Parotid gland. In section 251 the epithelium shows a thickening, almost forming a semi-circle around the buccal sulcus. This is the anlage of the parotid gland. No other gland is seen in this specimen. (See fig. 5).

Embryo 736 of the Harvard collection—length, 10.2 mm.

Submaxillary gland. Section 125 shows a sagittal view of an embryo in which the lips have not yet become separated from the structures within the mouth. The tongue is distinctly visible. Anterior to the tongue we find an epithelial thickening, a band of considerable length. It is my opinion that from this the anlage of the submaxillary gland is developed. No other organs of the mouth have yet developed.

*Embryos 2036, 189 and 1605 of the Harvard collection—length, 11
11.5 and 11.7 mm., respectively*

Submaxillary gland. The transverse frontal sections of these three embryos all show the anlagen of the parotid gland, but none of the submaxillary or sublingual glands.

Embryo 816 of the Harvard collection—length, 12 mm.

Submaxillary gland. In frontal section 259 we see the anlagen of the submaxillary glands. They start from the lingual sulcus of the oral epithelium just above the place where the lingual nerve, infiltrated by the ganglion, crosses and enters the substance of the tongue.

Embryo 839 of the Harvard collection—length, 13.6 mm.

Submaxillary gland. Transverse section 265 shows the submaxillary anlage posterior to the lingual nerve, which crosses the lingual

sulcus in *section 272*. The epithelial sprout is further developed than in *embryo 816*. It is dumb-bell shaped and a distinct change in the mesenchyma is visible. The connective tissue cells have become condensed, forming a capsule which surrounds the epithelial sprout. This is shown in the high-power photomicrograph of this section. (See *fig. 9*).

Embryo 1129 of the Harvard collection—length, 18.1 mm.

Submaxillary gland. No. 227 of the serial sagittal sections shows that even at this stage the alveolar part has not yet become separated from the lip, although in *section 120* we find the labial lamina well formed. *Section 127* shows the anlage of the submaxillary gland extending backward from the anterior margin of the tongue. The oral epithelium shows a marked thickening anterior to this part, which is identical with the band seen in *embryo 1000*. Ventral to the epithelial sprout is the submaxillary ganglion.

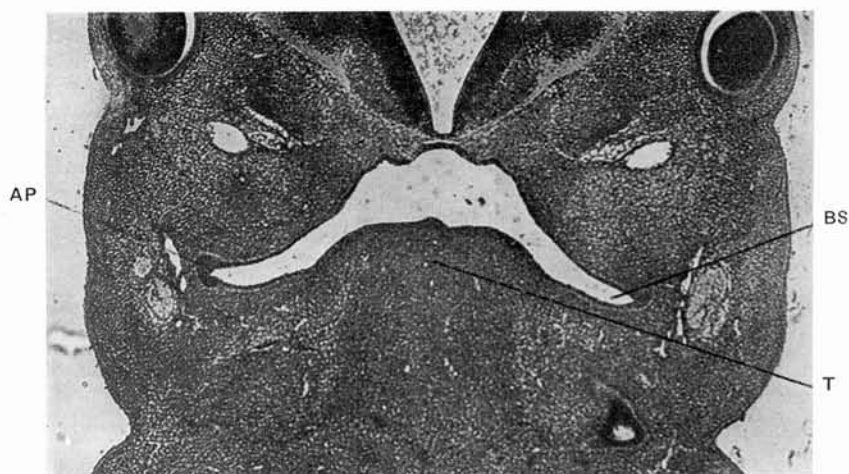


FIG. 5. EMBRYO 1000, H. E. C., LENGTH 10 MM., SECTION 251

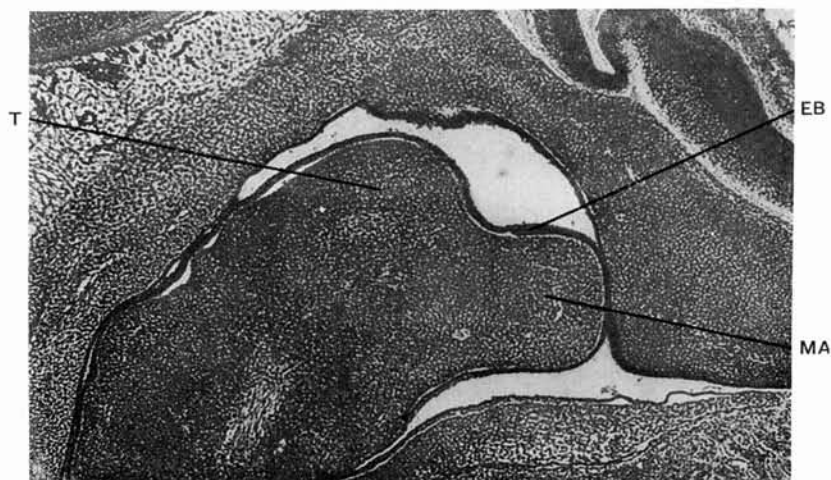


FIG. 6. EMBRYO 736, H. E. C., LENGTH 10.2 MM., SECTION 125

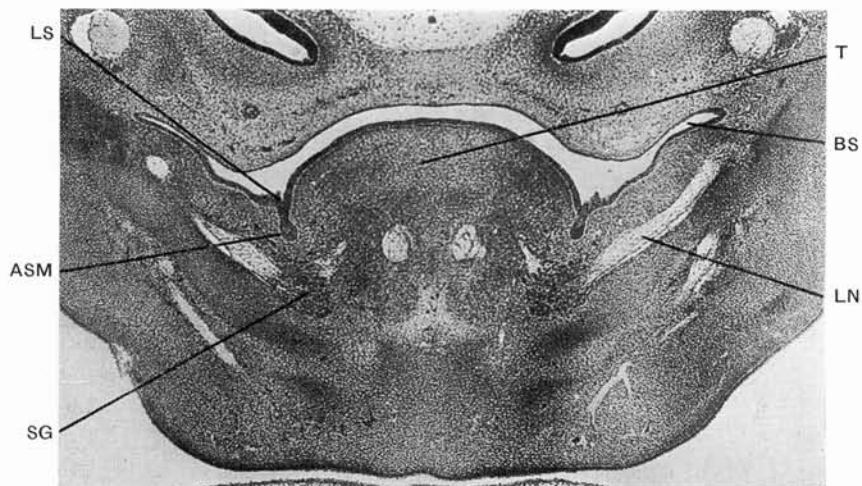


FIG. 7. EMBRYO 816, H. E. C., LENGTH 12 MM., SECTION 259



FIG. 8. EMBRYO 839, H. E. C., LENGTH 13.6 MM., SECTION 265

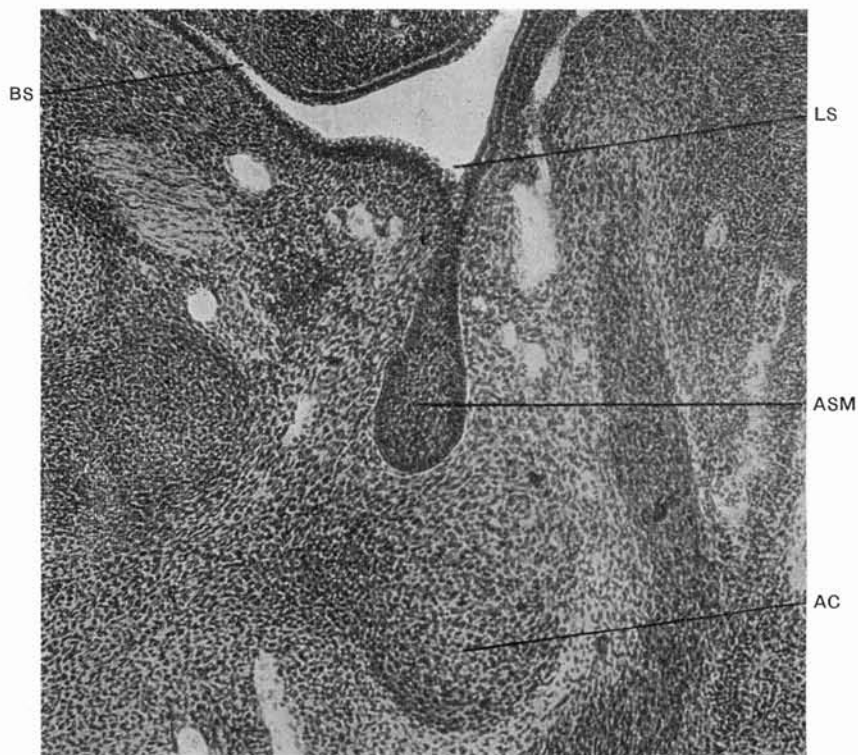


FIG. 9. EMBRYO 839, H. E. C., LENGTH 13.6 MM., SECTION 269 (HIGH POWER)

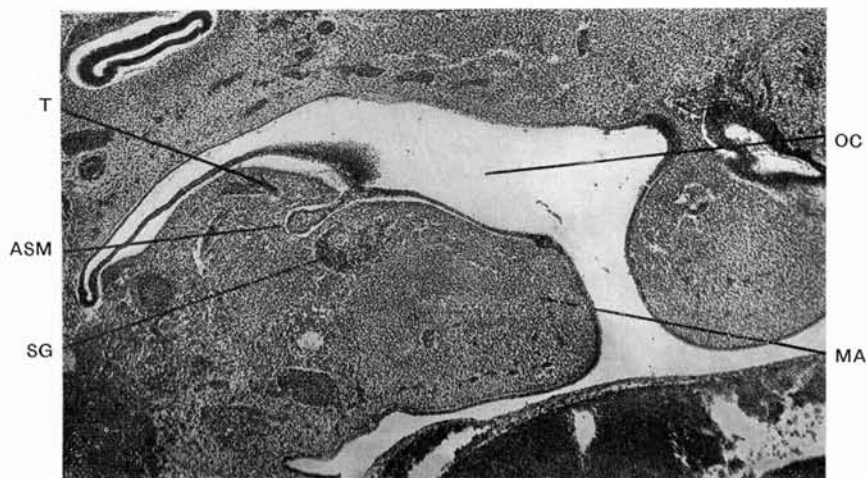


FIG. 10. EMBRYO 1129, H. E. C., LENGTH 18.1 MM., SECTION 227

Embryo 2037 of the Harvard collection—length, 20 mm.

Submaxillary gland. This specimen is a little older than *embryo 1129*. The advance in the development of the submaxillary gland is, however, very marked, which indicates the rapidity of growth of this organ in its early development. The dental lamina is well-formed at this stage. The submaxillary gland shows five branches in sagittal *section 239*, which is quite a distance from the median line. In *section 266* we see the place where the epithelial cord is given off from the comb, formed from the oral epithelium. The future duct is still solid along its entire course.

The greater sublingual gland. From the middle of the ventral aspect of the comb, referred to above, a bud is about to form, which is probably the first indication of an anlage for the sublingualis major gland. (See *sec. 266, fig. 11.*)



FIG. 11. EMBRYO 2037, H. E. C., LENGTH 20 MM., SECTION 266

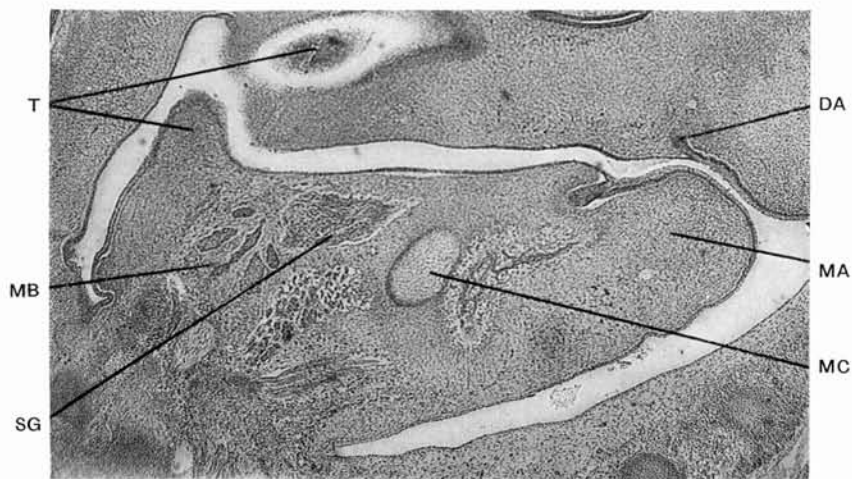


FIG. 12. EMBRYO 2037, H. E. C., LENGTH 20 MM., SECTION 239

Embryo 851 of the Harvard collection—length, 22 mm.

Submaxillary gland. In *section 248* we see the opening of the duct into the floor of the mouth. Previous slides show that its lumen has been partly formed as far back as the mylohyoid muscle. If we follow the duct backward we find that soon a branch is given off, which is the anlage for the sublingualis major gland. On the other side the submaxillary duct runs more nearly parallel with the plane of the section. Its opening is seen in *section 276*. If we follow the sections laterally we find that on this side, also, a branch is formed ventrad (*sec. 278*) anterior to the place where the duct, proceeding backward, passes over the submaxillary ganglion. A sprout is given off here (*sec. 289*). The main duct then curves down behind the mylohyoid muscle. The formation of its lumen has also on this side proceeded as far as this point. Here several branches are formed (*sec. 294*). The branches are solid epithelial cords from which buds sprout in various directions (see *fig. 18*). All are enclosed by condensed connective tissue cells, forming at this stage a capsule which is easily recognized (*sec. 295*). The sprout, seen in *section 289*, is entirely apart from the main gland and not included in its capsule. It represents the anlage of a ventral accessory submaxillary gland (see *fig. 17*). No such condition was found on the other side.

The greater sublingual gland. The anlage of this gland is present on both sides. Its origin has already been described in connection with the submaxillary ducts. On the first side a branch of slightly smaller size is given off, ventrad and laterally, a short distance from the orifice of the duct (*sec. 242*). In *section 240* the cross sections of the two ducts are easily recognized. On the other side we find the branch in *section 278*, from which place oblique sections can be followed backward in the succeeding sections. *Section 279* already shows the two ducts quite a distance apart. The sublingualis major duct, still one solid cord, presents two branches of equal size in *section 288*, comprising a glandular mass, the outline of which indicates the formation of buds, as seen in *section 289*. The mesenchyma surrounding the anlage of the sublingualis major shows little reaction at this stage, two or three layers of connective tissue cells surrounding it loosely in concentric arrangement being the only indication of a capsule.

The lesser sublingual glands. Several anlagen of lesser sublingual glands are visible in this embryo. On each side two small sprouts are seen developing from the epithelial band anteriorly to the opening of the submaxillary duct. One of these is seen in *section 248*. If we proceed in a lateral direction we find two or three more of still smaller size, all in the anterior portion of the mouth.

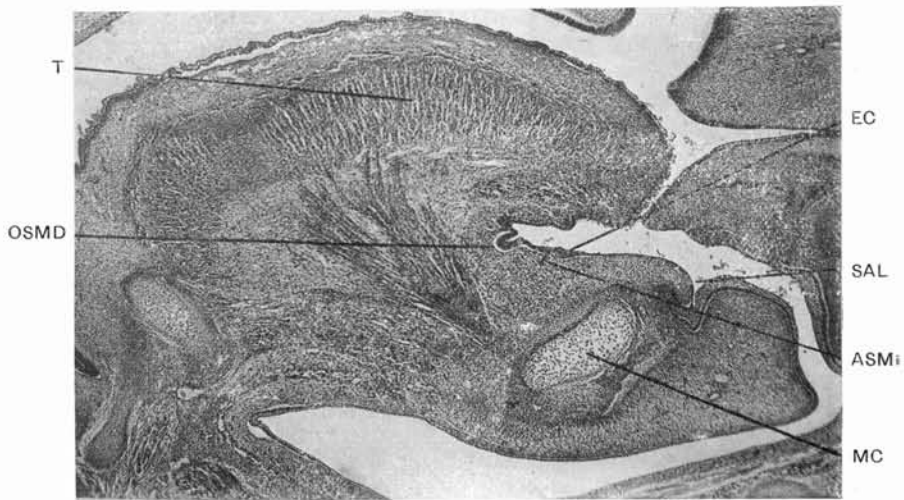


FIG. 13. EMBRYO 851, H. E. C., LENGTH 22 MM., SECTION 248

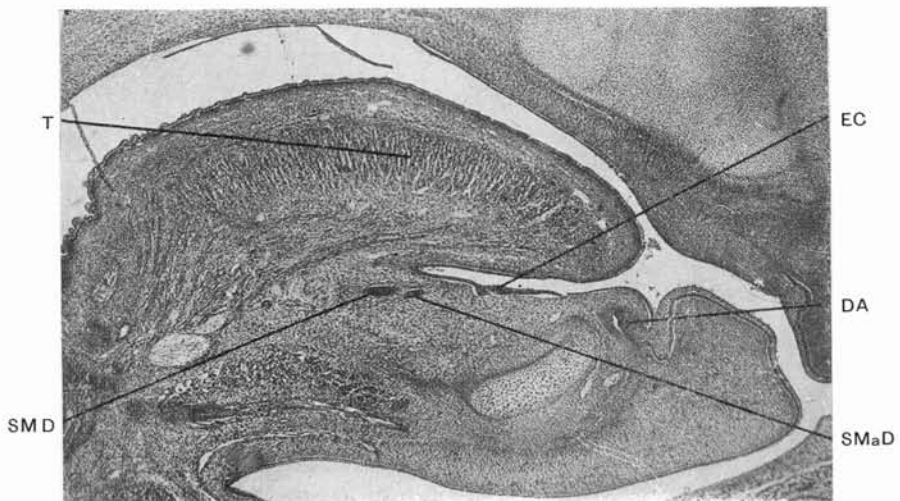


FIG. 14. EMBRYO 279, H. E. C., LENGTH 22 MM., SECTION 279



FIG. 15. EMBRYO 851, H. E. C., LENGTH 22 MM., SECTION 289

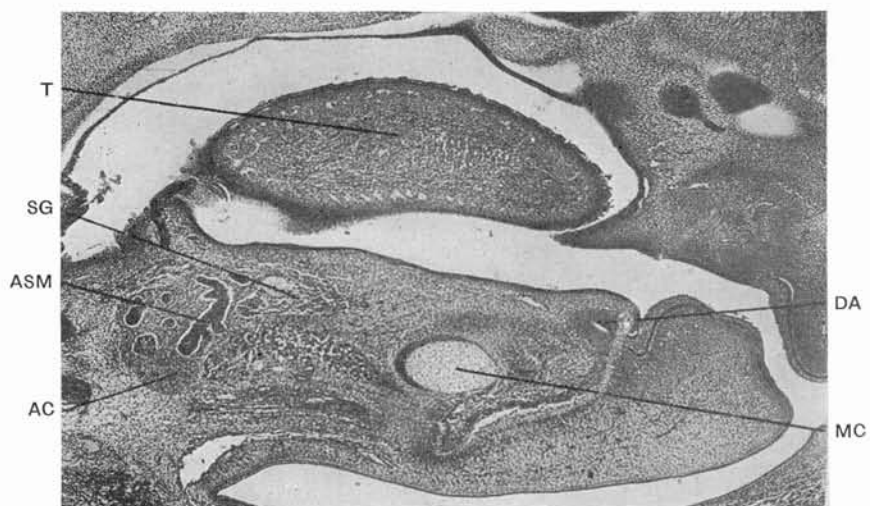


FIG. 16. EMBRYO 851, H. E. C., LENGTH 22 MM., SECTION 295

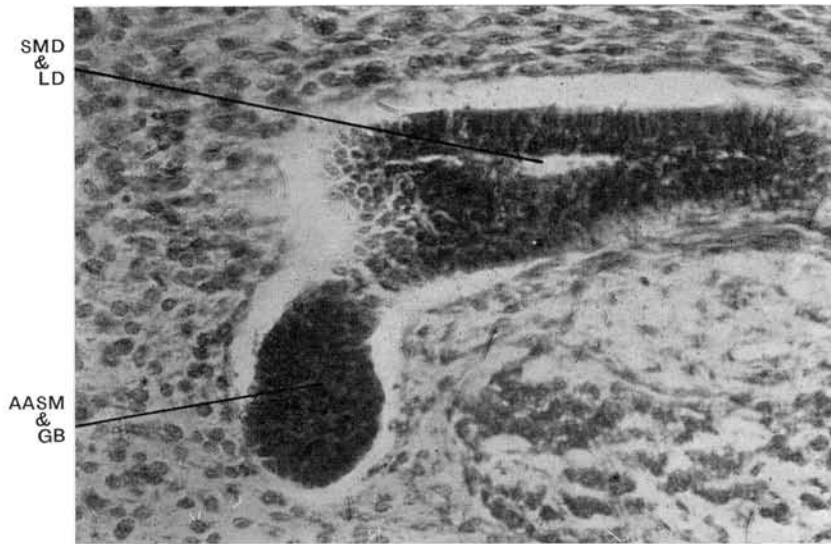


FIG. 17. EMBRYO 851, H. E. C., LENGTH 22 MM., SECTION 289 (HIGH POWER)

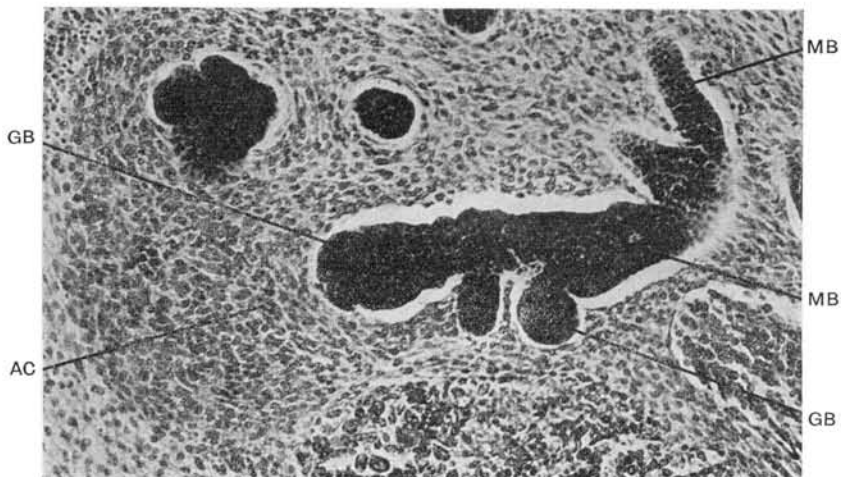


FIG. 18. EMBRYO 851, H. E. C., LENGTH 22 MM., SECTION 295 (HIGH POWER)

Embryo 1598 of the Harvard collection—length, 28.8 mm.

In this embryo the conditions on the two sides are almost identical, so that a description of one side will be sufficient.

Submaxillary gland. The orifice of the submaxillary duct is seen in *section 259* on one side and in *section 274* on the other. It has a wide lumen which can be followed as far back as the place where the duct curves down ventrad after it has passed over the submaxillary ganglion. Branches are then given off that ramify in the connective tissue, which has formed a distinct capsule. Proliferation of the epithelium is quite marked at this stage, as is indicated by the large accumulation of cells in the many buds found on the various branches (see *sec. 233*).

Greater sublingual glands. *Sections 258* and *275*, both next to the sections which show the orifice of the submaxillary ducts, in a lateral direction show a small sprout growing ventrad from the anterior margin of the opening of the duct (see *sec. 275*). These are probably anlagen of the greater sublingual glands. They are visible in only two sections on each side and show no sprouts or branches yet. While their size and location might give us the right to call them anlagen of greater sublingual glands, it is also possible that they are lesser sublingual glands and that their larger size is in accordance with their anterior position.

Lesser sublingual glands. Three very short round sprouts are given off from the oral epithelium, one of which is shown in *section 253* and the other two in *sections 249* and *250*. These are located further away from the median line and are also further caudad than the orifice of the submaxillary duct. Three or four similar sprouts are seen on the other side, all of which are considerably shorter than the sprout of the sublingualis major, being rounder and only about one quarter of its length with the exception of the anterior one on the other side, which is almost two-thirds the size of the sublingual major, but not so thick.

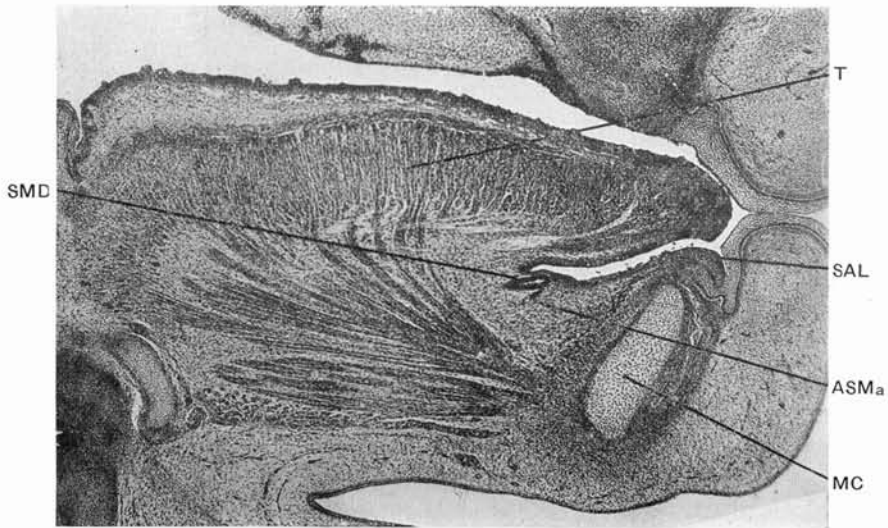


FIG. 19. EMBRYO 1598, H. E. C., LENGTH 28.8 MM., SECTION 275

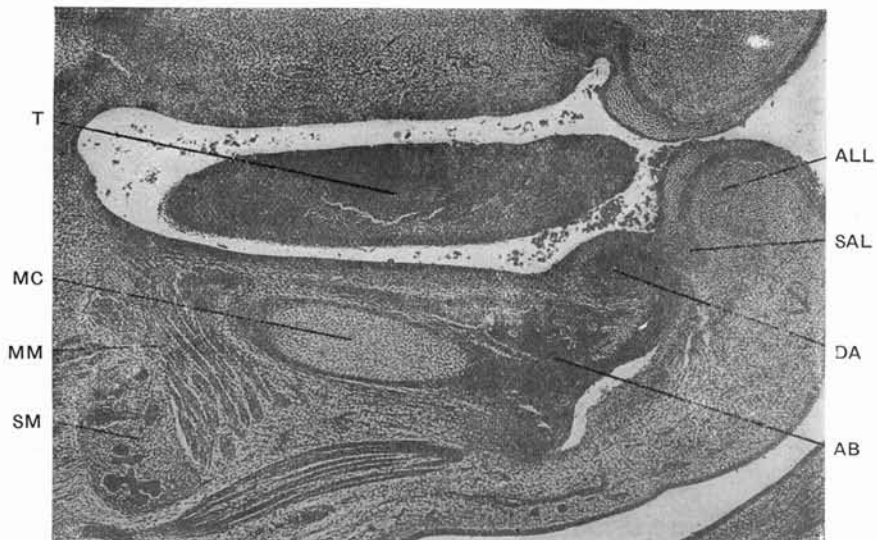


FIG. 20. EMBRYO 1598, H. E. C., LENGTH 28.8 MM., SECTION 233

Embryo 1706 of the Harvard collection—length, 31 mm.

Submaxillary gland. The opening of the duct is seen in *section 323* on one side and *291* (see illustration) on the other. It describes a curve, not only in a ventral direction but also toward the median line. The most medially located part of the duct is, therefore, seen in *section 297*, where a sprout is given off. In *section 296* a longer sprout is visible. In the succeeding sections two cross sections through the submaxillary duct are found, until the caudal one joins the oral epithelium and forms its orifice (see *sec. 291*). If we follow this duct on the other side about one-third of its course we find, in *section 326*, a branch given off which accompanies the main duct at its ventral side (see *sec. 332*). This is a condition corresponding to the one found in *embryo 851, section 279*, except for the fact that in the latter the main duct appears ahead of its branch in a posterior direction, indicating a course toward the median line, the direction in which the ductus sublingualis major grows. In *embryo 1706*, however, the reverse is seen (*sec. 332*), indicating a slightly more lateral direction taken by the secondary than by the main duct. This distinction, and the extremely posterior position of the anlage of the gland body, pronounce this a secondary lobe of the submaxillary gland. In *section 341* the secondary duct takes a turn ventrad. A lumen has already formed in its duct which can be followed to this point. In *section 343* three round buds are seen, which form the branches of this small submaxillary component. A condensation of the surrounding mesenchyma indicates the formation of a capsule. If we proceed further laterally we come to the main body of the submaxillary gland, which is seen in *section 362*. It is located below the submaxillary ganglion and at the posterior border of the mylohyoid muscle. On the other side the development of the anlage of the secondary lobe has started further back and has not progressed so far. The branch is given off in *section 284* about half way between the orifice of the main duct and the body of the gland.

The greater sublingual gland. The submaxillaris major is missing on one side, but on the other side a sprout is given off from the main duct at the place where it turns to follow a posterior course.

This sprout has already acquired a lumen, as seen in *section 297* and a small glandular head appears in the two sections on either side.

The lesser sublingual glands. Lesser sublingual glands are given off both from the epithelial comb anterior to the submaxillary duct near the median line and posteriorly where smaller buds are seen in lateral sections (see *sec. 291* and *343*).

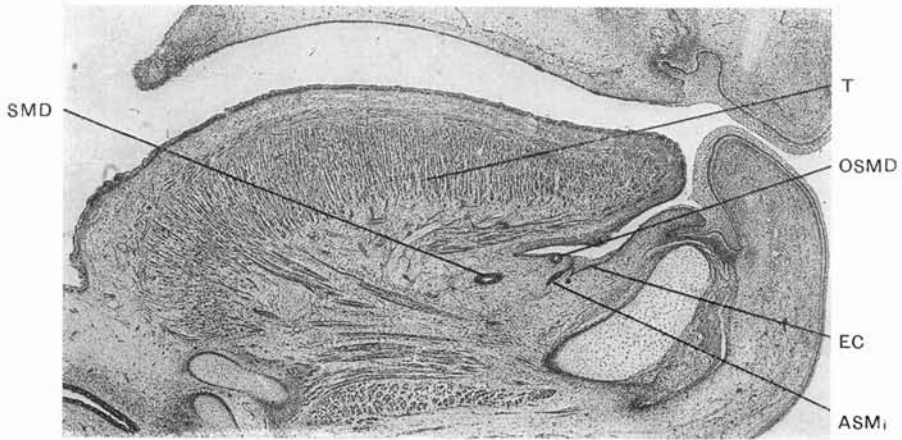


FIG. 21. EMBRYO 1706, H. E. C., LENGTH 31 MM., SECTION 291

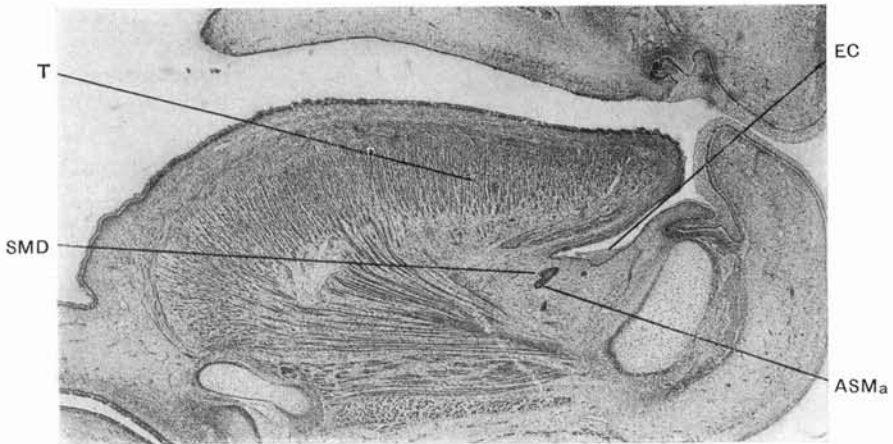


FIG. 22. EMBRYO 1706, H. E. C., LENGTH 31 MM., SECTION 297

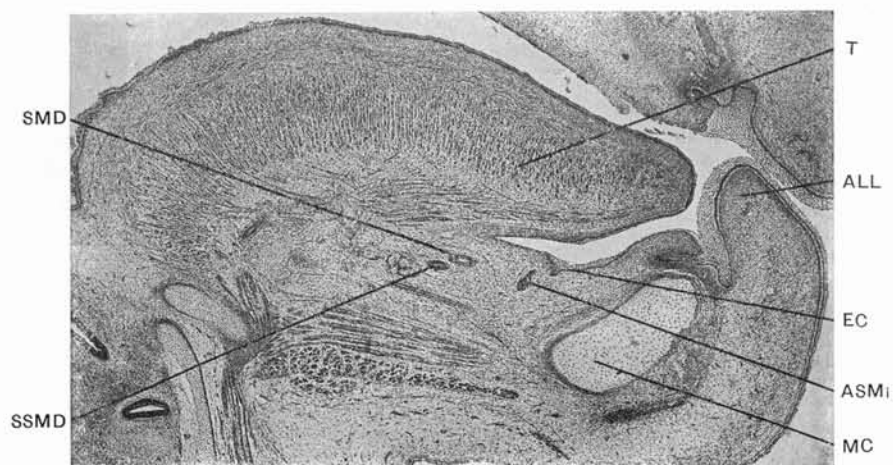


FIG. 23. EMBRYO 1706, H. E. C., LENGTH 31 MM., SECTION 332

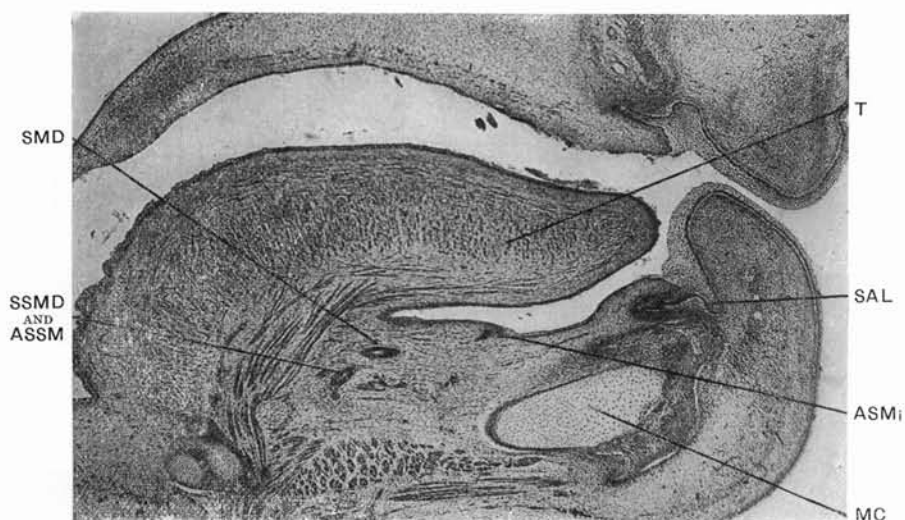


FIG. 24. EMBRYO 1706, H. E. C., LENGTH 31 MM., SECTION 341

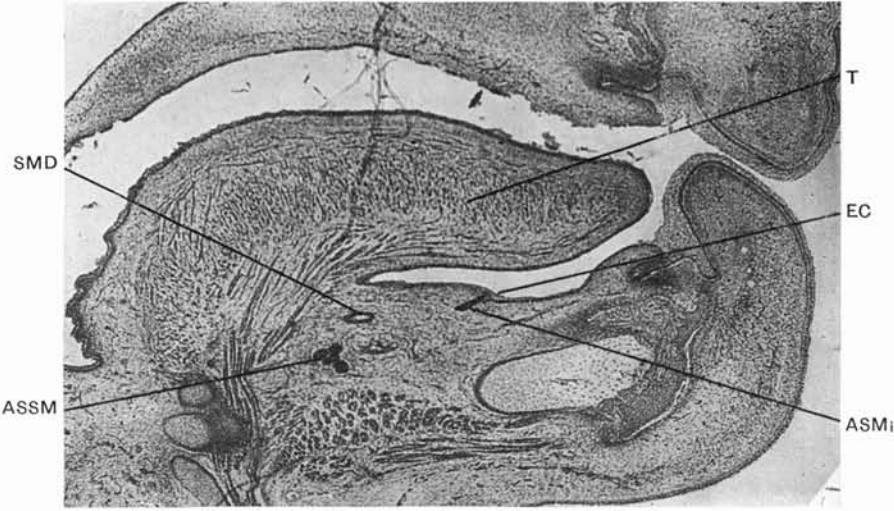


FIG. 25. EMBRYO 1706, H. E. C., LENGTH 31 MM., SECTION 343

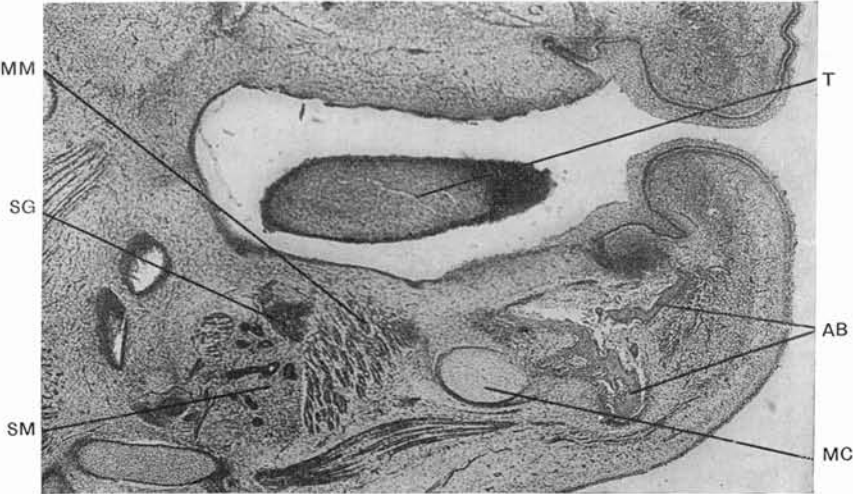


FIG. 26. EMBRYO 1706, H. E. C., LENGTH 31 MM., SECTION 362

Embryo 290 of the Harvard collection—length 32 mm.

Submaxillary gland. In *section 196* the submaxillary duct passes, down vertically to the floor of the mouth. It soon bends caudad, however, almost at right angles and passes backward until its course is again changed, when it passes ventrad behind the mylohyoid muscle. No secondary or accessory glands have been found.

Greater sublingual glands. No greater sublingual gland has been found.

Lesser sublingual glands. Five or six sprouts are seen in the various sections, given off from the posterior part of the epithelial band, already described, in younger embryos. Near the median line they are largest and closest to the anterior part of the mouth, while the more lateral the section the smaller is the sprout and the further caudad its position. Only one half of the embryo has been cut in sagittal sections. As it presents nothing specially new and records no further progress than *embryo 1706*, no illustration of this series is added.

Embryo 4, Special—length 47 mm.

This embryo is approximately ten and one half weeks old. Serial sections were made of the face in sagittal plane. Unfortunately it was not quite sufficiently decalcified, which resulted in the tearing of some of the sections.

Submaxillary gland. The orifice of the submaxillary duct is seen in *section 96*. Its first part describes not only the regular curve but also an inclination toward the median line, so that two sections through the duct may be seen in all sections from 96 to 108 (see *sec. 102*, which is cut through the most medial part of the curve). *Section 98* is very near the outlet of the duct. The sublingual gland which is seen in this section is not connected with the duct. If we follow the duct backward we find it cut obliquely and a higher magnification (of *sec. 80*) is shown in *figure 30*. Still further back in *section 73* we come to a place where two branches are given off. On the ventral side an accessory duct curves cephalad. It has already acquired a lumen and belongs to the accessory submaxillary gland placed over the mylohyoid muscle (see in *sec. 98*). A dorsal accessory duct branches from

the same part of the main submaxillary duct; the latter continues in a ventral direction and forms the main part of the submaxillary gland. The main part of the submaxillary gland is seen in *section 46*. Its main branches show at this stage a lumen extending into the side branches, from which new buds are given off. *Figure 33* shows a higher magnification of a duct with side branches and buds which are to form the end pieces of alveoli. The epithelium at this stage is still in a state of proliferation. The other side of the embryo shows similar development of the main gland, but no accessory glands.

Greater sublingual gland. It is the writer's opinion that there are no greater sublingual glands in this specimen, although one might be tempted to take one of the well-developed lesser sublingual glands for a sublingualis major (see *sec. 98*). Its ducts, however, are of smaller size than the ductus sublingualis major has appeared to be in previous specimens and show scarcely any indication of a lumen.

Lesser sublingual glands. On one side of the embryo a large sublingual gland is given off laterally from and slightly anterior to the submaxillary orifice. Its duct is of moderate size, and not connected with the submaxillary duct. Part of it is seen in *section 154* and its head, from which several buds are formed, is seen in *section 163*. Seven or eight sprouts in all are given off from the sublingual region at various places. They are small in the lateral section, while towards the median line they become larger and are placed further toward the anterior part of the floor of the mouth (see *sec. 249*). On the other side of the embryo two large sublingual glands are found in the anterior part, starting slightly lateral and anterior to the submaxillary orifice. They both grow in a ventral direction at an angle of about 45 degrees, their course being also inclined toward the median line. In *section 107* the head of one gland is seen with branches sprouting in five different directions. Part of its duct is shown in *section 102*. *Section 98* shows part of another duct near its orifice and a second sublingual gland. The biggest development of the latter's head is seen in *section 100*, while the more lateral *section, 93*, shows the middle part of its duct with the formation of two main branches. We also find on this side but further back about five more lesser sublingual glands (see *sec. 73* and *46*).

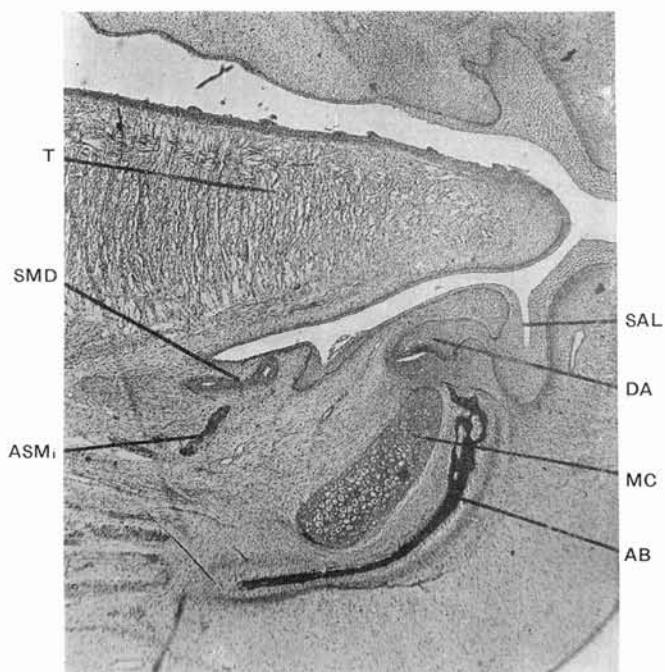


FIG. 27. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 102

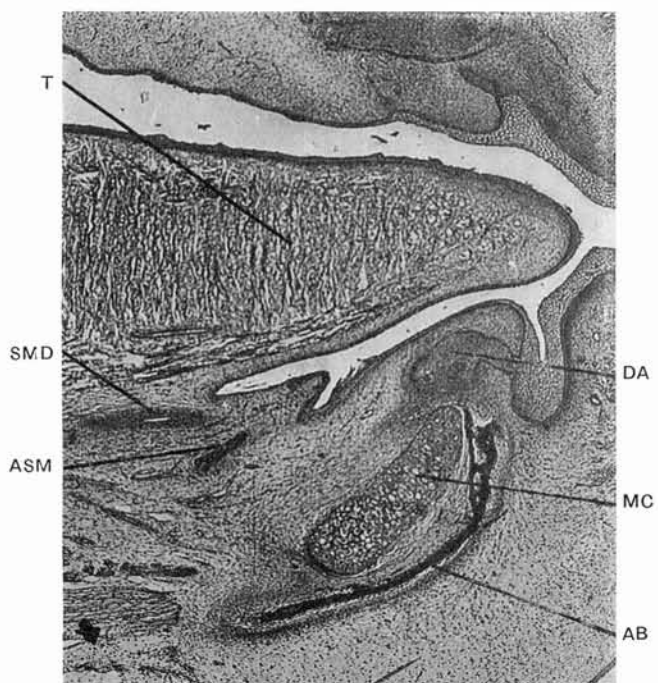


FIG. 28. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 93

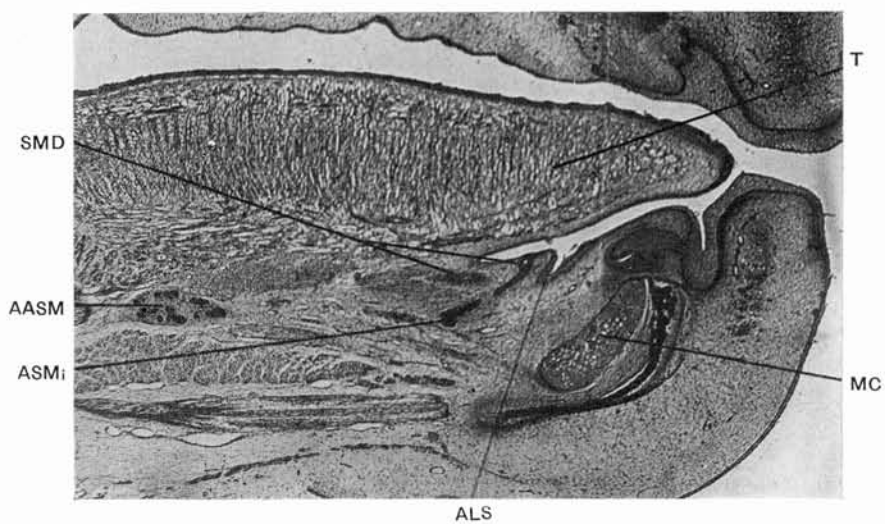


FIG. 29. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 98

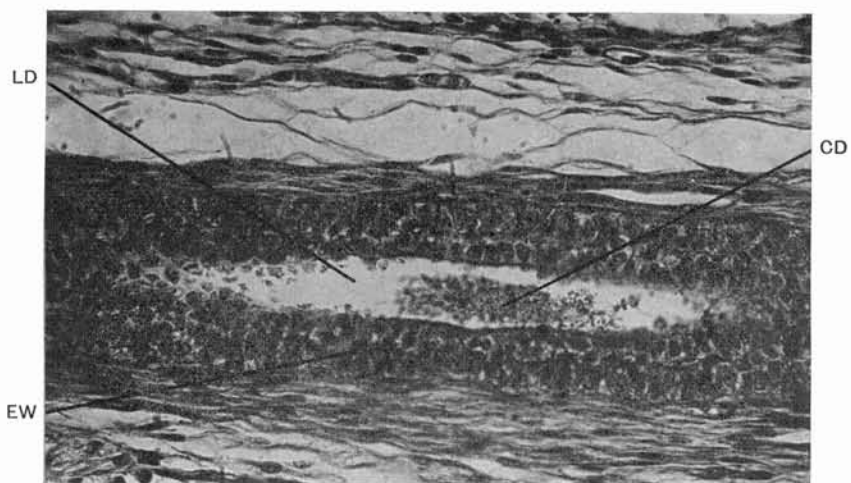


FIG. 30. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 80 (HIGH POWER OF SUB-MAXILLARY DUCT)

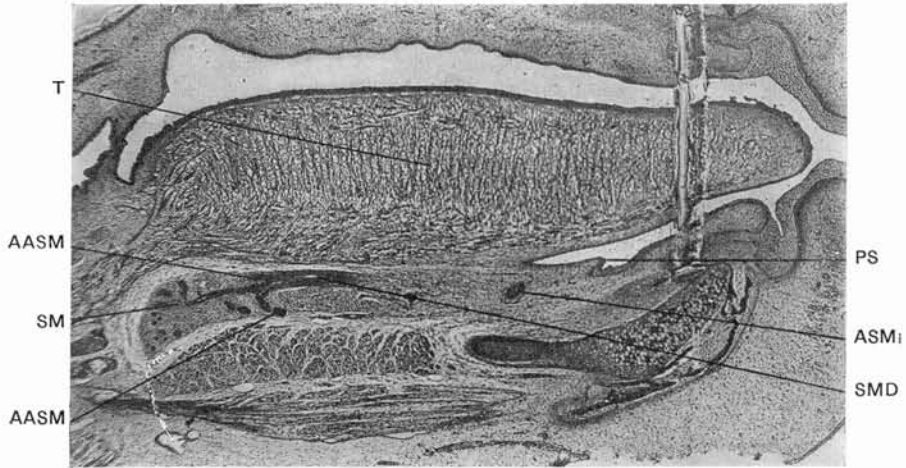


FIG. 31. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 73

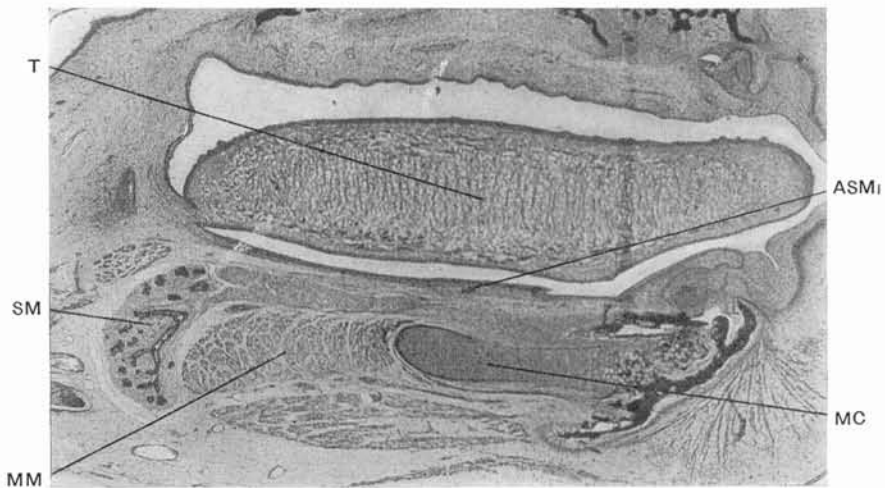


FIG. 32. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 46

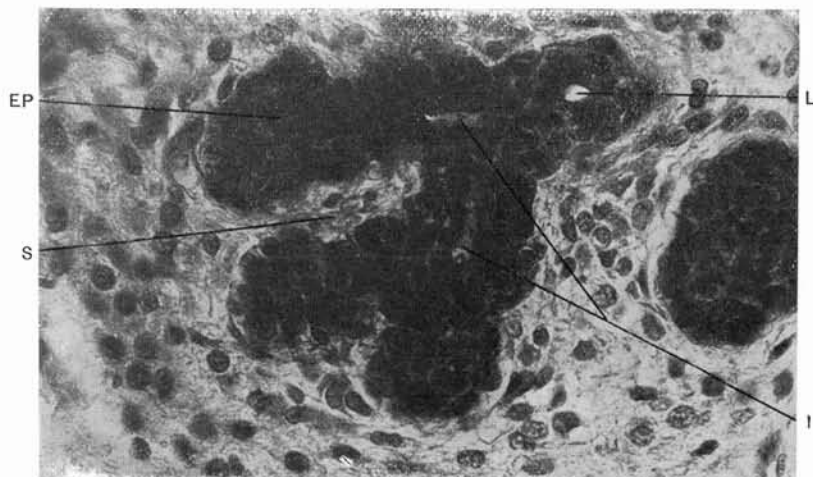


FIG. 33. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 62 (HIGH POWER OF END PIECES)

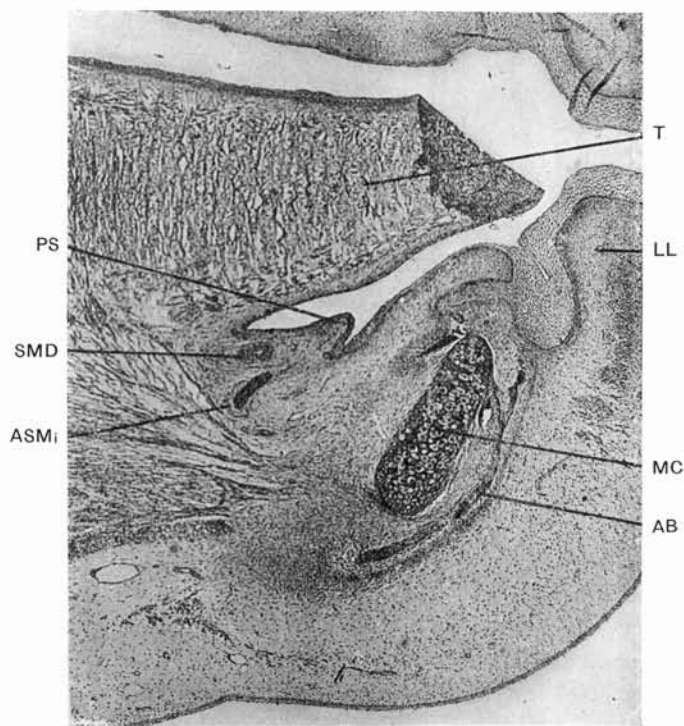


FIG. 34. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 154

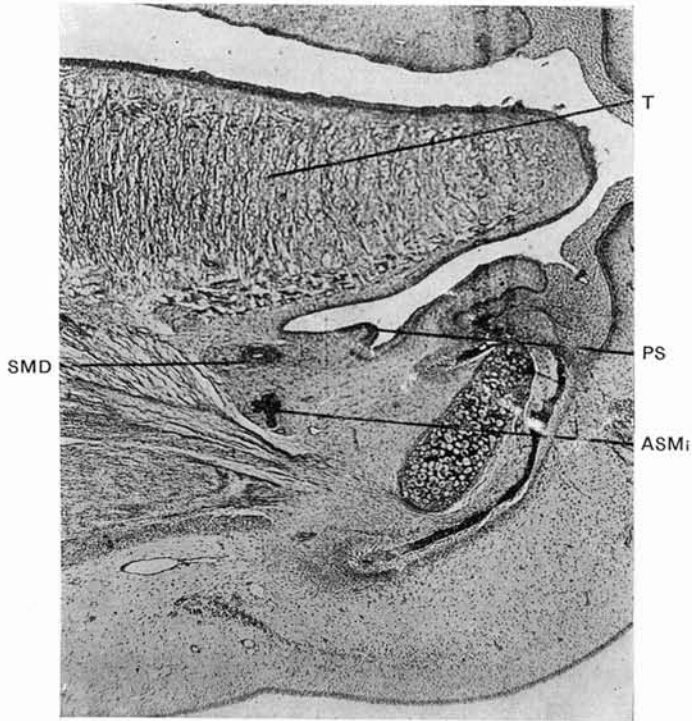


FIG. 35. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 163



FIG. 36. EMBRYO 4, SPECIAL, LENGTH 47 MM., SECTION 249

Embryo 2, Special—length 52 mm.

The head of this embryo is cut in transverse frontal sections. I shall use only two of the series to show the relation of the various structures in a frontal plane. It is a little older than *embryo 4*.

Submaxillary glands. In *section 172* the submaxillary glands are seen to be of large dimensions extending well under the lower border of the inferior maxillary bone. Immediately over the superior part and mesial to the developing mandible and Meckel's cartilage we find the internal pterygoid muscle. The large ducts in the middle of the gland are well shown on the right side. They are made up of two rows of epithelium and a large lumen containing considerable debris and early secretions (see *fig. 39*). A few layers of connective tissue cells are arranged parallel with the main ducts to give them support and the immediate neighborhood is extremely vascular. Nerve fibres are also encountered occasionally. The end pieces are more or less peripherally placed, some having also already acquired a lumen; and it appears as if the mucous cells were in the making too, although no typical ones can as yet be seen. Smaller ducts and their branches are shown in cross and longitudinal sections. The connective tissue of the gland has become condensed and is distinctly different from the surrounding mesenchyma. *Section 20*, which is quite a good deal further toward the tip of the tongue, shows on the left side a cross section through the main duct of the submaxillary gland; and at its ventral side, slightly toward the inside, it also shows a section through a smaller duct, a secondary submaxillary duct. On the other side a ventral accessory gland can be found in serial examination.

Sublingual glands. No effort was made to secure photomicrographs of sublingual glands. Fragments of a smaller sublingual gland are visible however in *section 20*, their direction being ventral and toward the median line.

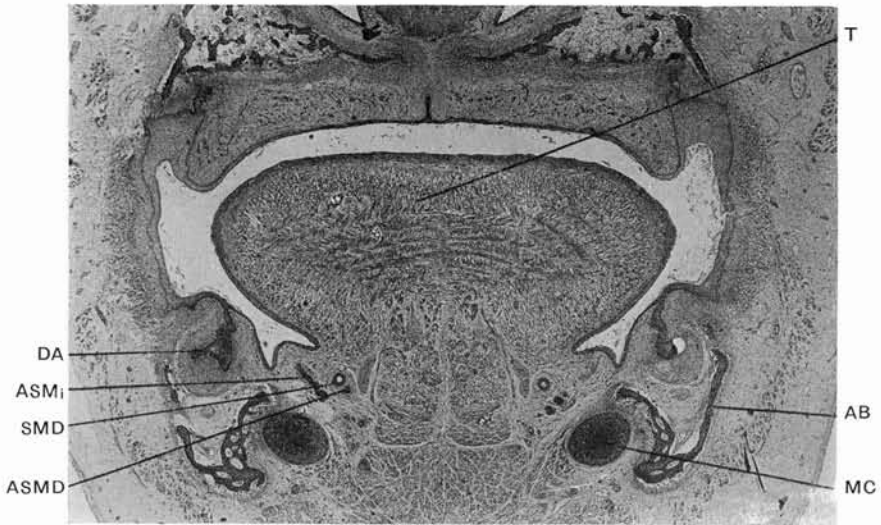


FIG. 37. EMBRYO 2, SPECIAL, LENGTH 52 MM., SECTION 20

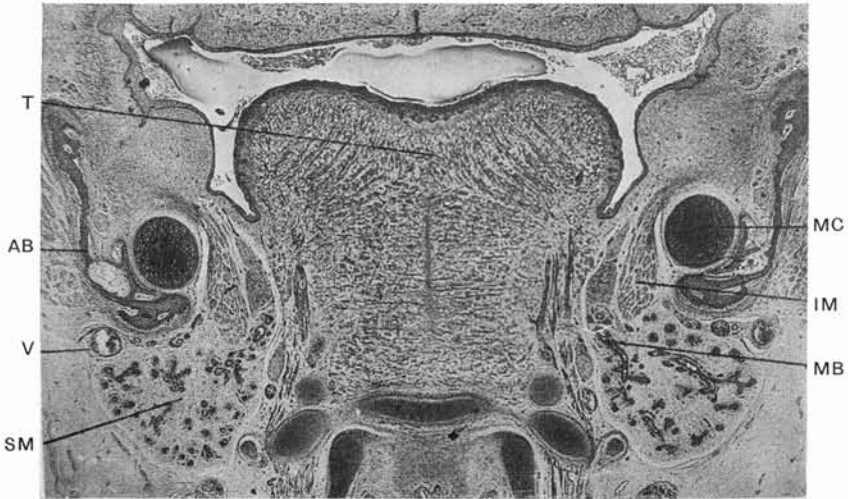


FIG. 38. EMBRYO 2, SPECIAL, LENGTH 52 MM., SECTION 172

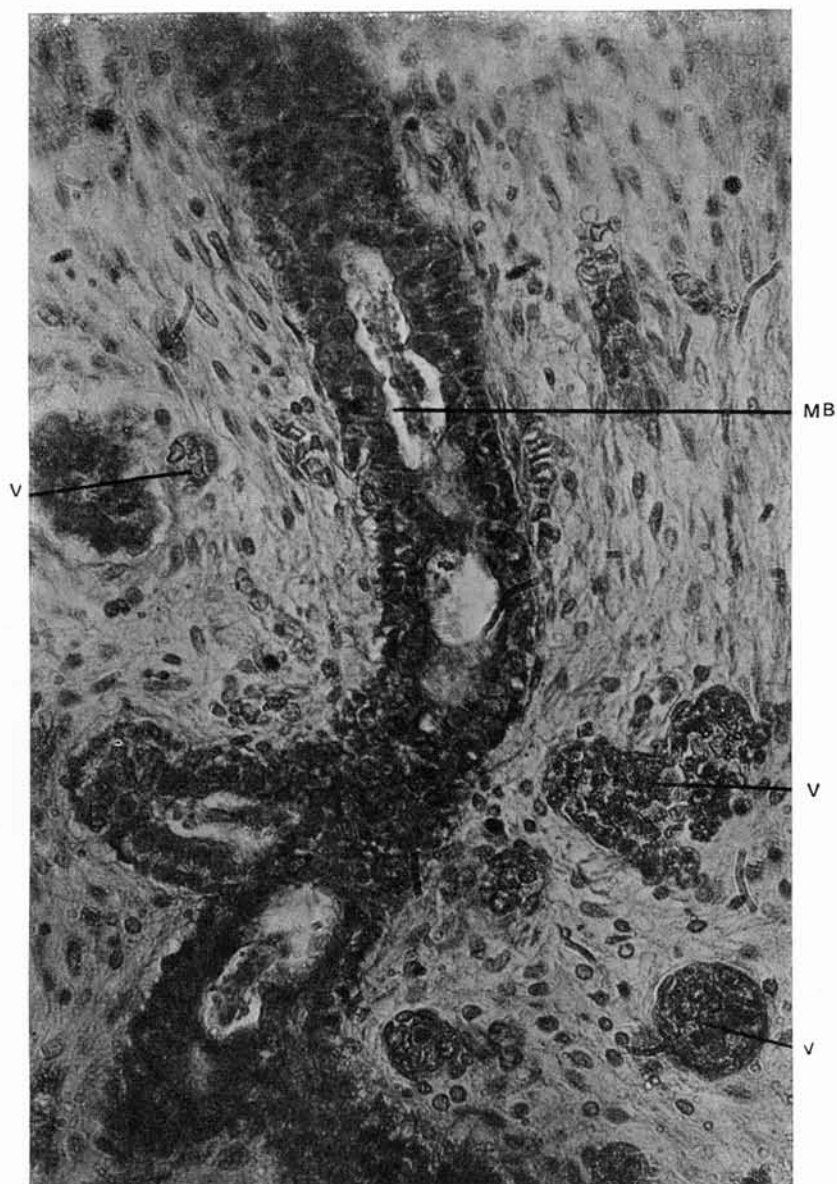


FIG. 39. EMBRYO 2, SPECIAL, LENGTH 52 MM., SECTION 172 (HIGH POWER OF LARGE GLANDULAR BRANCH OF SUBMAXILLARY DUCT)

Embryo 5, Special—length, 62 mm.

This embryo had not been very well preserved, and the epithelium was in poor condition and could not be used for high power study. The sections from the median line to the first branches in the body of the submaxillary gland on both sides have been mounted.

Submaxillary glands. On one side we see the orifice of the submaxillary duct in *section 50*. The sections are cut at a slight angle to the median line, so that on this side we get long oblique sections through the ducts. Two ducts are given off from the same place, the dorsal one being the submaxillary duct. On the other side the submaxillary duct is given off alone.

Greater sublingual gland. This gland occurs only on one side and starts with the submaxillary duct in *section 50*. The ductus sublingualis major is smaller and shows a well-formed lumen. It runs along the ventral side of the submaxillary duct in *section 39*. Its diameter is only about half the size of the submaxillary duct. In *section 32* we see it curve more downward into the floor of the mouth. At the caudal end of this long duct, branches are given off that form an elongated gland body, the posterior extremity of which extends as far back as the submaxillary ganglion, over which the submaxillary duct passes to its destination.

Lesser sublingual glands. A large number are found on both sides. They are well-developed in the anterior part and near the middle line, where they show small branches all along their main ducts, from which the end pieces are developing. The ducts and branches show a lumen. On the side where there is no sublingualis major gland we find specially large lesser sublingual glands, one of which is shown in *section 157*. A number of sublingual glands of smaller size and not so well developed are seen further back in the lateral sections.

Anterior lingual glands. Two sprouts are seen growing into the substance of the tongue from the epithelium on its ventral surface. One is distinctly seen in *section 46*, and there is indication of another a little further toward the apex. The head of this glandular anlage is already of good size. Cross sections through it appear in a number of sections, the largest ones being in *section 39*.

Labial glands. These are formed in like manner from the basal cells of the epithelium of the lingual part of the lip. About eighteen or twenty sprouts were counted in all. Their heads are not quite as far developed as the ones of the anterior glands of the tongue.

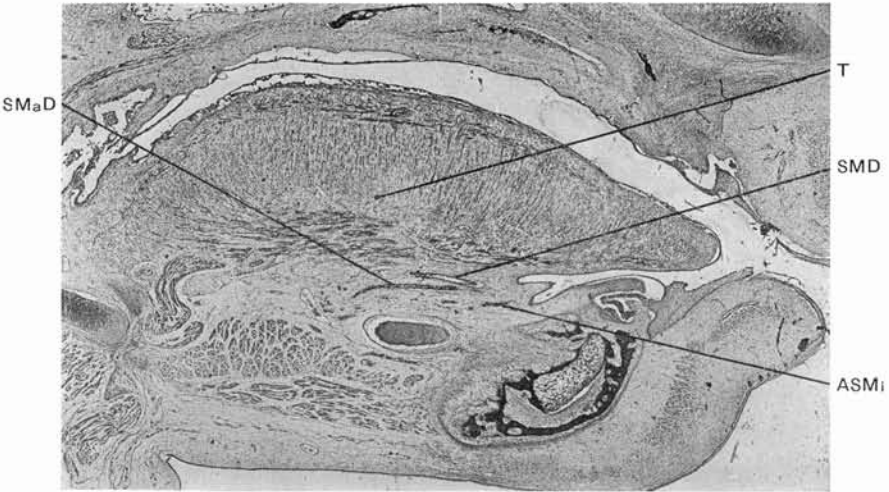


FIG. 40. EMBRYO 5, SPECIAL, LENGTH 62 MM., SECTION 32

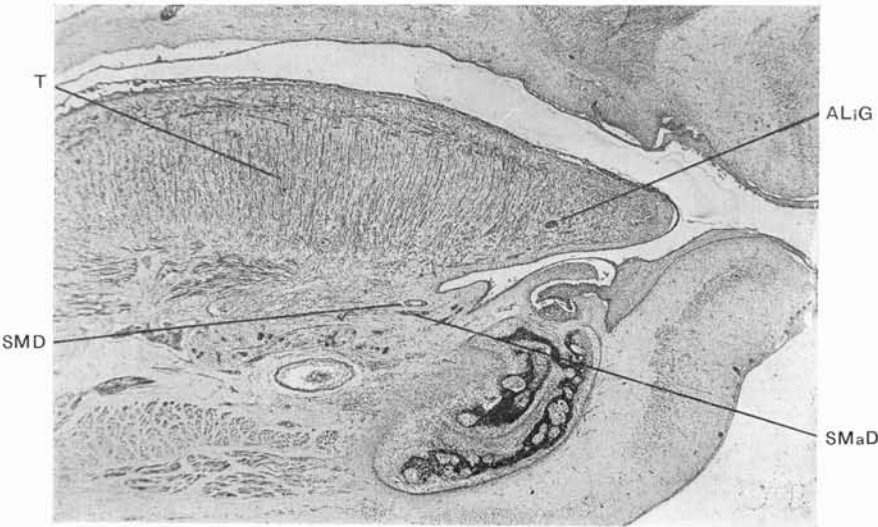


FIG. 41. EMBRYO 5, SPECIAL, LENGTH 62 MM., SECTION 39

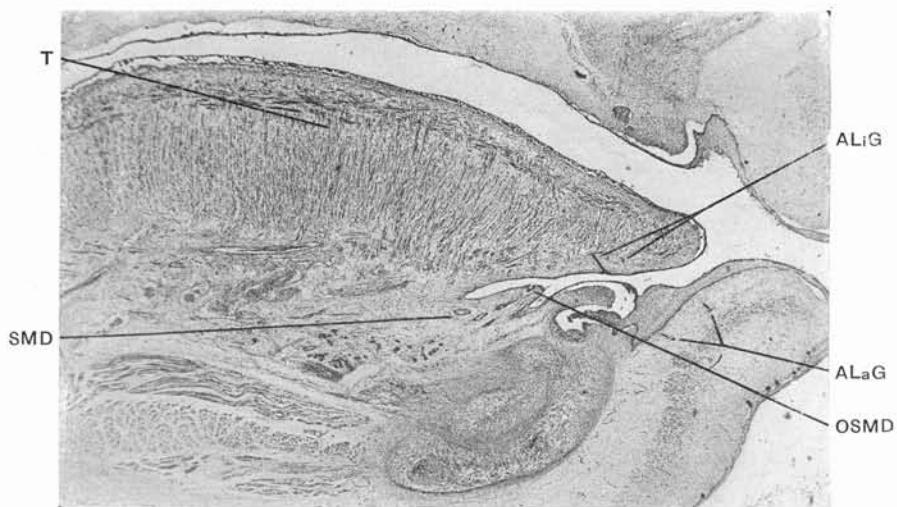


FIG. 42. EMBRYO 5, SPECIAL, LENGTH 62 MM., SECTION 46

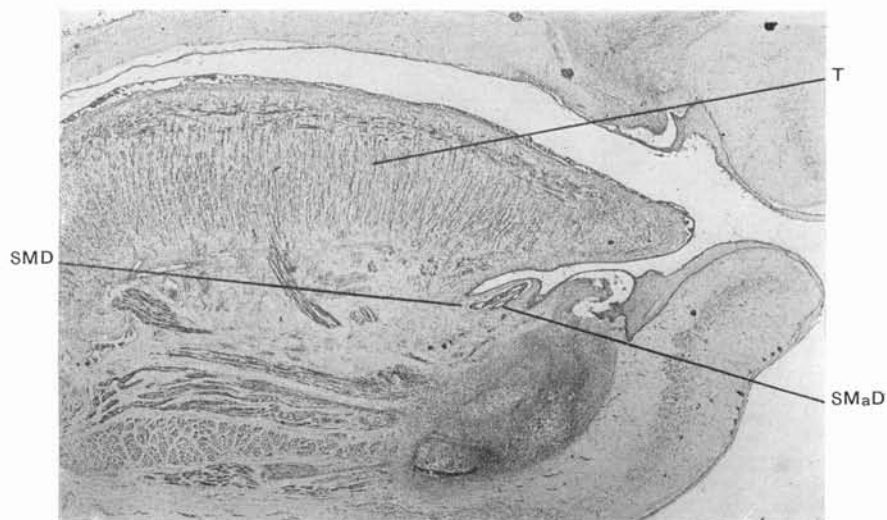


FIG. 43. EMBRYO 5, SPECIAL, LENGTH 62 MM., SECTION 50

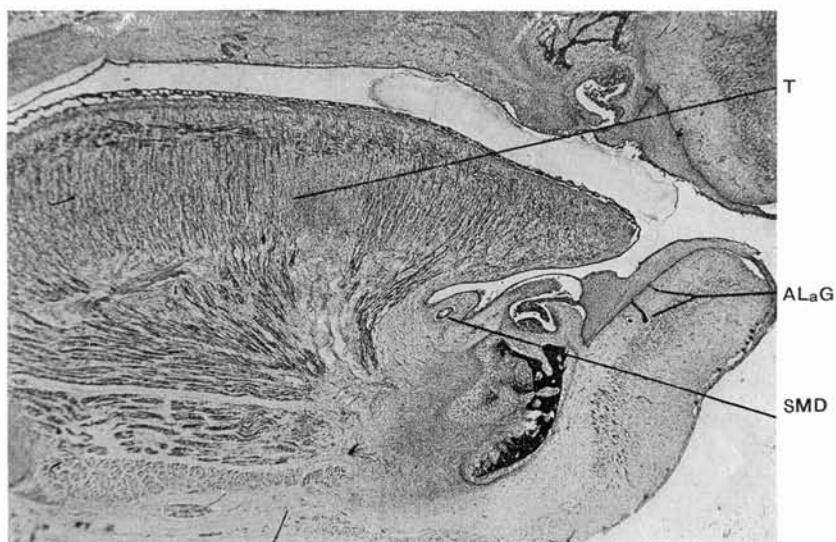


FIG. 44. EMBRYO 5, SPECIAL, LENGTH 62 MM., SECTION 82



FIG. 45. EMBRYO 5, SPECIAL, LENGTH 62 MM., SECTION 157

Embryo 6, Special—length probably 230 mm.

The anterior part of the lower jaw of this embryo was prepared for teaching purposes. The serial order of the sections was not preserved, so that a systematic study was not possible. Some of the sagittal sections of this very much older stage, however, show interesting progress in development.

Submaxillary glands. Cross sections through the submaxillary duct are seen in the sections. The submaxillary glands were not included in the specimen.

Lesser sublingual glands. These have developed very abundantly. Their ducts are simple and show small branches extending from their sides at right angles, each draining a small lobule made up of end pieces (see low and high power illustrations of *sec. 79*). The end pieces show the formation of a number of mucous cells.

Lingual glands. These are few in number, there being perhaps only two on each side. They seem to have small and short excretory ducts with many branches ramifying in a disproportionately large gland body. Mucous cells are abundant in the alveoli (see *sec. 40*).

Labial glands. There are a great many of these which have already developed to large size. Their ducts seem to describe tortuous curves before reaching the oral epithelium. They are seen in *section 79* and one gland with higher magnification from *section 58* is seen in *figure 49*. In this the lumen of the ducts extends far into the alveoli, where many mucous cells have already formed.

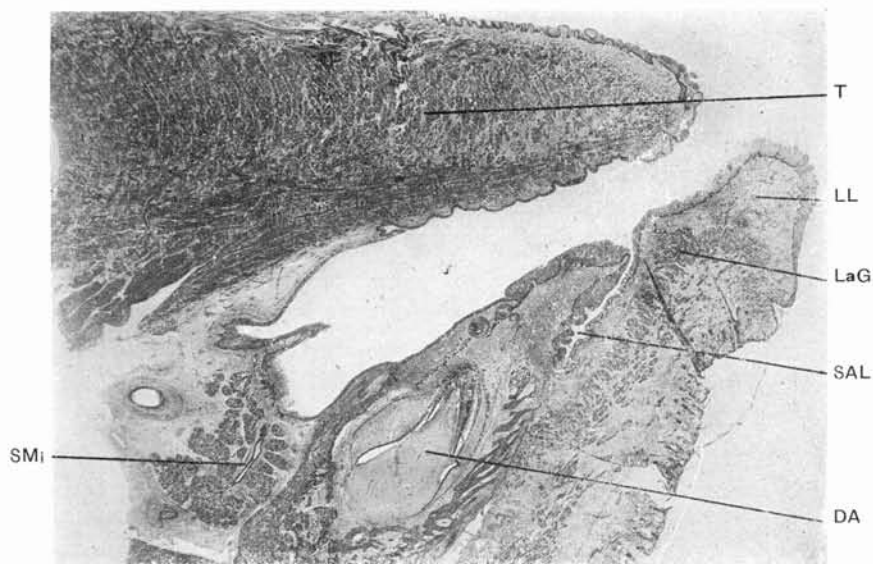


FIG. 46. EMBRYO 6, SPECIAL, LENGTH 230 MM., SECTION 79

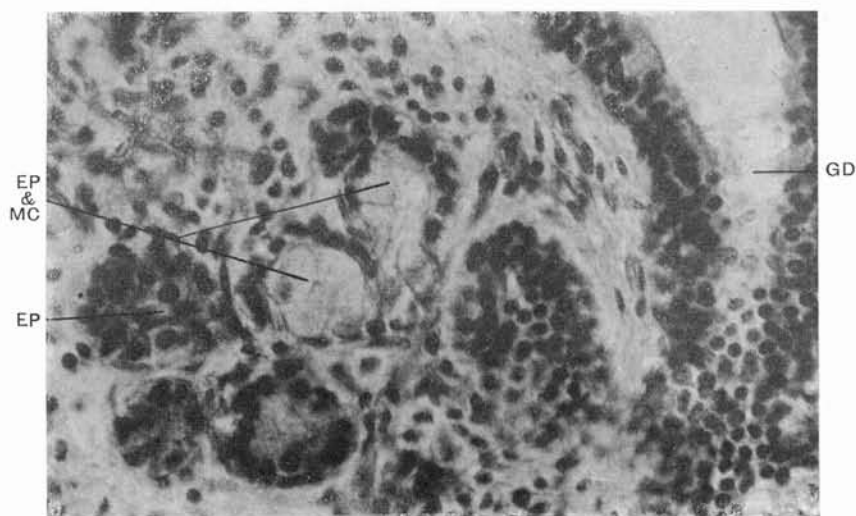


FIG. 47. EMBRYO 6, SPECIAL, LENGTH 230 MM., SECTION 79 (HIGH POWER)

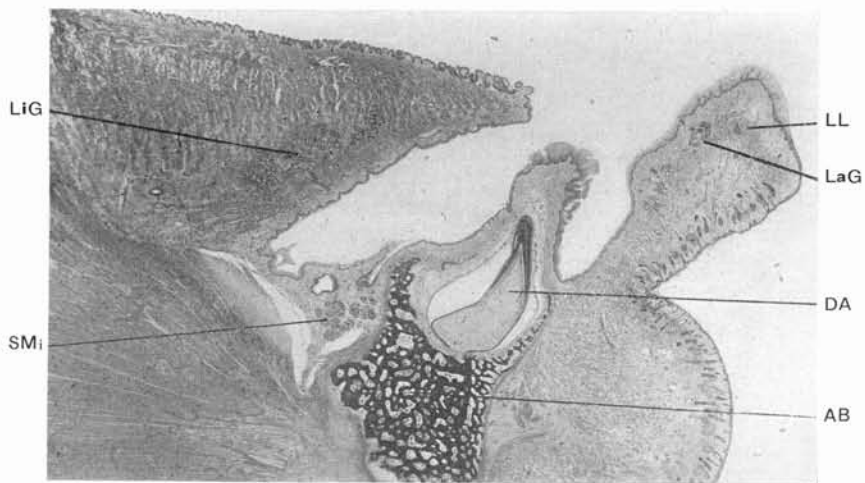


FIG. 48. EMBRYO 6, SPECIAL, LENGTH 230 MM., SECTION 40

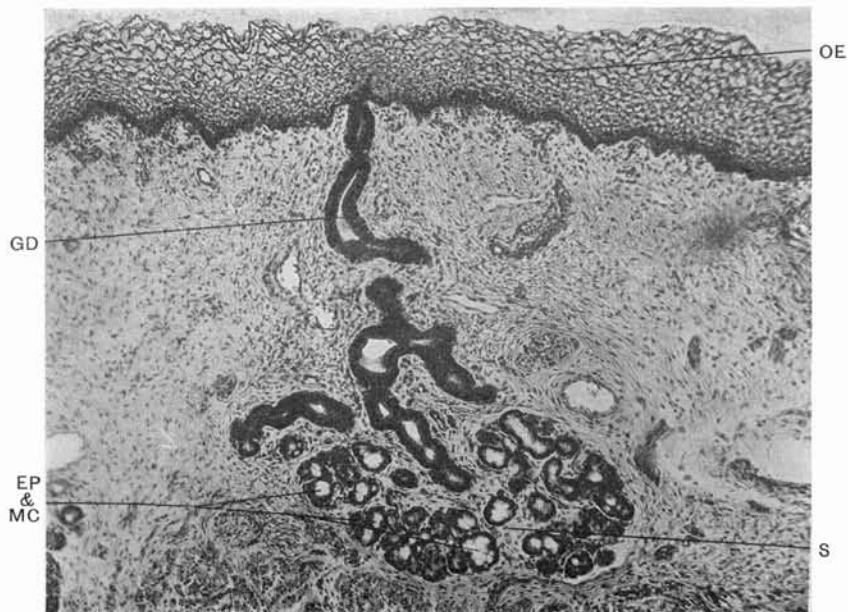


FIG. 49. EMBRYO 7, SPECIAL, LENGTH 230 MM., SECTION 58 (HIGH POWER OF LABIAL GLAND)

CONCLUSIONS

The glands

The parotid gland. The younger embryos examined show that the anlage of the parotid gland is developed first. The anlage is quite definitely formed in the embryo of 10 mm. length.

The submaxillary gland. In the 10.2 mm. embryo an epithelial band is seen, which, in the writer's opinion, gives rise to the anlage of the submaxillary gland. In the transverse frontal sections through the embryos measuring 11, 11.5 and 11.7 mm. only the anlagen of the parotid gland can be seen. In the transverse frontal sections of the 12 mm. embryo the anlage of the submaxillary gland may be seen distinctly; in the 13.6 mm. embryo it has already developed into a large dumb-bell shaped sprout. Unfortunately, there were no embryos at my disposal cut in sagittal sections between 10.2 mm. and 18.1 mm. In the latter the anlage has already developed to a sprout of considerable size. Branches are first noticeable in the 20 mm. embryo, in which they have already acquired appreciable length.

Accessory and secondary lobes are first visible in an embryo of 22 mm. length.

Accessory and secondary glands occur rather frequently in all the embryos of 22 mm. or more in length which I examined. One or more such glands were found in four out of seven embryos, or 57 per cent (see table 2).

TABLE 2.
Data on the occurrence of accessory and secondary glands

EMBRYO NUMBER	SIZE	ACCESSORY GLAND		SECOND- ARY GLANDS	TOTAL	SUB- LINGUAL MAJOR	REMARKS
		Ventral	Dorsal				
	<i>mm.</i>						
851	22.0	1	—	—	1	2	
1598	28.8	—	—	—	—	2	
1706	31.0	—	—	2	2	1	
290	32.0	—	—	—	—	—	Only one side sectioned
4	47.0	1	1	—	2	—	
2	52.0	1	—	1*	2	?	* Secondary duct seen in frontal section
5	62.0	—	—	—	—	1	

The epithelial sprout which forms the anlage of the submaxillary gland is given off from the lingual sulcus at the posterior end of an epithelial comb, just behind the lingual nerve, where the latter becomes infiltrated by the cells of the submaxillary ganglion. In older embryos the ducts first extend down ventrally, inclined toward the median line, and, after running a short distance, curve caudad and toward the side. On account of the general growth of the mouth the orifice is moved considerably forward and the duct becomes elongated. Soon after crossing over the submaxillary ganglion, through which the lingual nerve passes to enter into the tongue, it curves ventral around the mylohyoid muscle, where it gives off various branches. Here the anlage of the gland body is formed. It consists of proliferating epithelial sprouts surrounded by a capsule.

The accessory and secondary submaxillary glands form lobules resembling, except for their smaller size, the main gland. They are also surrounded by a capsule. The secondary glands are located anteriorly to the submaxillary ganglion and the mylohyoid muscle and have a duct of considerable length.

Greater sublingual (Bartholinian) glands. These glands develop at a still later period, the first well-defined anlage being seen in the 22 mm. embryo. They grow much more slowly than the submaxillary glands, but the ductus sublingualis major forms a lumen early. It is either given off from the submaxillary duct at its very beginning, or is formed separately from the epithelial comb directly anterior to and lateral from the orifice of the submaxillary duct. It may be present on only one side of the embryo. In two cases out of six (the 52 mm. embryo was not cut far enough forward to include the sublingual glands), it occurred on both sides, in two on one side, and in two cases it was entirely missing.

The lesser sublingual glands are also first found in the embryo measuring 22 mm. (*sec. 248*). In the younger embryos they are seen developing from the anterior part of the epithelial comb. Later we also find sprouts given off from the posterior part of this structure (embryo 31 mm., *section 343*). In older specimens buds are seen still further back, given off from the oral epithelium. The anterior ones develop earlier and grow to larger size than the latter. There may be between ten and twenty sprouts. They form short branches on all

sides along their ducts. These in turn form secondary ducts, on which the end pieces or alveoli develop.

The anterior lingual glands are noticeable for the first time in the 62 mm. embryo and develop from sprouts which originate from the epithelium on the ventral surface of the tip of the tongue. They apparently start without any accumulation of epithelial cells or an epithelial ridge and are found on both sides of the median line. In the 62.0 mm. embryo two of these were found on each side (*sec. 46*). The epithelial cord, which is to be the duct, shows no lumen yet, but an enlargement has occurred at the end forming the anlage of the gland body (*sec. 39*). This is contrary to the theory of Schulte, who described this gland, "the apical gland of the tongue," as being derived from a sprout given off from the dorsal aspect of the submaxillary anlage. In *embryo 6* many mucous cells are seen in these lingual glands.

The labial glands develop simultaneously with the anterior lingual glands. In the 62.0 mm. embryo, from twenty to thirty sprouts could be found in the various sections through the lower lip. Here they are seen as epithelial cords with enlarged endings. A lumen has not yet formed, nor can any branching be seen at this stage. A later development is seen in *embryo 6*.

The development of the glandular epithelium and the reaction of the surrounding connective tissue

The development of the cellular elements of all these glands is in the main the same, except that the labial, anterior lingual and sublinguales minores remain comparatively simple in structure, while the sublingualis major and especially the submaxillary gland develop into highly compound forms.

Epithelium. The epithelial cells first accumulate before growing down into the mesenchyma and can be clearly differentiated, even at this stage, from the oral epithelium. The anlage soon takes on a more pronounced shape, so that a head and a cord can be distinguished. The sprouts at first grow perpendicular to the surface. The labial, anterior lingual and lesser sublingual glands stay short and comparatively straight (except the labial), while the duct of the greater

sublingual gland, and especially of the submaxillary, form long cords which bend toward the direction of their future destination. A differentiation of the epithelial cells is shown in a little later stage. The ones on the periphery grow more cylindrical and become arranged in a layer while the inner cells remain of the primitive rounded type. The head of the sprout shows a crowding of cells which soon gives rise to small buds from which the main branches develop. The duct now acquires a lumen and is lined with two or three layers of epithelium, the inner and outer layer being made up of more or less cylindrically shaped cells. The center cavity of the duct contains broken down cells and secretions (*fig. 30*). The lumen is probably caused by enlargement of the circumference of the duct, occurring from pressure due to secreted fluids (Chievitz, page 413). This lumen extends only as far as the main branches, which remain solid. Small buds grow out of the branches at right angles and from these, side branches are formed which give rise to several end pieces often arranged in a group or rosette around the terminal branch (see *fig. 33*). At first the appearance of the cells of the end pieces is uniform. Later a lumen is formed in the center and large cells of lighter color become apparent. These are mucous cells and are entirely filled with mucus. Their nuclei are pressed towards the periphery and become flattened out as the secretions accumulate (see *fig. 47*). They are first seen in the submaxillary gland of the 52 mm. embryo as cells which have attained a much larger size than the others. The nucleus is still in the center, however, the secretion not yet having accumulated. In the six months embryo mature mucous cells are seen in large numbers in the sublingual, anterior lingual and labial glands. Certain alveoli appear to show crescents, but this cannot be accepted as an assured observation, as it is almost impossible to say whether or not they are only young undifferentiated glandular epithelial cells.

Connective tissue. The mesenchyma surrounding the head of the submaxillary epithelial sprout shows a reaction at an early stage. The connective tissue cells accumulate, take on a concentric arrangement and are easily distinguished from the surrounding tissue. They form the anlage of the capsule which, in *embryo 839*, seems much larger than the sprout itself. It is well defined at its ventral end,

while toward the floor of the oral cavity it gradually passes over into the connective tissue. When branches are developed from the epithelial anlage of the gland they become surrounded by two or three layers of connective tissue cells arranged with their long axis parallel to the surface of the sprouts. Later, connective tissue fibres are formed which support the larger ducts and form so-called septa. Many vessels and occasionally nerve fibres are seen in the capsules of older specimens (see *fig. 39*), especially in the neighborhood of the main ducts and their larger branches.

The accessory and secondary lobes of the submaxillary gland also show formation of a capsule, which develops in similar manner.

The greater and lesser sublingual glands, as well as the lingual and labial glands, are not seen to develop a distinct capsule. Even in well-developed glands, such as are found in the six months old *embryo*, ♂, there are only a few layers of connective tissue cells investing the periphery of the glands. The interlobular septa, however, are made up of dense connective tissue bundles which, at the periphery, give off a small number of fibres to surround the gland, the rest spreading into the adjoining connective tissue.

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EXPLANATION OF LEADERS FOR ALL ILLUSTRATIONS

<i>AASM</i> , Anlage of accessory submaxillary gland	<i>L</i> , Lumen
<i>AB</i> , Alveolar process	<i>LaG</i> , Labial gland
<i>AC</i> , Anlage of capsule	<i>LaGD</i> , Labial duct
<i>AcSM</i> , Accessory submaxillary gland	<i>LD</i> , Lumen of duct
<i>AL</i> , Alveolar sulcus	<i>LiG</i> , Lingual gland
<i>ALaG</i> , Anlage of labial gland	<i>LL</i> , Lower lip
<i>ALiG</i> , Anlage of lingual gland	<i>LN</i> , Lingual nerve
<i>ALL</i> , Anlage of lower lip	<i>LS</i> , Lingual sulcus
<i>ALR</i> , Alveolo-lingual region	<i>MA</i> , Mandibular arch
<i>ALS</i> , Alveolo-lingual sulcus	<i>MaM</i> , Masseter muscle
<i>AP</i> , Anlage of parotid gland	<i>MB</i> , Main branch of duct
<i>AR</i> , Alveolar ridge	<i>MC</i> , Meckel's cartilage
<i>ASM</i> , Anlage of submaxillary gland	<i>Mdiv</i> , Mandible divided
<i>ASMa</i> , Anlage of sublingualis major gland	<i>MM</i> , Mylohyoid muscle
<i>ASMD</i> , Duct of accessory submaxillary gland	<i>MuCe</i> , Mucous cells
<i>ASMi</i> , Anlage of sublingualis minor gland	<i>NS</i> , Nasal septum
<i>ASSM</i> , Anlage of secondary submaxillary gland	<i>OC</i> , Oral cavity
<i>BM</i> , Buccinator muscle	<i>OE</i> , Oral epithelium
<i>BS</i> , Buccal sulcus	<i>OrG</i> , Orbital gland
<i>C</i> , Capillary	<i>OSMD</i> , Orifice of submaxillary duct
<i>CD</i> , Contents of duct	<i>PP</i> , Palatal process
<i>DA</i> , Dental anlage	<i>PS</i> , Plica sublingualis
<i>DM</i> , Digastric muscle	<i>S</i> , Septum
<i>EB</i> , Epithelial band	<i>SAbG</i> , Superior alveobuccal gland
<i>EC</i> , Epithelial comb	<i>SAL</i> , Sulcus alveolo-labialis
<i>EP</i> , End pieces	<i>SG</i> , Submaxillary ganglion
<i>EW</i> , Epithelial wall	<i>SM</i> , Submaxillary gland
<i>FA</i> , Facial artery	<i>SMa</i> , Sublingualis major gland
<i>GB</i> , Glandular bud	<i>SMaD</i> , Duct of sublingualis major gland
<i>GD</i> , Glandular duct	<i>SMD</i> , Submaxillary duct
<i>GeM</i> , Geniohyoid muscle	<i>SMi</i> , Sublingual minor gland
<i>GhM</i> , Geniohyoglossus muscle	<i>SSM</i> , Secondary submaxillary gland
<i>HyM</i> , Hyoglossus muscle	<i>SSMD</i> , Duct of secondary submaxillary gland
<i>IhM</i> , Infrahyoid muscle	<i>StgM</i> , Styloglossus muscle
<i>IL</i> , Intermediate sulcus	<i>StM</i> , Sternocleidomastoid muscle
<i>IM</i> , Internal pterygoid muscle	<i>T</i> , Tongue
	<i>V</i> , Blood vessel
	<i>WG</i> , Weber's gland