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WASHINGTON UNIVERSITY
Central Institute for the Deaf

STUDIES ON THE ANATOMY AND PHYSIOLOGY OF THE TONGUE

by

Jacqueline Keaster

A dissertation presented to the Board of Graduate Studies of Washington University in partial fulfilment of the requirements for the degree of Master of Science in Education

June, 1939

Saint Louis, Missouri

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CHAPTER I.
INTRODUCTION

-1-

Throughout the literature on the production of speech sounds one finds such statements as

From time immemorial the tongue has been recognized as the chief constituent of the mechanism of articulation.¹

Teachers of speech and speech pathologists working with articulatory defects of speech i.e. oral inactivities, oral inaccuracies, or sound substitutions, have gone on the assumption that the degree of a pupil's or a patient's difficulty depended largely upon the degree of malformation or malfunction in the muscles of the tongue. Exercises have been given to strengthen these muscles. More accurate positions have been striven for.

Many children develop an unintelligible, slovenly mumbling of sounds in their effort to speak. Upon investigation it is usually discovered that there is very little activity in the tongue muscles. The child is apparently unable to raise the tongue for the production of the anterior linguapalatal sounds, l, t, d, n, and their consonant combinations. There may be a physical defect known as tongue tie.....or there may be no physical defect but only a functional inactivity of the tongue due to a poor speech environment or poor speech training. As this condition is due to sluggish tongue muscles plenty of tongue exercises should be given to correct it.²

¹ Seth and Guthrie, Speech in Childhood, Oxford Univ. Press, 1935, p. 29

² Peppard, Helen, The Correction of Speech Defects, The MacMillan Co., New York, 1925, pp. 81, 82

In the last two years cases have been referred to the Speech Department of Central Institute for the Deaf which substantiate the opinion that proper functioning of the muscles of the tongue is necessary for the production of articulate speech sounds. There is, for example, the case of a young man twenty years old, who has been a private pupil since October 1, 1937. He has a tongue whose intrinsic muscles are completely inactive. His speech, when he entered Central Institute, was unintelligible. He could read very little. He had finished only the third grade in school because of his speech defect. His general health is good, he has good teeth and normal occlusion. His hearing is normal. He has always understood all that was said to him. He was given a performance test in March 1939. His I.Q. is 89.

The action of J's tongue muscles has improved very little with training. He cannot lift the tip of it to his teeth ridge or move it to either side of his mouth. His articulation has not made appreciable improvement. There seems to be a positive correlation between the tongue muscle spasticity and speech intelligibility. The lack of movement in the tongue seems to prevent articulate speech.

To cite another case, G who has been a day pupil in the Speech Department of Central Institute for the Deaf since September, 1936, has a tongue that is almost inactive. When he entered school he had no speech. He now has speech, but it is almost unintelligible. His general health is

good, he has normal hearing, normal eyesight, and understands all that is said to him. He has an I.Q. of 91. G has a very short memory span and poor manual dexterity. He cannot lift the tip of his tongue back of his upper teeth or move it from side to side. There seems to be again, a positive correlation between this child's lack of tongue movement and the unintelligibility of his speech.

Two brothers were recently brought into the speech clinic, one six years old, the other eight, whose cases are interesting as an observation on tongue muscle function. The six year old's frenum was cut for tongue-tie, but in the opinion of Goldstein, who examined the child's tongue, it was not cut back far enough. He has some free tip but not as much as is normal. He cannot lift it back of his upper teeth or move it from side to side. His speech is very difficult to understand.

The tongue of the eight year old boy has a frenum that binds the entire apex of the tongue to the floor of the mouth. It has no free tip whatever. The speech in this case is very easily understood. The boy has learned to lift the back of his tongue to his hard palate rather than lifting the tip to his teeth ridge when making l, t, d, and n. His voice quality is very nasal because he is producing his sounds posteriorly rather than anteriorly.

Three other cases have been observed that definitely do not bear out the opinion that articulate speech sounds are dependent upon the proper functioning of the tongue muscles.

PLATE I.

Fig. 1. Showing Preoperative Condition

Fig. 2. Showing Preoperative Condition

**Presented by Courtesy of
Dr. E.L. Keyes, St. Louis, Mo.**

Two of these were cases in which the entire tongue had been amputated at the hyoid bone. One operation was performed some twenty years ago. The speech of this patient is easily understood. The other tongue was operated eight years ago. The surgeon who removed it says:

The patient was seen when he was forty-nine years of age with a very bad carcinoma of the left-side of the tongue. In July 1931, I did a complete left-sided neck dissection and complete removal of the tongue. The neck wound was left open and he was fed with a feeding tube for several weeks. He had an almost uninterrupted recovery and the oral fistula from the mouth out onto the neck was closed some weeks later.

Since this time the patient has made a remarkable rehabilitation of his life, he is able to carry on his work as a plumber, is easily understood by anyone and completely understood over the telephone. He states that he has the same sense of taste that he always had and requires the same seasoning in his food. He has been issued three insurance policies and at this date, April 26, 1939, he is apparently in perfect health with no sign of local or distant lesion.³

A third case was observed in which the posterior third of the tongue remains on the left side. The surgeon who operated the case reported:

S aged sixty-one at that time, consulted me on January 15, 1937. Patient stated that he had sores on his tongue for about a year and a growth on his tongue for three months which was painful when he chewed. Examination at that time showed a large ulcer over

³

Brown, James Barrett, M.D., Personal Correspondence, April 26, 1939.

the anterior third of the dorsum of the tongue measuring 1.7 X 1.5 cm., involving chiefly the mid-portion and extending somewhat to the right. The margins were raised and pearly and the growth was papillary. There was a second similar area on the right margin of the tongue somewhat smaller.....On April 10, 1937, I amputated the tongue at Jewish Hospital. I removed all of the right half of the tongue and the anterior and middle thirds on the left, purposely leaving a portion of the posterior third of the left. Diagnosis by Dr. S.H. Gray of the Jewish Hospital Laboratory, on microscopic examination was carcinoma of the tongue. The patient made an uneventful convalescence from the operation and since that time has shown no evidence of recurrence.⁴

On February 18, 1939, Keyes demonstrated Mr. S's ability to speak with so small a residuum of tongue tissue before a meeting of "The Progressive Oral Advocates" held in the Auditorium of Central Institute for the Deaf. S was readily understood in the back of the room. His only defective speech elements were voiced and unvoiced "th".

(d) (c)

These three cases of tongue amputation present a speech situation that is completely contrary to the long accepted opinion that the tongue is the all important factor in the formation of consonant sounds. Two of the cases cited have no tongues at all, the other only a small residuum of tongue tissue, yet they speak fluently and articulately. Is the tongue----the facility with which it moves, its size, its shape, so important in articulation as has been thought?

⁴

Keyes, E. L. M.D., Personal Correspondence, April 5, 1939.

PLATE II.

Fig 3. Showing the Postoperative Condition
Tongue drawn back.

Fig. 4. Showing the Postoperative Condition
Tongue pretruded.

Little has been written in the field of speech or of medicine on the anatomy and physiology of the tongue that would apply to an explanation of this apparently paradoxical situation: articulatespeech in cases without tongues; inarticulate speech in cases with inactive tongues. This investigation is an attempt to answer the question of just how large a part must the tongue play in the articulation of speech sounds.

CHAPTER II.

HISTORY

Medical history contains more cases that deal with unusual speech adaptations than does the literature in the field of speech. Apparently there have been other such cases as the three cases of tongue amputation seen at Central Institute. A case was reported by Jussieu in 1718 which appears in the *Historie de l'Academie des Science* of congenital absence of the tongue, or Aglossia. This condition is thought to be due to failure of union of the projection from the inferior maxillary arch with that from the second pharyngeal arch. Jussieu made particular mention of the speech of the patient cited:

A girl of Allenteio in Portugal was seen at the age of fifteen. She had no tongue, but there was a nipple-like projection in the floor of the mouth three to four lines high. This was muscular and could be moved. Of the five functions of the tongue speech was so clear that no one could suspect the deformity; certain words were difficult, and she moved her head in pronouncing them. Certain consonants in the French alphabet were pronounced with difficulty, c, f, g, l, n, r, s, t, x, y, z; none of the vowels were included. Taste was apparently perfect. Mastication was difficult, as she could not clear the food from the cheeks and gums and had to use her finger to do this. Swallowing of food was easy if taken in small quantities; solids were negotiated, but the swallowing of the last part was difficult and she had to make it very fluid. She could spit with the aid of the mylohyoid muscle.⁵

Prinz and Greenbaum in commenting upon Jussieu's report says:

A small nodular elevation in the middle of the floor of the mouth took the place of the normal tongue. This nodule was moveable to some extent and assisted in speech that was not affected.....Loss of the tongue following some grave disease such as syphilis or carcinoma is not quite so rare as congenital absence of the tongue. Here also the chief difficulty is encountered in chewing and swallowing, while speech is usually not impaired.⁶

Kettner reported another case of aglossia with further error in development in "Deutsche Medizinische Wochenschrift" in 1907 in which he, too, calls attention to a lack of impairment in speech:

A boy with a cleft palate and a defect in the development of the hands and feet. A band stretched between the tongue and the bucco-pharyngeal membrane; this was divided. At the age of four the tongue appeared to be absent, but could be seen with a mirror as a three-cornered swelling far back in the mouth. He could pronounce the vowels and most of the consonants with the exception of "d" and "t."⁷

A divided tongue is occasionally seen as the result of accident or disease. According to medical opinion a congenital cleft of tongue does not interfere with speech. A case was cited by Bywater:

A man thirty-five years old, had a

⁶

Prinz and Greenbaum, Diseases of the Mouth and Their Treatment, Lea & Febiger, Phila., 1935, p. 426.

⁷

Fitzwilliams, Duncan, C.L. op.cit. p. 27.

Plate III
The Tongues of Whales

Figure 1-

Figure 2

Figure 3

Figure 4

tongue separated into two parts by a central depression extending backward for a quarter of an inch from the tip. From this depression a median groove (which was deeper near the bifid tip) extended backward on the dorsum of the tongue and also beneath it. The tongue was of normal size and healthy in appearance. The frenum was normal. The patient has had the deformity all his life.⁸

Another congenital malformation spoken of in the literature that does not apparently interfere with speech are supernumerary tongues. Seitz in the New York Medical Record for 1902 reported:

A Jewish boy aged five who had no family history of deformity, had beneath his tongue a rudimentary organ one inch long and a little broader than long. It arose where the tongue normally joined the floor of the mouth. The anterior end was blunt; the frenum was three-eighths of an inch thick. The smaller moved with the larger tongue and gave no trouble in talking.⁹

Gould and Pyle in "Anomalies and Curiosities of Medicine" quote a case of the Reverend Henry Wharton, Chaplain to Archbishop Sancroft, who, in his journal in the 17th century, says that he was born with two tongues and so passed through life. One tongue gradually atrophied. Apparently his speech was not affected.

The cases cited from the history of medicine do not, in any sense, prove that the functioning of the muscles

⁸

Bywater, H. Howard, "Case of Bifid Tongue," The Brit. Med. Jour., 154 1901, p. 1085

⁹

Fitzwilliams, Duncan, C.L., op.cit. p. 34.

of the tongue is not necessary in the production of articulate speech. They do, however, serve as a basis for asking the question: "With what muscles do tongueless people speak?" And further: "How is this speech adaptation made?"

CHAPTER III.

THE COMPARATIVE ANATOMY OF THE TONGUE.

Most writers have always considered the prime function of the tongue in man to be that of articulation. Yet animals as far down the evolutionary scale as some amphibians, the frog, for example, possess tongues with extrinsic muscles attached to a rudimentary hyoid bone, and intrinsic muscles innervated by the hypoglossal nerve, making the organ very comparable to that in man. Needless to say, frogs tongues do not function in articulation. Victor Negus in his book on "The Mechanics of the Larynx" makes a like observation concerning the larynx when he says:

The larynx is generally known as the organ of voice and yet it takes but a moment's reflection to observe that thousands of species which have a larynx, never or practically never, make use of voice.¹⁰

This study will present a compilation of some of the literature on the evolution of the tongue from fish through to the tongue found in man. It has been proved that articulate speech can be achieved without a tongue. Consequently this study will not commence with an "articulatory bias" but will trace the organ through the lower species and attempt to correlate the anatomical and physiological likenesses and differences with the tongue of man.

Little was found concerning the tongue of fish, other than that it is a very rudimentary organ. It consists of a fold of mucous membrane covering the basihyoid, which in higher vertebrates serves as the attachment for many lingual muscles.

¹⁰

Negus, V.E. The Mechanics of the Larynx, Wm. Heineman, Ltd., London, 1929, p. 1.

Taste is the only special sense not enclosed in a mesodermic capsule. The lowest form of the sense of taste is a nerve eminence in the integument of the lower animals. In bony fish these nerve eminences are scattered over the whole body and especially on the fins, the lip-folds and the mouth. In lung-fish they are found only in the mouth, pharynx and nose and are supplied by the facial, the glossopharyngeal and the pneumogastric nerves.

In the amphibian tongue there is greater range in structure than there is in that of the fish. In some, the tongue is almost absent; in others it contains intrinsic muscles and is innervated by the hypoglossal nerve. The tongue of the frog has both intrinsic and extrinsic muscles. The extrinsic muscles present are: 1. the hyoglossus and 2. the genioglossus. The intrinsic muscles are the transversus and the longitudinalis. The longitudinalis lies immediately beneath the mucosa on the dorsum of the tongue and is formed from the hyoglossus and the genioglossus. The transversus in frogs is not attached to the septum linguae. The tongue of the frog can be thrown out of the mouth with rapidity and with a hinge-like motion; bringing the food farther into the food channel than is possible with the tongue action found in other amphibians. Protrusion is accomplished by the action of the genioglossi and its retraction by the action of the hypoglossi.

The tongue of crocodiles, turtles and tortoises is

stronger than that in the frog but is less mobile. It is attached to the floor of the mouth.

In amphibians the sense of taste is in the papillae of the oral and the pharyngeal mucous membranes and on the jaws and tongue. The latter are the first to have taste function. The taste organs in the frog are flat discs and occur in hundreds on the tongue and soft palate.

The tongue of reptiles has parts found in the amphibian tongue together with a median growth, the tuberculum impar, a median lingual swelling in the floor of the mouth. The musculature is the same as that in amphibians with the addition of the verticalis and the longitudinalis inferior. In the lower part of the tongue lies the os-entoglossum which in higher mammals becomes the lyssa. (present in a dog's tongue.) The tongue lies in a sheath below the floor of the pharynx and is attached to the hyoid system which provides a firm support from which it can move. The tongue in most reptiles is used for protrusion and the capture of prey, but it is designed in such a way that its function ceases when it is drawn into the mouth. The trigeminal nerve appears in the reptilian tongue along with the hypoglossal and the glossopharyngeal.

In birds, the tongue has lost its lateral parts and with them the trigeminal nerve. It contains no intrinsic musculature. Birds' tongues vary greatly in form. They are scarcely an organ of taste as they are served by only a few filaments of the glossopharyngeal nerve and most of

the taste buds are in other parts of the buccal cavity.

In birds the distribution of the gustatory organs is apparently dependent on the size and form of the tongue: when the latter is narrow, they are situated on the thin glandular mucous membrane of the lower beak; and when it is broad on that of the upper beak or of the pharynx. The arrangement is irregular and their number varies greatly in different groups, being greatest in parrots in which their structure resembles that of mammals.¹¹

A bird's tongue is controlled by the usual hyoidean muscles plus four other pairs: the cerato-hyoideus muscle which passes from the thyrohyal and to the urohyal and is subservient to the lateral movements of the tongue. A singular pair of muscles, the cerato-trachealis, arises from the trachea twists four times around it and then passes forward to be inserted into the base of the thyrohyals. It is the principal retractor of the bird tongue.

Parrots have the largest tongues among birds due to fat vessels and glands rather than to any special muscular development.

The Evolution of the Mammalian Tongue.

It is generally accepted that the evolutionary history of the mammal tongue must be traced back to a group of cynodont reptiles. There are no fossil tongues so that the characteristics must be deduced from a wide view of the vertebrates. Sonntag suggests that the first tongues must

¹¹

Wiedersheim, Robert, trans. by Parker, W.N. Comparative Anatomy of Vertebrates, MacMillan and Co. Ltd., London, 1907, pp. 254, 255.

have been a simple plate traversed near its lower surface by an os entoglossum. The musculature must have been simple. The mucous membrane probably had gland cells and nerve endings that were tactile in function. The papillae must not have been prominent and were mainly conical. The mammalian tongue was evolved out of the reptilian tongue by an increase in its musculature and papillary structure. The increased musculature, principally the addition of the genioglossus and the lingualis inferior thickened the tongue. The os entoglossum and the lower part of the reptilian tongue became the lytta and the sublingua. These structures proceeded to disappear in various orders. Some orders retained both, others retained the sublingua, or the lytta, others eliminated both. The lytta became absorbed into the undersurface of the tongue. In many orders there is no trace, as a rule, of the sublingua in an adult, but its occurrence in the foetus and the very occasional appearance of remnants in young animals shows a condition that once existed.

Mammals differ from the lower vertebrates in mastication, in insalivation, and in their licking power. The movements in these actions have led to the emergence of the mammalian tongue and to its further development after it evolves.

General Characteristics of Mammalian Tongues.

Mammalian tongues, as a class, differ greatly in shape. They may be conical, oval, spatulate, triangular

or veriform.

The greatest width is usually between the attachments of the two faucial pillars; in spatulate tongues it is usually farther forward. The length is measured from the apex to the mid-point of the glosso-epiglottidean fold. The tongue is divided into three regions anatomically; the oral part, which is measured from the apex to the median circumvallate papillae; the pharyngeal part that is measured from the median circumvallate papillae to the glosso-epiglottic fold; the part from the mucous fold of the tongue to the epiglottis is sometimes talked of as the third zone.

The apex of the mammalian tongue may be round, flat or pointed, entire or notched. It may be small, narrow and deep or wide and shallow. It always bears papillae, though they are not always visible. When the tongue is protruded in most animals the apex is seen. The elephant is an exception. The apex is bound down to the floor of the mouth and a piece of the anterior part of the dorsum takes its place.

A median fissure may or may not be present in the mammal tongue. It may be continuous or interrupted. There may only be a separation between two lateral masses of conical papillae or it may indent the mucous membrane. The median fissure may be restricted to the front middle and back of the tongue; it may be narrow throughout or widened from before backward. The inferior surface of the tongue

like the dorsum may possess a median fissure or ridge. It is narrow and deep or broad and shallow. It may end abruptly or open into a triangular depression into which the frenum passes. In the kangaroo there is a firm hard median ridge passing back from the apex to the frenum.

Transverse ridges and fissures that appear in tongue specimens may be real or artificial. Artificial ones are those that appear in material after it has been in a fixative. One must examine fresh material to ascertain the presence of true transverse fissures. They are regular and symmetrical; complete or incomplete; straight or curved, with their convexities running forward.

The arrangement of the papillae on mammalian tongues varies. They are of three kinds: circumvallate papillae, fungiform papillae and conical papillae. At the sides are fissures and intervening laminae termed foliate papillae or lateral organs. These latter are not always present. The circumvallate vary in number from one to twelve. They are the largest and the fewest of the papillae and are usually arranged in a single row. Papillae may be above, flush with or below the dorsum of the tongue. The protruding type is commonest. They may be round, oval or keeled. Their surface may be smooth, polished and glistening or granular.

The tongue of the Badger has an interesting vallate region. It is colored brown. The papillae appear to be beneath the surface and shine through the mucous membrane, which

looks as if it were composed of transparent mosaics.¹²

The fungiform papillae on the tongues of mammals are more numerous than the circumvallate. They are bright red in color and vary in appearance, number and arrangement. They are small globular bodies lying in depressions of mucous membrane. They are sessile or pedunculated. The fungiforms lie close to the attachment of the faucial pillars on the dorsum. In the dog, the fungiform papillae are difficult to see.

The conical papillae are the most numerous of all the papillae. They vary more in distribution, size and form than do any of the others. In some primates they are restricted to the oral region, but in most mammals they appear on both the oral and pharyngeal regions. The papillae on the two parts sometimes differ histologically. They are ordinarily found in clusters behind the apex and dotted over the whole dorsum.

The functions of the papillae are many. Taste is not one of them. Papillae are tactile, retentive or mechanical, the function differing in different animals. They are assisted by the shape of the mouth, the nature and strength of the lingual muscles and the ridges and tubercles on the soft palate.

On the inferior surface of the tongue are found:

¹²

Sonntag, Charles F. "The Comparative Anatomy of the Tongues of Mammalia" Proc. of the Zool. Soc. of London, 1920 p. 121.

the papillary border, the mesial furrow or ridge, the frenum, and the openings of the sub-lingual glands. The papillary border may go all around or be interrupted at the apex. The frenum extends from the posterior end of the free part of the inferior surface of the tongue to the floor of the mouth. It originates from the plane surface of the tongue or from the bottom of the triangular depression. It varies greatly in length.

On the under surface of the tongue and sometimes within its substance is the remains of the glosso-hyal cartilage known as the lytta. It varies in situation and character. It is developed especially in the dog and aids in lapping. It is very elastic.

The Tongue of the Cetacea (Whale)

The tongue of the whale is the simplest of all mammal tongues. It is almost comparable to the tongue of fish and crocodiles. This is thought to be because all mammals, but whales, masticate. Lower vertebrates do not masticate. Consequently there is no reason for the whale tongue having developed beyond the lower vertebrate level.

In the toothed whale the tongue is firm, hard and muscular; the upper surface feels like parchment. In the Baleen whale the tongue is soft and has a great amount of fat or oil that separates the mucous membrane from the muscles. Some authors have likened it to a sack of blubber. The tongues of the former variety are more mobile than those of the latter. In the one the tongue is an organ of prehension;

in the other it is a passive organ; the food simply flows into the open mouth.

The type of tongue is due to the method of feeding. When the whale feeds it swims with considerable velocity under the water with its mouth wide open; the water enters by the fore-part but is poured out again at the sides and the food is entangled and sifted by the whale-bone that does not allow anything to escape.¹³

The mobility of the tongues of toothed whales varies. In one order it is great because the free part extends back to the fourth interdental arch. In another the apex is bound to the mandibular symphysis by a fold of mucosa. The edges of the apex are free. In a third order the tip is mobile from side to side. In all orders the tongue is more mobile in the new-born animal than in the adult. The shape of the tongue is comparable to that of most other mammals.

The apex of the whale tongue varies considerably in different orders. In some it is full and rounded, in others it is not so full and has warty processes and growths protruding from the epithelium. In still others, it has a smooth surface and is pointed. In most cases there are no median or dorsal sulci present.

The inferior surface of the tongue, in many species, is corrugated and may rest on a kind of a cushion formed by mucosa in the floor of the mouth. The degree of corrugation

¹³

Sonntag, Chas. F. "Comparative Anatomy of the Tongues of Mammalia," Proc. of the Zool. Soc. of London, 1922, 2, p.243.

found varies with the age of the animal. In one order a thick fold surrounds the tongue below the apex. The whale tongue, while being very deficient in muscular development, has a more highly developed glandular system than any other mammal. The orifices of innumerable oil glands appear on the inferior surface. They vary greatly from one order to another in their extent and prominence.

In most orders of whale the papillae are scanty or absent altogether. Those that do appear are almost always tactile or mechanical. The sense of taste is absent or very slight. It is more deficient than in any other mammalian order. It is because the gustatory and mobile functions of the whale tongue are so deficient that it is the lowest mammalian tongue in the evolutionary scale. Authorities differ as to whether it is the result of lack of evolution or of degeneration.

The Tongue of the Rodents

The tongue of the rodents is a great deal more complicated than that of any of the whales. The rodents, as an order, are very diversified but their tongues do not differ very widely. They are all very thick, and have short frenae. The tongue fills the mouth closely and is, in many cases, divided into a low anterior part and a raised posterior interdental eminence.

The Squirrel's Tongue

The tongue of the common ground squirrel is long, narrow, thick and tapering. The free part is moderately long.

Plate IV
The Tongues of Rodents

Figure 5
The Tongues of Squirrels

Figure 6

A, B, The Tongue of the Beaver
C, The Tongue of the Dormouse

The oral part comprises more than the anterior two-thirds of the dorsum. On the squirrel's tongue there is no intermolar eminence. The apex is round and devoid of a notch with thick lateral borders.

There are three circumvallate papillae arranged in a triangle on the posterior part of the dorsum. The tongue is richly supplied with taste-buds whose nerve supply has been traced into the epithelium.

On the inferior surface there are the openings of many glands. There are no traces of frenal lamellae, sublingua, plissae fimbriatae, or lytta.

The Beaver's Tongue

The tongue of the beaver is relatively shorter, broader and thinner than that in the squirrel. There is a low, broad intermolar eminence extending across the tongue in its posterior part. There are three circumvallate papillae just as in the squirrel and numerous fungiform papillae. The entire base of the tongue is covered with glands both mucous and serous. The apical gland of Nuhn, which is present all of the way up the evolutionary scale, first appears in the tongue of the beaver.

The Tongue of the Dormouse.

The dormouse has a tongue that is small, narrow and thick. The oral part makes up more than two-thirds of the dorsum. The apex is rounded and has no notch or prominent papillae. On the inferior surface the frenum is short and has no frenal lamellae. But, there is a very well developed

Plate V.

The Tongues of Rodents (continued)

Figure 7

The Tongues of Mice and Moles

Figure 8

Rat-like Animals from South America

Sonntag, Charles F.

Proceedings of the Zoological Society of London, 1924; vol. II.
Figures 33 and 34; pps 730 and 733

sublingua in the form of a soft, flat plate extending back from the apex to the frenum. The dormouse is the only rodent that has a sublingua.

The Tongues of Rats, Mice and Muskrats

The tongues in these little animals are long, narrow and thick. Their oral parts are long, while the base is short. The apex is thick, rounded and devoid of a notch. No prominent papillae of any kind appear on the apex. There is an internolar eminence in most species.

Most rats, mice, and muskrats have a single, median circumvallate papilla. It is usually of considerable size and forms an obstruction in small tongues. This single papilla is rounded or flattened and covered with secondary papillae. Taste buds have been observed on the upper surface of the secondary papillae in many species. They receive their nerve supply from a large encapsulated ganglion within the papilla. The fungiform papillae are scanty. The conical are numerous, minute and close together.

On the inferior surface of the tongue there is no trace of the sublingua, plica fimbriatae, frenal lamellae, lytta or apical gland of Muhn.

The Tongue of Moles

A mole's tongue is long, narrow and thick. On the anterior surface there is a median dorsal sulcus; and on the posterior surface a flat internolar eminence. Three circumvallate papillae are present rather than just the one found on the tongue of rats and mice. The fungiform papillae

Plate VI.

The Tongues of Rodents (concluded)

Figure 9

The Tongues of Porcupines

Figure 10

Figure 11

- A. Cavy
- C. Chinchilla
- D. Aquatic Cavy
- E. Rabbit

Figure 12

are scanty, while the conical are numerous, simple, and very close together.

The Porcupine's Tongue

In all types of porcupine the tongue is long, narrow and thick. It has a rounded apex that may have a notch. In this rodent two circumvallate papillae are found on the posterior part of the dorsum. In some species there is a flat, horny plate on the anterior surface.

The Tongue of the Guinea Pig

The largest rodent tongue is found in the guinea pig. It is long, narrow and thick in the anterior half, but is wide and thick at the base because the intermolar eminence is encircled by a transverse sulcus. The apex is rounded and has no notch, or prominent papillae. The lateral borders of the guinea pig tongue are massive. The intermolar eminence is covered with innumerable papillae. The most peculiar characteristic of this rodent tongue is that it has no circumvallate papilla at all. At least one appears in all other mammals.

The Rabbit's Tongue

The tongue of the rabbit is spatulate in shape. The intermolar eminence is long, prominent, and pointed. Unlike the intermolar eminence on the tongue of the guinea pig, the one on the rabbit's tongue is narrower than the tongue itself and consequently does not add to the width of the tongue at the base. Two circumvallate papillae appear on this rodent tongue. The fungiforms, as on the tongues of

all other rodents, are scanty and minute. The conical papillae are also very small.

The Tongues of the Edentata

Anteaters and sloths comprise the order edentata. Their tongues are characterized by extrinsic muscles with a high degree of specialization and glands and gustatory organs with a slight or moderate degree of development. Their mobility is greater than that of all other mammalian tongues. The mobility is designed for prehension and for mechanical action on food.

The tongue is long, in some, and not flattened anteriorly; in some other species the tongue is long, flat and triangular; and in a third type it is short with the usual mammalian form. The apex in the order edentata bears peculiar globular or pointed organs; in different species it has a varied form. In some it appears as a globular expansion of the whole apex, in others it takes the form of a button-like structure attached to the center. Some authors say that these are sense organs, others that they are definitely gustatory in function.

In some species of edentata there are two sharp processes with their ends directed forward and inward beneath the apex. They receive prolongations of the lingual musculature. Their function is probably to capture and grip food.

In the scaly anteater there is a median dorsal sulcus in the form of a wide shallow groove on the flattened anterior part of the tongue. Another species has a fine groove running along the greater part of the dorsum.

Plate VII.

The Tongues of the Edentata

Figure 13
The Tongue of the Great Anteater

Figure 14
The Armadillo

Figure 15
The Scaly Anteater

In edentata with long, veriform, protrusible tongues, there are sheaths into which the tongue can be retracted. In the scaly anteater it is in the form of a corrugated cuff-like sheath.

All species of edentata have two circumvallate papillae. They are circular with the apex of the cone attached to the tongue. The surface of the papillae is smooth or granular. Close examination shows that when the surface appears to be granular it indicates the presence of secondary papillae. The long axes of the taste buds seem to run downward and outward toward the fossae which pass under the base of the cone-like papillae.

The lytta is present in the manis or scaly anteater. It is as large as it is in many carnivora.

The frenum is short in all edentata.

The Tongues of the Insectivora

In all insectivora, moles, hedge-hogs and like animals the tongue is very simple. It is long and narrow and the free part is of considerable extent. The dorsum usually thickens gradually from before backwards, but its thickness is never greater than its length. The oral part of the dorsum is long, the pharyngeal part short, in all species.

The apex in the tongue of the insectivora varies in shape. In some it is rounded, in others it is truncated, and in still another species it is pointed. It is usually devoid of a notch. The lateral borders are rounded.

There is no median dorsal sulcus on the tongue of the

insectivora, but transverse ridges and sulci may be present or may be produced by the impression of the palatal rugae on the tongue. In all species there are two or three large circumvallate papillae arranged in a triangle.

The frenum is short in all species. In some the lytta is well developed. It is composed of muscle fibers, fat and fibrillar tissue but no cartilaginous elements are present.

The Tongues of Carnivora (beasts of prey)

Felidae (cats)

The tongues of these beasts, the lion, the tiger, the jaguar, the wild cat, the hyena and others, are long and comparatively narrow. The tongues of the lion and the tiger are wider than the others. They thicken progressively from before back. The free part is never very thick.

The apex is rounded in all species, but usually devoid of a notch. It has small conical and fungiform papillae on its surface but they do not stand up very prominently. There is no large cluster of papillae containing taste-buds as is found on the tongue of the primates.

The base of the tongue is usually close to the epiglottis with the exception of the lion and the jaguar. In these two animals there is a long stretch of mucous membrane between the base of the tongue and the epiglottis. This large space is associated with the roaring habits of these animals.

Plate VIII
The Tongues of Cats

Figure 16
The Tiger

Figure 17
Felis caracul, *felis sylvestris*
felis caffra

Figure 18
The Earth wolf; the Hyena;
Nandinia binotata (W. Africa)

The papillae in many species have thick, sharp, or round horny sheaths that have a mechanical action on the food.

Cynoides (dogs, wolves, foxes)

The general form of the tongue is the same in this group of carnivora as in the cats. The number and kind of papillae vary.

The dog tongue is wide and thin in front and very mobile. It is deep red in color with a dorsum that has a wide median groove. In the inferior part of the tip there is a fusiform cord composed of fibrous tissue, muscular tissue and fat. In the large dog it may be two inches long. It is called the lyssa or sublingua and is supposed to correspond to the last vestige of the tongue of lower vertebrates which has been replaced by the more highly developed tongue. A remnant can be seen in the human tongue just after birth.¹⁴

In the dog and the common fox serous glands surround the circumvallate papillae and mucous glands cover the base of the tongue. The frenum is well marked in all species. The median glosso-epiglottic fold may run forward for a considerable distance onto the pharyngeal part of the tongue. The lytta is well marked in all cynoides.

The Tongues of the Ungulata

The tongues of the hoofed mammals or ungulata are long, comparatively narrow and very mobile. The tongue in the rhinoceros, is an exception, being broad and flat. The

¹⁴

McGregor, Gregor, "Comparative Anatomy of the Tongue,"
Annals of Otol., Rhinol. and Laryngol., March 1933,
47, p. 200.

tongue of the giraffe has the greatest mechanical power of any mammal.

The giraffe's tongue is very extensible, flexible, and deeply pigmented. He is able to twine his tongue around small objects. The muscles are the same as in other mammals; the difference is in the great extent of the organ anterior to the insertion of the genioglossus. The intrinsic muscles are less closely interwoven which allows for more separated action.¹⁵

The apex of the tongue in the hoofed animals may be truncated, pointed or rounded. The anterior part is flat and very mobile in most species. Posterior to the apex is the intermolar eminence, found also in the tongue of the little rodents, which serves to raise the food to the molar teeth. The intermolar eminence is entire in all species but the rhinoceros where it is cleft. In the horse it is low and flat, but well marked. Ungulata have well developed salivary glands but few lingual glands. The tongue of the giraffe has more papillae than any other mammal.

The frenum in the ungulata is always present and permits the tongue to be very mobile with the exception of the elephant whose apex is bound down to the floor of the mouth. The tongue of the hog has a double frenum.

¹⁵

McGregor, Gregor, op. cit., p. 201.

The Tongues of the Anthropoid Apes

The Chimpanzee

Of the three tongues examined one was fresh, one was from the society's prosectorium and the other from the museum of the Royal College of Surgeons. The fresh specimen was a female from South West Africa.¹⁶

The measurements of the fresh tongue were: total length 9.1 cm; the length from the apex to the anterior median circumvallate papilla was 6.1 cm; from that papilla to the epiglottis 3.0 cm. The width between the attachments of the faucial pillars was 4.5 cm; the width of the apex was 3.0 cm; the thickness in the region of the antero-median vallate papilla was 3.5 cm; the thickness of the apex was 3.0 cm. The tongue of the chimpanzee, taking these measurements into consideration is long and narrow. The width does not decrease greatly from the base to the apex. The elongated form of the tongue is said to be due to the shape of the mouth.

The antero-median circumvallate papilla stands a short way from the top of an elevation whence the dorsum slopes toward the base and the apex. The declivity is greater toward the base. The chimpanzee in this respect is preeminent among anthropoids. The degree of slope varies in individuals. The apex of all anthropoid tongues is blunt and may or may not have a notch. In the three tongues examined by Sonntag only the fresh specimen had a notch.

¹⁶

Sonntag, Charles F. "The Comparative Anatomy of the Tongues of Mammalia," Proc. of the Zool. Soc. of London, 1921 p. 3.

Plate IX.

The Tongues of the Anthropoids

Figure 19
The Chimpanzee

Figure 20
The Gorilla

The apex is roughened by conical papillae and tuberculated by large prominent fungiform papillae. The size of the latter type varies in individual tongues. They are always numerous.

The mesial sulcus may be present on the dorsal and inferior surfaces. It is usually irregular. On the base of the tongue the median row of circumvallate papillae is situated on a depressed row of mucosa which is bounded by large papillae and lymphoid nodules. There are always eight circumvallate papillae arranged in the form of a "V". They have granulated surfaces.

The base of the tongue contains much lymphoid tissue which gives the surface a lobulated appearance. The lymphoid nodules vary in size; the larger ones have a small central pit.

The inferior surface of the tongue of the chimpanzee presents a mesial sulcus, the papillary border, the frenum and the sublingual fold. The frenum is short and thick. It runs from the sublingual fold to the under surface of the tongue.

The Tongue of the Gorilla

There is not such a great disproportion between the length of the tongue and its width in the tongue of the gorilla as there is in that of the chimpanzee. It is comparatively broad, appearing almost rectangular. It slopes gently from the circumvallate papillary region to the apex and more steeply to the epiglottis.

Plate X

The Tongues of the Anthropoids (Continued)

Figure 21
Simia Satyrus (orang outan)

Figure 22
The Siamang

The apex of the tongue of the gorilla is square-cut and has no mesial notch. It bears conical and fungiform papillae in thick clusters. The medial sulci are present on the dorsal and inferior surfaces. On the dorsum it is wide and shallow and terminates in a pit at the antero-median papilla. There is no median sulcus on the base of the tongue. The median inferior sulcus begins in front at the posterior edge of the papillary zone and runs back, widening as it goes, and terminates in a triangular pit into which the frenum passes. On the anterior two-thirds several transverse sulci are present.

The Orang Outan

The tongue of the orang outan resembles man's in the proportion of its length to its width and in certain structural peculiarities. Preserved specimens were examined from the Royal College of Surgeons.¹⁷

The apex of the orang outan tongue is round and has no mesial notch. It has conical and fungiform papillae on its surface. Both forms are small. The lateral borders are massive with both conical and fungiforms papillae. The dorsum has no median or transverse sulcus.

Papillae cover most of the surface of the dorsum, and a bounding zone on the inferior surface. The fungiforms are very small. A double row forms a prominent arch around the anterior extremity of the frenum. Conical papillae are

¹⁷

Sonntag, Charles F., ibid., p. 21.

a marked feature on the anterior two-thirds of the dorsum. They increase in size from before backward, and from without inward. They are arranged in clusters, transverse rows and oblique chains. The base of the tongue is devoid of long conical papillae present in other anthropoids. In this respect the orang's tongue resembles man's.

The orang agrees with man and differs from all other anthropoids in the possession of the Apical Gland of Muhn, or the anterior lingual gland.

Finally, on the inferior surface of the tongue on either side of the frenulum, near the apex, are the anterior lingual glands. In man, each is about fifteen mm. in length, and is composed of a group of racemose glands with about five very small ducts opening on the surface between the anterior portions of the plicae fimbriatae. The anterior lingual glands are deeply placed and are covered not only with mucosa, but also by longitudinal muscle fibers. The gland is of mixed type, though chiefly mucous.¹⁸

The tongue of the orang outhan resembles the tongue of man in several respects:

1. It is like in general proportions.
2. It has a rounded apex.
3. The circumvallate papillae are arranged in a "V" pattern.
4. It has no long conical papillae on its base.
5. It has a well marked frenum.

¹⁸

Jackson, C.H., Morris' Human Anatomy, P. Blakiston's Son & Co., Phila. 9th Ed. 1933, p. 1203.

Plate **XI**

The Tongues of Anthropoidea (concluded)

Figure 21
The Hylobates Hoolock

Figure 22
The white-Handed Gibbon

6. The orang's tongue possesses a sub-lingual fold.
7. It possesses the Apical Gland of Nuhn.

The Siamang

The tongue of the siamang is long and narrow. The distance between the antero-median vallate papillae and the epiglottis is greater than in other anthropoids. The apex is rounded and devoid of a notch with its surface covered with conical and fungiform papillae. The lateral borders are full and rounded. Papillae are present on the apex, the lateral borders, the entire anterior two-thirds of the dorsum, and the sides of the posterior one-third. On the posterior one-third of the dorsum there is a large central area, devoid of papillae.

There are five circumvallate papillae arranged in a "v". There are no lymphoid nodules on the base. The frenum is short and runs from the floor of the mouth to a triangular depression on the inferior surface.

The Hoolock Gibbon

The tongue of the hoolock gibbon is short, compact and rough. It tapers from the base to the apex. The tongue of the hoolock gibbon has no non-papillary region, at the base. There are four circumvallate papillae on this tongue. The frenum is of moderate length.

The Bornean Gibbon

A fresh specimen was examined; a female. The tongue measured 6.5 cm. in length; and 2.8 cm. in width from the attachment of the faucial pillars. The tongue, was long, narrow and

pigmented. The dorsum, in front of the vallate papillae is bluish black in color and glistening bluish black papillae appear prominently. Their color is darker than the dorsum itself. The dorsum behind the vallate papillae is white. The inferior surface has a central unpigmented surface shaped like a spearhead.¹⁹

A median sulcus is present in the tongue of the Hooleck Gibbon, both on the dorsum and on the inferior surface. The inferior surface is surrounded by a papillary border that is rough to the touch. There are three circumvallate papillae arranged in a triangle. At the base of the tongue there are large conical papillae. Their surfaces are granular. The frenum in the tongue of the Bornean Gibbon is short and thick.

The Tongue of Man

The previous section dealing with anthropoids leads to a detailed discussion of the tongue of man. Anatomists consider that Merkel's Work "Anatomie und Physiologie des Menschlichen Stimm-Und Sprach-Organen" includes the most authoritative account yet presented of the anatomy and physiology of the tongue of man. His chapter dealing with this organ has therefore been translated for this paper.²⁰

The tongue can assume more different movements, shapes, and positions than any

¹⁹

Sonntag, Charles F., op. cit., p. 23.

²⁰

Merkel, Carl Ludwig, "Die Zunge," Trans. by Tikvah Alper Sterne, Anatomie Und Physiologie des Menschlichen Stimm-Und Sprach Organen, Verlag, Von Ambrose Abel, Leipzig, 1863 pp. 227-240.

other organ in the body. It is located between the inner surface of the chin and the hyoid bone. It is hardly ever protruded in speech.

The genioglossus muscle is the largest and most complicated tongue muscle and forms to a large extent the base of the entire organ. It spreads out into a vertical surface along the length of the tongue. It originates from a perpendicular, rough, oval, tubercle on the inner surface of the chin by means of a band of short, sinewy, spread-out fibers. The muscle fibers arise from, and next to this band, and then form a cord which is five to six lines ('''') thick and flattened laterally. This cord is divided clearly into bundles of fibers and passes into the body of the tongue from below and spreads out fan-wise to the tongue-tip. The lowest of these fibers lie on the genio-hyoid muscle and run parallel with the fibers of the latter, perpendicular to the hyoid. Anteriorly the muscles of both sides, to a depth of a few lines below the back of the tongue, are bound together by simple cellular tissue which further back becomes fatty tissue. In the posterior third of the distance between the chin and the hyoid, the fibers meet and merge. The lowest fibers broaden out somewhat at this point in the perpendicular and are thus attached to the hyoid over the whole superior half of the anterior area. The adjacent fibers are attached partly to the small cornu of the hyoid, and according to Kelliker and others, some of the fibers (known as the levator epiglottidis Morgani, glosso epiglottius Heister) are attached to the anterior surface of the epiglottis. Still further along laterally, the fibers merge into the glosso-pharyngeus. The bulk of the whole muscle passes between the median section and the edge of the tongue and fanwise toward the back. This muscle, therefore, occupies the middle of the tongue from its tip to its posterior root, and forms a long, fairly wide, compact mass of tissue.

In the tongue itself, the fibrous bundles of the genioglossus are separated by the inferior edge of the lingual septum. Here and there some of the fibers join and cross over.

On both sides the fibers lie in the form of thin lamellae near together, but separated by the fibers of the Transversus. These lamellae are vertical, for the most part, but some are slightly crimped anteriorly and posteriorly. They disappear toward the back of the tongue. This arrangement into lamellae is most clearly seen in the anterior two-thirds of the tongue. There the fibers terminate in the mucous membrane. The fibrous bundles continue in groups in the mucosa in the form of sinewy bands of connective tissue. These merge partly into the firm inferior layer of the mucous membrane and partly into the base of the papillae. In the posterior third of the tongue, however, where the circumvallate papillae are present, the bundles reach to the mucous membrane only in the median line and then only in isolated bundles. At the root of the tongue the muscle fibers do not extend to the mucous membrane at all; they terminate at and among the lingual glands; being connected together by bands of connective or fibrous tissue. These fibers that reach to the tongue tip turn over in the form of an arch.

Outside and beneath the genioglossus lie the lingual gland, the mylohyoid, the longitudinalis inferior, the hyoglossus, and the styloglossus. The geniohyoid lies immediately below the genioglossus.

The function of the genioglossus is fairly complex since the individual bundles are differently placed and can act either singly or together. These fibers, which are attached to the hyoid, draw this bone forward and so work in conjunction with the geniohyoid in the act of swallowing and in various movements in phonation and in stretching the tongue. On the other hand, the fibers which spread out in the anterior part of the tongue serve to draw the outstretched tongue back into the mouth. Those fibers that are attached to the epiglottis assist in raising it. If the whole muscle is functioning at once the tongue will be depressed to the floor of the mouth as in swallowing and in the production of certain phonetic elements. At the same time the opening from the oesophagus into the mouth will be widened and the tip of the tongue drawn back somewhat from the edge of

the teeth and curved slightly downward. The genioglossus works in conjunction with the geniohyoid and the transversus when the tongue is stretched out.

The hyoglossus muscle is a thin muscle roughly square in cross section. It arises as fleshy tissue from the superior edge of the lesser cornu of the hyoid. (This part is known as the keratoglossus muscle.) Another part rises from the exterior part of the body of the hyoid next to the point of insertion of the geniohyoid. (This part is sometimes known as the baseoglossus.)

Those bundles of fibers which arise from the lesser cornu were considered by earlier anatomists to be an integral part of the hyoglossus. Zaglas considered these fibers as a separate muscle which he called the chondroglossus. All of these fibers run upward and curve first toward the outside of the tongue and then toward the inside. The anterior fibers are about two inches along their free length, the posterior fibers about one inch. The hyoglossus plays the same role at the side of the tongue as does the genioglossus in the middle. At the inferior surface of the side of the tongue the fibers in the thickest bundles, the baseoglossus, merge into thin laminae which run between the layers of the transversus. The lamellae of the hyoglossus border on those of the genioglossus and are very similar except for the direction of their fibers passing upward toward the back of the tongue. In the hyoglossus they slant and curve slightly inward. In the back of the tongue the hyoglossus lies between the genioglossus and the superior edge of the transversus. It forms longitudinal layers with perpendicular fibers between which lie the superior longitudinal fibers. These fibers of the hyoglossus also end in the mucous membrane. It is not very clear how the hyoglossus spreads out posteriorly, in the area where the weaker fibers of the baseoglossus lie. They lie more or less horizontally, and end in the back of the tongue. The most anterior fibers disappear in the point of the tongue. They run over the fibers

of the longitudinalis inferior and the styloglossus and disappear just before their union at the edge of the hyoglossus.

In the tongue itself, the hyoglossus lies between the longitudinalis inferior on the inside and the styloglossus; it also borders inferiorly on the glossopharyngeus and the end fibers of the hyopharyngeus at the hyoid bone. It is covered by the digastricus and the styloglossus. Considered from before and below it lies over the mylohyoid.

The functions and directions of this muscular system are not as simple as the usual descriptions make them seem. It is the most active agent in keeping the tongue in a curved position. The curvature increases in swallowing, serving the purpose of closing the aperture of the larynx. I confess, I have not been able to form a clear picture of just how this muscle works.

The Muscle Transversus Linguae forms the actual core of the tongue. It consists of numerous lamellae to be found on both sides of the tongue. These lamellae form regular layers between the perpendicular layers of the genioglossus and are to be found in all sections of the tongue. Each lamellae is from one to six lines in thickness and stands about three quarters lines high in the middle of the tongue. Each lamella is a perpendicular leaf of muscle fiber stretching from the septum to the side of the tongue. The lamellae arise directly from the total depth of the septum, arising partly by means of sinewy tissue which is not really part of the longitudinal fibrous tissue of the septum. The fibers of the transversus are divided into small, flat bundles and run at first straight toward the edge of the tongue, the short superior fibers bending upward run to the side of the tongue at the back. The longer inferior fibers reach the edge of the tongue and run into the mucous membrane to which they are connected by small bands of cellular tissue. The latter fibers, therefore, describe a curve which is convex downward and outward. The lamellae of the

transversus run between the lamellae of the genioglossus and the hyoglossus. The lamellae, however, do not run continuously from their origin to their end. Some of the fibers are divided into small bundles, which, after leaving the original lamellae, pass through and between the lamellae of the other two muscles, thus making a network of fibers.

In vertical, longitudinal cross-sections the lamellae of the genioglossus are interconnected and the lamellae of the transversus separate into numerous, small, flat, superimposed bundles. For the rest, the transversus lies between both longitudinal muscles of the tongue; roughly in the same region where the genioglossus and the hyoglossus are to be found.

The function of the transversus is to make the tongue narrow and pointed at the same time hollowing it along the median and the longitudinal line. The muscle also functions in pressure movements against the the hard and soft palate. When the tongue becomes narrower it is also longitudinal and if the hyoid bone is at the same time drawn forward and the mouth opened, the tongue is thrust out.

The Inferior Longitudinal Muscle, to be called simply the Lingualis between the genioglossus and the hyoglossus on the under surface of the tongue and is a fairly strong bundle of fibers about two inches in length. The beginning and end of this muscle are not easy to determine. The posterior part consists of flat, superimposed bundles which disappear between the transverse fibers of of the genioglossus where the latter merges into the glossopharyngeus, into the styloglossus and into the transversus at the root of the tongue. Anteriorly, the longitudinalis unites with the stronger bundles of the styloglossus, and ends at the tip of the tongue. It is in the form of numerous, thin, weak lamellae running between perpendicular fibers. Its behavior at the edge of the anterior third of the tongue is the same as that of the hyoglossus further back.

The function of the lingualis muscle is to shorten the tongue in the longitudinal direction and to draw the tongue tip backwards and to some extent downwards. It is possibly active in curving the tip as well. It does not appear to cause any movement in the back of the tongue; this region should rather be considered as the point of insertion of the greater mass of the muscle, and it is from here that its contractions in the anterior part of the tongue take place.

The muscle called the Longitudinalis Superior is a layer of longitudinal muscle fibers covering the whole back of the tongue lying between the superior fibers of the transversus and the mucous membrane.

Its origin is at the chondroglossus muscle, a muscle ignored by nearly everyone. The chondroglossus is a fairly strong bundle of fibers arising from the lesser cornu of the hyoid. It is separated at its origin from the baseoglossus and the keratoglossus by the arteria lingualis and the glossopharyngeal nerve, and remains separate from the latter two muscles. It must be distinguished from the hyoglossus throughout its length. Earlier anatomists also mentioned the asymmetrical muscle, the glosso-epiglotticus, though its existence has been ignored by later workers. According to my researches it should be included along with the chondroglossus. The glosso-epiglotticus is active mainly in altering the dimensions of the ligamentum glosso-epiglotticum lying just above it, but it covers at least a part of the back of the tongue and may thus be considered as the posterior middle part of the lingualis muscle (superior.) In any event, its fibers are anatomically connected anteriorly with the latter muscle. These fibers are under the mucous membrane of the root of the tongue, being rather deeply inserted as a result of the looseness of the tissue in this region. The bundles spread out in a brush like formation partly under deeper lying gland tissue; and partly through the gland tissue and between the ends of the genioglossus and the longitudinalis inferior. Anteriorly, they spread out still

more and approach the mucous membrane again.

In front of the circumvallate papillae, the two muscles, the longitudinalis superior, and the glosso-epiglotticus, are broad enough to occupy almost the whole width of the tongue. They touch in the median line and run immediately under the mucous membrane between the ends of the genioglossus and the hyoglossus as far as the tip of the tongue where they disappear in the skin of the superior surface. In the latter part of the course, the fibers run in the form of narrow longitudinal lamellae which are joined here and there at an acute angle.

Anteriorly the longitudinal bundles become markedly thicker so that the fibers of the chondroglossus are not numerous enough to be their source. Either the fibers of the latter muscle divide, as in the frog, or the thicker bundles arise from other sources. Some writers even go so far as to give them another name: the notoglossus. Others think that the chondroglossus increases in the number of prime fibers or that some of the longitudinal fibers arise from the firmer tissue of the glandular layer in the root of the tongue, and more anteriorly from the mucous membrane itself. The latter view is supported by the fact that the chondroglossus is not always present, whereas the sub-mucosal layer of the longitudinalis superior is always to be found.

The function of the superior longitudinal muscle is to shorten the superior surface, thus lifting the whole organ as far as it is free to move, and curving the tip upward.

The Perpendicularis Linguae muscle is to be found only in the point of the tongue. It is spread out in weak bundles between the inferior and superior mucous membranes. The inner part of these fibers is crossed by the anterior part of the transversus, and the outer part by the longitudinalis superior and the styloglossus, so that in transverse sections longitudinal and vertical fibers are seen alternately. This muscle is said to form

the perpendicular core of the tongue. Its fibers run from the posterior fascia in rows and pass through the cortical muscles like the fibers of the genioglossus. Its function is to contract the tongue in the articulation of "t" and "d" and similarly formed sounds.

The styloglossus muscle enters the tongue from the outside. Two other such muscles have already been discussed, the glossopharyngeus and the glossopalatinus. The styloglossus arises by short sinewy fibers from the point and the anterior surface of the styloid process. It arises partly from the stylomaxillary ligament, a flat sinewy band between the inferior part of the stylus and the posterior edge of the mandible. The styloglossus is spindle-shaped and rather flat. It passes obliquely downward, forward, and inward over the hyoid to the edge of the tongue. It is often strengthened by bundles coming from the hyoid, from the stylohyoid and the stylopharyngeus. It lies on the hyoglossus muscle to which it is bound by firm cellular tissues and by muscle fibers. The styloglossus covers the full depth of the side of the tongue, as far as the tip and appears to send numerous fascicles into the body of the tongue. It is usually divided into two bundles. The posterior bundle goes between the keratoglossus and the baseoglossus. It presses between the lamellae of the lingualis (inferior) and the genioglossus, some bundles reaching the septum. Here they attach to the fibers of the transversus which lie rather higher. The main bulk of the styloglossus attaches to the lingualis (inferior) just in front of the hyoglossus. It ends in the point of the tongue and in the mucous membrane of the under surface.

The function of the styloglossus is to help in lifting the tongue at the side. In this process the base of the tongue becomes somewhat broader. It shortens the tongue from front to back and draws the tongue sideways to the cheek. In swallowing, the styloglossus holds the tongue against the velum, the hyoid bone being drawn forward. These muscles guard against the too rapid pulling down of the tongue. There are no other muscles to carry out this important function, which has always been overlooked. Some of the fibers of the glossopharyngeus assist in this function.

The stylohyoid is an indirect agent in raising the tongue. It arises by tendons from the base of the styloid process or from the exterior surface of the superior part of the latter. It is a spindle-shaped muscle body passing downward, forward, and inward. It is attached to the hyoid, near the root of the great cornu above the insertion of the omo-hyoid. There is usually a slit in the lower portion of the muscle belly, through which passes the tendon of the digastricus. The lower end of the stylohyoid is connected with a tendon which passes from the anterior belly of the digastricus to the hyoid. It raises the hyoid, together with the attached root of the tongue and pulls it somewhat backward, thereby narrowing the isthmus of the fauces.

This muscle is usually accompanied by the stylohyoid ligament which lies between the glossopharyngeus, the keratopharyngeus and the hyoglossus. It is an elastic band stretched between the tip of the styloid process and the lesser cornu of the hyoid. It is from one-half to one-quarter inch thick at the tip and base and rather thicker in the middle. Its elasticity assists in the contraction of the stylohyoid and prevents sharp or sudden movements of the hyoid bone. It acts in opposition to the muscle that draws the hyoid down.

The normal movements of the tongue are:

1. Normal myotonic position in the closed mouth. The organ has here its greatest physiological volume, being wide and relaxed. The curvature of the tongue corresponds to that of the palate, the tongue filling the mouth. The hyoid bone is in a median position. The muscles exert an equal tension in all directions. The mechanical forces are such that the position of the hyoid is back rather than forward and low rather than high. The hyopharyngeus is in a state of considerable contraction as are all vegetative muscles when they are not functioning. This applies also to the deep oropharyngeal muscles. The hyoglossus, the genioglossus and the transversus are relaxed with slack fibers. This gives the tongue its breadth and high arch in

the mouth. The longitudinal muscles are also relaxed and curved without exerting tension. The styloglossus, the glossopharyngeus and the palatoglossus on the other hand, are in a tonic state or are voluntarily relaxed, keeping the tongue suspended at medium height and drawn back.

2. These relationships are changed as soon as the mouth is opened. Air comes between the palate and the tongue and exerts pressure on the latter. This, together with the lowering of the jaw causes the hyoid to move downward, and the isthmus of the fauces to become enlarged. The tongue still rests on the floor of the mouth, but its volume is reduced.

3. The geniohyoid, the genioglossus, the mylohyoid, and the anterior belly of the digastricus stretch the tongue forward. It is pulled back by the action of the hyopharyngeus, the omohyoid, the stylohyoid, and the posterior belly of the digastricus. It may be remarked that the hyoid bone is free to move through a distance of from six to seven lines from front to back; and one and one-half lines vertically. Because of this there are many possible positions of the hyoid.

The tongue is capable of the following types of movements: movements of, and in the tongue itself, independent of movements of the tongue as a whole; of parts of the tongue, with reference to any special point, such as: lengthening, stretching, shortening, drawing backward, raising of the anterior portions, lowering, bending, and sideward movements in various forms.

Lengthening is produced by stretching the transverse fibers so that it is accompanied by narrowing. In this process it can clearly be seen how in the anterior portion the cross-fibers draw the sides inwards, the mucous membrane being wrinkled and the whole tongue lengthened.

Some stretching out of the tongue accompanies the lengthening as there is not

enough room in the closed mouth for the horizontal, lengthened tongue. If it be still further stretched out, the roots of the tongue are pushed forward, the genioglossus and the geniohyoid being active. Usually when the tongue is stretched out the tip is curved downward and rests against the lower lip. This occurs through simultaneous contraction of the longitudinalis inferior and the anterior bundles of the genioglossus.

The tongue can only be shortened if it is at the same time arched in the middle, as the tongue can be broadened to only a very limited degree when the mouth is shut. In this process the tip recedes to about one-half inch behind the lower incisors. The longitudinal fibers, the styloglossus and the anterior fibers of the genioglossus are active in this process. The hyoid can, at the same time, assume various positions.

Shortening of the tongue is most clearly seen in vowels ah and o-e. More marked degrees of drawing back are always associated with raising of the posterior root, which, moreover, is not possible without the simultaneous raising of the hyoid bone. Examples are: "k" and "g", uvular "n" and "ng". No marked raising of the hyoid is necessary in lifting the anterior part of the tongue, in fact, it is impossible, since there is no muscle to draw the tongue directly upwards. The superior longitudinal fibers and the styloglossus are active in raising the point of the tongue, and if it is not at the same time shortened the transverse fibers are also active. The latter is true in the "t" sounds. In pronouncing "n", "l", "i", "e", "a", the tongue is raised in varying degrees.

In normal processes of phonation we do not find sideward movements of the tongue. Such movements are produced by one sided contractions of the styloglossus, the longitudinalis inferior, the transversus, and the muscles at the tongue root. They seem always to act simultaneously.

Pressure movements of the tongue are exerted in the back consonants and in the explosives as well as in swallowing. Such movements are produced in general by two physiological processes. One of these is a thickening in part of the parenchymatous part of the tongue; the other a movement of this thickened part against a hard or tensed body. This is an example of musculature constructed as involuntary muscle tissue acting, to a certain extent, as voluntary muscle. Each single longitudinal transverse or vertical fiber is able to contract independently of its neighboring fibers. Furthermore, at every point in the tongue there are three fibers, one of each kind, which can work together, being activated by the one nerve impulse. When this occurs in a relatively large part of the tongue, as in the middle of the back, this part becomes hard because of the simultaneous contraction in three dimensions. At the same time this part will be somewhat elevated owing to the accompanying thickening of the fibers. The process may be compared to so called cramp occurring in certain parts of the stomach or intestine, but there the thickening is only in two dimensions.

When such a thickened portion is drawn against any body that is hard, such as a tensed piece of striped muscle found outside of the thickened portions of the tongue, a pressure movement takes place. Such movements are found otherwise only in lip movements and to some extent in the heart. These localized pressure movements, made in speech, occur in the back and upper parts of the tongue, mostly in the convex portion and also in the tongue tip. Normally they are momentary being perseverant only in stuttering.

Merkel,²¹ in his treatise on the tongue of man dismisses the nerves as being unimportant from the point of view of phonetics. However, from the standpoint of com-

²¹

Merkel, Carl Ludwig, op.cit.

parative anatomy the nerves, together with the glands and the papillae will be briefly outlined.

The sensory nerves of the tongue are the lingual, which is a branch of the mandibular, serving the anterior two-thirds of the tongue with sensory fibers; the chorda tympani, a branch of the facial which runs in the same sheath with the lingual, is regarded as the nerve of taste in the anterior two-thirds of the tongue; and the lingual branch of the glossopharyngeal that sends sensory fibers to the base and the sides of the tongue. The superior laryngeal nerve sends some fine filaments to the root of the tongue near the epiglottis. The motor nerve of the tongue is the hypoglossal.

The papillae are thickly distributed over the anterior two-thirds of the dorsum. The circumvallate papillae are of large size and range in number from eight to twelve. They are found in the same position as in lower mammalian tongues and are in a "V" shape.

The fungiforms are more numerous. They are found chiefly on the sides and on the apex and rather sparingly on the dorsum.

The filiforms or conical papillae cover the anterior two-thirds of the tongue. They are very minute and are arranged in lines parallel with the rows of vallate papillae except at the apex where their direction is transverse.

The simple papillae are similar to those of the skin and cover the whole of the mucous membrane as well as the larger papillae.

The glands of the tongue are both mucous and serous. The mucous glands are found on the apex, the sides and particularly on the back, behind the vallate papillae. The anterior lingual glands require special notice. They are found on the under surface of the apex, one on either side of the frenum where they are covered with muscle fibers. This gland is present only in the tongue of the orang outhan and in man.

PLATE XII

The Extrinsic Musculature of the Human Tongue.

Figure 23

1. styloglossus
2. stylopharyngeus
3. stylomandibular ligament
4. constrictor pharyngeus
5. great cornu of the hyoid
6. hyoglossus
7. geniohyoid
8. mandible
9. genioglossus
10. longitudinalis inferior
11. body of the hyoid

The Intrinsic Musculature of the Human Tongue.

Sagittal Section

Figure 24

1. longitudinalis inferior
2. longitudinalis superior
3. transversus
4. genioglossus
5. geniohyoid
6. body of the hyoid
7. epiglottis

CHAPTER IV.

DISSECTION TECHNIQUE

Three nine months foetal heads were dissected in the Laboratory of Central Institute for the Deaf. The following technique was used:

Starting with a curved incision through the skin on the right side of the face, it was carried from in front of the ear near the articulation of the mandible and extended to the outer corner of the mouth. A second incision was made downward in the midline from the lower lip to the symphysis of the mandible and was carried below the chin to the hyoid. Skin flaps were reflected from the sagittal incision exposing structures below the tongue forming the floor of the mouth. The superficial fascia, from the right side below the chin, was removed exposing the anterior belly of the digastricus. Slightly in front and medially a smooth bundle of muscle fibers was encountered coming from beneath the digastricus and ending in the median raphe. This proved to be the medial portion of the mylohyoid muscle.

The anterior belly of the digastricus was now reflected back by cutting it away from its attachment to the mandible. The mylohyoid muscle was thus exposed as the thin sheet of muscular fibers described above. It arises from the mylohyoid line upon the medial surface of the body of the mandible by an origin which extends from the symphysis of the mandible to the hyoid. The two

PLATE XIII.

Cross Section Through the Body of the Tongue

Figure 24

1. longitudinalis
inferior
2. longitudinalis
superior
3. transversus
4. genioglossus
5. geniohyoideus
6. body of the hyoid
7. epiglottis

Cross Section Through the Apex of the Tongue

Figure 25

mylohyoid muscles stretch across from one side of the body of the mandible to the other above and in front of the hyoid. They form a sling for the structures of the floor of the mouth.

The mandible was then removed with the tongue from the remaining portions of the head. This was done by cutting through the capsule of the temporo-mandibular joint, the external and internal pterygoid muscles and through the temporo-mandibular ligament. The orifice of the mouth was widened by cutting back the corners of the lips in order to prevent injury to the tongue.

The mandible was split at the symphysis and the tongue removed from its anterior and lateral attachments. The dorsum of the foetal tongue was observed to be much smoother to the touch than is the adult tongue. The papillary structures are there, but in a lower stage of development than in the adult tongue. From this observation it was concluded that the papillae develop as the diet of the individual changes. The plica fimbriatae and the sublingua are more highly developed in the infant tongue than in that of the adult. They appear to degenerate as the child matures.

A study of the extrinsic and intrinsic musculature was now made. The extrinsic muscles were identifiable as the styloglossus, the glossopalatinus, the glossopharyngeus, and the genioglossus. Between the fibers of

PLATE XIV.

The Nerves and Arteries of the Tongue

Figure 27

1. accessory
2. vagus
3. ganglion nodosum
4. jugular ganglion
5. pharyngeal branch
6. superior laryngeal
7. hypoglossal
8. descendens
hypoglossi
9. ascending
pharyngeal
10. internal carotid
11. glosso-pharyngeal
12. superficial
temporal
13. internal maxillary
14. external carotid
15. posterior auricular
16. occipital
17. external maxillary
18. lingual
19. branch to the
thyreo-hyoid
20. internal-laryngeal
21. superior thyreoid
22. external laryngeal

Figure 28

1. stylo-glossus
2. stylo-pharyngeus
3. glosso-pharyngeal
nerve
4. stylo-hyoid ligament
5. lingual nerve
6. lingual artery
7. hypo-glossal nerve
8. supra-hyoid artery
9. submaxillary ganglion
10. sublingual gland
11. sublingual artery
12. genio-glossus
13. geniohyoid
14. lingual artery

the styloglossus and the genioglossus the inferior aspect of part of the longitudinalis inferior could be seen.

The next step was to remove the extrinsic muscles preparatory to making microscopic sections of the intrinsic musculature.

The dorsum of the tongue was divided longitudinally at the lingual septum. The material was put into eighty percent alcohol, ninety percent alcohol, one-hundred percent alcohol, into zylol and lastly into paraffin.

When the tissue was thoroughly infiltrated with paraffin it was placed in a metal form and hot paraffin poured around it. When the block was thoroughly hardened it was cut with a microtome into slides six microns in thickness. After the slides were cut they were stained with hematoxylin.

In studying the foetal tongue by means of the dissections it was found that the foetal tongue does not differ from the adult tongue in muscular structure. The only point of difference is on the dorsum. The foetal tongue is smooth to the touch because of a deficiency in papillary development. The adult tongue is rough, with countless papillae arising above the level of the epithelium.

CHAPTER V.

CONCLUSIONS

The tongue, throughout the animal kingdom, is different from other organs of special sense, such as the eye or the ear, in that it serves not one function but several. The tongue in the lower vertebrates has as its most specialized function that of prehension. The tongue of the frog can be thrown in and out with a hinge-like action as the frog goes after food. A snake's tongue can be protruded from the mouth with great rapidity in the act of prehension.

In the lowest animal of the mammalian order, the whale, the tongue is almost a useless organ. It has no prehensile power or function in mastication because of the manner in which the animal eats. Further along in the mammalian order the tongue again assumes as its principal function, that of prehension. The anteater's tongue is long, sharp and easily protrusible; the tongue of the giraffe is long and has very facile movement. It can be twined around small bits of food such as leaves and twigs.

The function of the tongue as an organ of deglutation and mastication has developed with the change in the manner in which various animal groups eat and the variety of diet which they eat. These functions are most highly developed in the primates.

The sense of taste has developed from nerve eminences all over the bodies of bony fish to highly developed taste buds on the tongue and oral cavities of all mammals, but the whale. In man the sense of taste is most highly developed, because of the enormous number of papillae rising above the level of the epithelium on the dorsum of the tongue, in the buccal cavity, in the fundus of the pharynx, and on the inside of the lower lip.

The musculature of the tongue varies very little from one order to another, with the exception of the musculature of the whale tongue, which, again, through disuse, is almost nonexistent. The tongues of the rodents have minute muscles that are the same in structure as those in the tongues of the larger animals. Sonntag ²² goes so far as to say that if one were given two tongues, one of a man, the other of an Orang Outan, one would have difficulty in differentiating between them because they are so similar in muscle structure, in size, in shape, and in papillary arrangement.

The foregoing discussion on the phylogenetic development of the tongue indicates that its prime functions are prehension, mastication, and deglutition. Articulation becomes an added function in Man. Judging from the fact that speech is the least impaired of all of the functions in cases of tongue amputation it was concluded that teachers

of speech may have been too empirical about the exact functioning of the muscles of the tongue in speech being a necessity in the production of aurally acceptable speech. The patients studied have difficulty in deglutition and in mastication, but they can and do speak without a tongue.

After dissecting three nine months foetal tongues, it was observed that the foetal tongue does not differ from the adult tongue in musculature. Its one point of difference is the epithelium of the dorsum of the tongue. In the foetal one, the dorsum is smooth to the touch with undeveloped papillary structures.

This investigation will be continued in order to determine what musculature replaces that of the tongue in producing the articulate speech of those without tongues.

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