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AN ESSAY ON THE ORGANS OF TASTE.*

AN ORIGINAL MONOGRAPH.

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"Each has its power distinctly and alone,
And every sense's power is its own."

—*Lucret*, iv., 487.

"*De gustibus non est disputandum*" is an old and well-known commonplace, to which, while prefixing it as motto, I might give a rendering somewhat different from the usual one, and say, about taste there is little to be said. No doubt, upon such a theme many pages might easily be filled, were I minded to enter the arena of æsthetics and pursue the chameleon-like idea into all its ramifications; but a sober exposition of the physiological conditions of the sense is so unpromising a subject that I could not help fearing an exposure of the poverty of science, as in my consideration of the sense of smell.† I

*This Monograph is a companion to the one, "A Memoir on the Odoriferous Sense," by the author. Presented to the same Society in May, 1896.

†"Memoir on The Odoriferous Sense." Dr. J. Mount Bleyer, of New York City, Transaction French Laryngological Society, Paris, 1896, and reprinted by the *Homeopathic Throat, Nose Journal*, 1896.

propose rather to clear up some of the inveterate errors prevalent among the uninformed, than to furnish as thorough an investigation as might be desirable. I reckon herein but little on the interest of the gourmands who may suppose that physiology can be advanced by their manifold experience in regard to this favorite sense, and who will, therefore, learn with the deeper indignation that physiology has not only known how to profit by their researches, but even regards them as the chief sources of the common and widespread errors just alluded to. The fleshy and wonderful member which, as such persons would seem to opine, has been placed at the very inlet of the alimentary canal, with scarcely any other view than to preside over gustatory pleasures, offers to our keenest inquiries just as profound an enigma as the organ of smell. Very far are we from being able to explain how that specific sensation, which, without any further power of description, we denominate taste, arises; what is the essential difference between a sensation of sweet and sour; what the real principle which resides in any substance so as to occasion our applying to it one or the other epithet, to say nothing of any possible explication, by the aid of science, of the different shadings, as it were, of sapidity cognizable by a nice palate, or of the jargon by which we attempt to characterize them. Here common nerve fibres, between which and those of other organs of sense the closest inspection fails to detect much difference, serve to interpret to the sensorium, by means of their extremities in the mucous coat of the tongue, the endless variety of so-called flavors of sapid substance; but we seek in vain, either at the outer or inner extremities of these conducting fibres, for any specific apparatus which might enlighten us as to their operations. The present state of our knowledge, which the microscope has given us, nevertheless baffles somewhat the physiologist in searching to disclose to him the entire ends of the nerves of taste provided with minute vesicles or filaments, or any other elementary form. Should we understand them any more than we do the already-discovered cells of the cerebral termination of all nerves, or the small bulbs at the outer extremity of the nerves of touch, it would probably fare with us as with some ancient Roman raised from the grave and suddenly placed in presence of a telegraphic apparatus, telephone or electric light.

In the meantime it would seem the next most important problem of science in this connection to study, with more exactness than heretofore, the terminal points of the nerves of taste in the mucous membrane, in order to discover here, as has very recently been effected in the nerves of the other senses, the elementary form of the nerve ends by which the sensation in question is communicated, whereby

we may hope to approach, in the future, somewhat nearer to a solution of the mysterious relation which exists between the contact of sapid substances with the tongue and the peculiar sensations which they are destined to excite.

If we bring into contact with the nerves of sight or of feeling a solution of sugar, or of some intensely bitter substance, such as quinine, they remain undisturbed; neither class of nerves is roused to that state of activity by virtue of which a "*current*" is hurried to the brain, there to call forth an appropriate sensation. We may conclude then with absolute certainty that there is present in the tongue a mechanism, a contrivance which sugar and quinine excite into different specific kinds of action; that this action is suited to evoke in the nerve filaments peculiar modifications of the before-mentioned current; and that this current again must find at the cerebral end of the nerves of taste a special apparatus which so operates upon what we call the soul that, as the final result, a perception of sweetness or bitterness arises. These successive preliminaries to a sensation of taste are at present beyond our scrutiny; it will be well if means are at our disposal to resolve, step by step, with clear physiological facts and indications, the questions which present themselves in connection with each of them. Nor shall we repine that such problems lie before us. The novice errs if he thinks that a science affords to its votaries a higher satisfaction; the greater the completeness with which it presents itself, the more exactly finished the edifice into which it introduces them. A satisfaction of a different and perhaps superior kind is afforded by science through its very gaps and obscure spaces, but only to him who loyally loves it for its own sake; to accompany a science in its development, to contribute, though it were but a small, inconspicuous stone, to the growing structure, affords a more vivid pleasure than being admitted to a participation in what is already accomplished. There are, it is true, self-styled savants to whom also the deficiencies in a science are more welcome than the completed structure, because those deficiencies are regarded not in a spirit of earnest inquiry, but as affording opportunities for the acquisition of easy notoriety and applause. Shunning the toils of research, they find it more convenient to guess at the future revelations of science than acknowledge their own ignorance, and overweaving all chasms with flimsy theories, they vaunt the result as knowledge converted into luxury and amusement. With these self-satisfied sciolists, who but too often and easily gain access to the public ear, the detail facts and laws is derided as pedantry; the slow and cautious processes of inquiry as unworthy drudgery; the reserve and modesty of true science as

tame mediocrity or affected obscurity. These remarks are made simply against this form of charlatanism; it is because no occasion seemed more proper than when attempting to place before the general practitioner a comprehensive work of this kind, without dissembling difficulties or courting effect, one of the most obscure departments of physiology, I turn to my subject.

It is not improbable that the first inquiry I have to propose will at the first glance appear to my readers superfluous, and surprise will scarcely fail to be awakened when it is shown how much obscurity really rests upon the seemingly simple question: *What is the seat of taste, and what organs produce the sensation?* With the common and general answer, *the tongue*, unfortunately we cannot rest satisfied, for it remains further to be asked: first, what part of the tongue receives the peculiar impressions which we call taste; secondly, whether, besides the tongue, other parts of the cavity of the mouth are endowed with this faculty; thirdly, to what structural arrangements is it due? Strangely enough the answers to the three questions are still in dispute, and in part at least are extremely defective. It would seem, on the whole, highly probable that to a very small tract has been assigned the sense of taste, for with more exact exploration its boundaries have been found to be more circumscribed. While older physiologists acquiesced in the popular notion that the tongue is the organ of taste, and ascribed to the whole mucous coat of the mouth, and even of the jaws and pharynx, the faculty of exciting impressions of taste, most of the modern school of thought are unanimous in the opinion that only a small portion of the dorsum of the tongue, and that indeed the hindmost and nearest to the throat, exercises the prerogative of deciding on the rapid properties of transmitted substances. It is true that there are those even now who regard the whole surface of the tongue, including its under side and even the mucous membranes which line the orifice of the throat, as embraced within the province of this sense, but in the opinion of many improperly. No one, however, disputes that the hinder part of the dorsum of the tongue is endowed with at least a finer sense of taste; a conclusion which receives countenance from the commonly observed fact that whenever it is proposed to submit any substance to a closer scrutiny of the sense in question, we instinctively transfer it to that portion of the mouth where the hard palate also lends its mechanical aid to the investigation; while it never occurs to any one to test the properties of taste with the point of the tongue, or to introduce the object under the lower surface of that member. If it be difficult to prove conclusively that the rest of the mucous regions under review do not possess a sense of taste, it certainly exists there

in a much weaker and more obtuse degree. The discrimination is not so easily made as might be supposed; in such inquiries there are not a few incidental sources of error. In the first place, care must be taken for trial of this sort, to choose substances which excite a pure and simple sensation of taste, and not simultaneously a sensation of touch, which may readily be confounded with the former. We ought not, for example, to select substances having what is called a sharp, hot, or rough flavor, for those are qualities of a sensation of touch, as are the pungent odors spoken of in my previous article on the sensation of smell.* Now, as the sense of touch is unquestionably spread over the entire cavity of the mouth, it will be granted that such substances as the above may readily lead to false conclusions respecting the extent of the gustatory area. In the second place, it is of importance to the proposed investigation that the substance submitted to proof should not be conveyed through the medium of the saliva, in which it is of course dissolved (for only soluble substances are capable of being tasted), to other regions of the oral cavity, and so be carried to that hinder part of the tongue, whose special susceptibility to such impressions is admitted. Nor for this is any movement of the saliva necessary; as a lump of sugar placed at the bottom of a vessel of water will, in dissolving, gradually diffuse itself through the whole mass and reach the surface, so may the solution of a similar substance introduced beneath the tongue penetrate the salivary stratum which overlies every part of the cavity, and attain the nerves of taste situated elsewhere. If this be the case, it will of course be difficult to determine the exact seat of the sensation. On the other hand, we are always prone to refer the sensation of taste to the point to which, by virtue of the sense of place (Ortssin), we refer the impression of touch produced by the contact of the substance with the ends of the nerves of feeling.

If the proposed inquiry be conducted with scrupulous regard to the precautions indicated, the conclusion, I think, can scarcely fail to be reached that only the hinder surface of the tongue is qualified to communicate sensations of taste. The trial may readily be made by every one for himself. Let a small piece of sugar, for instance, be laid on the end of the outstretched tongue, or, as rubbing will tend greatly to promote the sensation of taste, be rubbed thereon, and no perception of the property of sweetness will ensue. Still more convincing will be the result if an intensely bitter substance be employed. The same negative result is obtained if an experiment be made upon other parts of the cavity of the mouth, and with this view the parts to be examined

* "Memoir on the Odoriferous Sense." Bleyer, 1806.

may be touched with a small and delicate brush dipped in the concentrated solution of a sweet or bitter substance. If, in this way, a little drop of melted sugar be conveyed to the uvula which overhangs the surface of the throat, no taste of sweetness is perceived, provided care is taken, in the first place, that the tongue be not brought by the involuntary retching which is apt to ensue from touching this part, into contact with the uvula; and in the second place, wait not so long that the solution shall have time to be diffused gradually with the saliva to the underlying surface of the tongue. If the solution be rubbed in with the brush, the sweet taste will be more quickly produced; but even then it unquestionably arises, not from the uvula, but from the back of the tongue, and the more quickly because diffusion is promoted by the rubbing. I think, in short, that others propose nothing unreasonable, when we thus showed by these experiments that the circumscribed place of the sense of taste to the small tract of surface to which we are disposed to assign it.

The question next occurs, to what arrangements does this region owe its adaptation as an organ of sense? Were there here an apparatus as distinctly destined for the service of the sense as is found for that of sight in the eye, we should be absolved from the necessity of so nice an investigation respecting the local extent of the sense of taste as that just described. But this is not the case. On the contrary, as there is not known a single peculiarity of the region of the tongue empirically assumed as the province of the sense in question; none at least which can be assigned to it with any such manifest certainty as that with which the dioptrical apparatus of the eye, and the auditory apparatus of the ear, may be assigned to their respective functions. Unfortunately, after a long debate, it is not yet quite agreed to which of the special nerves of sense is appropriated the function of taste. No less than three distinct pairs are directed to the tongue, each a fasciculus of those minute fibres which can be compared to the wires of the telegraph, and each springing right and left from different parts of the brain. These are the lingual branches of the widely distributed fifth pair, the glosso-pharyngeal and the hypo-glossol nerves. It is known that neither by microscopical observation nor from any peculiarity can we conjecture the distinctive operation of such a nerve; just as it is impossible for us to infer whether a conducting wire, when we observe it at any intermediate point, is destined to set in motion the hands of a clock or the index of a telegraph. Anatomical research, however carefully it may explore the divarications of each nerve in the tongue, leads us here to no definite decision; as well because the local boundaries of the sense of taste are not established

beyond doubt, as because many parts are at the same time supplied by more than one nerve, and because, moreover, that nerve which is directed preferably to the hinder part of the dorsum of the tongue, and therefore has the greater probability in its favor, is distributed also to the entrance and neck of the throat surfaces, to which we know the sense of taste is denied. There remains then, only the physiological experiment from which to await a decision, and this also has its difficulties, though less in the realization than the interpretation of its results. It consists in dividing one of the three nerves, and in this manner intercepting all communication between its two extremities in the periphery and the brain; thus, of course, as effectively preventing the transmission of any current by which a sensible image may be formed, as the communication between two telegraphic stations would be intercepted by a rupture of the wires. After the division of either of the three nerves in a living animal, it remains to try whether the latter still possesses the power of tasting, for should it appear that upon the division of any particular nerve the faculty of the tongue to communicate impressions of taste, on being touched with some intensely flavored substance, is wholly lost, we shall be justified in concluding that the nerve on which we have operated was the vehicle of those impressions. But here lies the difficulty—how to verify the absence or presence of this sensation in the animal. The animal wants speech to indicate it, and an impression furnishes us with no direct objective token of its existence. Resort must, therefore, be had to circuitous proceedings, in using which much circumspection is requisite. We should infer the loss of taste if, after the operation, the animal devours, without signs of repugnance, ill-flavored aliments which, in its normal state, were constantly refused. On the other hand, if such substances are rejected we shall be authorized to infer with more certainty the persistence of the sense of taste, when due care has been taken that the nature of the substance is not recalled to the animal by its effects upon some other sense than that which we are investigating. In such an investigation, therefore, we should employ in the trial no substance which, through its characteristic form, is familiar to the animal's eye, and as little one which is readily known by its peculiar smell; nor is a substance to be chosen which, through the medium of the nerves of touch in the tongue, produces a sensation of smarting or roughness, so commonly confounded with impressions of taste. Finally, in this inquiry, discard anything to which the animal is altogether indifferent. Only such articles, therefore, are free from objection and suitable for a decision of the question as those whose properties can be made sensible to the animal

through the sense of taste alone, and none better answers the purpose than a decoction of so bitter and repulsive a substance as colocynth presented in milk. If this mixture be offered to the unwounded dog, allured by the sight of the milk and without suspicion of the foreign substance, he will greedily apply himself to what he supposes to be a well-known dainty; but let a drop once pass the seat of taste and no sign of disgust will be wanting which a dog can manifest.

If, now, one of the three nerves be divided, the glosso-pharyngeal for instance, which chiefly supplies the hinder part of the tongue surface, and find that the dog devours the milk, notwithstanding its bitter ingredient, with accustomed avidity, we may safely infer that the divided nerve was the channel of the sensation of taste, especially when, after a division of the two other nerves, persistent refusal on the part of the animal has testified a perception of the nauseous admixture.

Now, this has been tried with seemingly decisive results: the most careful experiments have uniformly led to the conclusion that the true impressions of taste can only exist when the glosso-pharyngeal nerves are intact; while on the other hand it has been shown with great certainty that the filaments of the hypo-glossal nerve pass to the muscular fibres of the tongue, and by conveying to these the motive current from the seats of the will in the brain, communicate to the organ the power of motion; that, further, the lingual branch of the fifth pair furnishes to the tongue its sensations of touch, thus notifying us of the form, size, weight, softness, or solidity, as well as the temperature, of whatever is introduced into the mouth, and sometimes, too, giving accession to those perceptions of mordacity or roughness which we are apt to confound with the genuine impressions of taste. I shall not here enter into a discussion of the importance of the service rendered by the two last nerves; my good readers will, perhaps, take the trouble of reflecting for themselves upon the manifold disadvantages under which we should lie in the affair of eating and drinking; nay, how impossible in some cases it might prove, if our tongue possessed not the faculty of moving voluntarily in all directions, nor its exquisite delicacy as an instrument for examining the quality of all substances introduced into the mouth. I must also be excused for not attempting to give a detailed anatomical description of the true nerves of taste, as reference can be made to them in all works on anatomy, but give an illustration which will aid you at a glance to search out their course at a glance of the picture. I might,

FIGURE 1.

indeed, have contented myself here, with assuring you that to a certain nerve, called the glosso-pharyngeal nerve, we owe the sensation of taste, but thought best to present to you an explicit statement of the manner in which this fact has been arrived at, because my object in this essay is rather to interest the general practitioner than the specialist. The result of these scientific methods in evincing the glosso-pharyngeal nerve to be the vehicle of the impressions of taste, besides the experiments on animals above described, rests also on some scanty observations made upon man himself; for which, but with extreme rarity, a morbid degeneration or even destruction of the nerve in question has afforded opportunity.

My readers will no doubt willingly dispense with a critical discussion of the dissenting opinions of certain physiologists who regard the lingual branches of the fifth pair as partially, if not exclusively, invested with the functions of taste. The fact above mentioned—that the glosso-pharyngeal nerve, as its name implies, sends filaments to the pharynx, very numerous to posterior epiglottis and anterior surface of soft palate, as well as the tongue—does not furnish an objection to the results obtained by experiments, and affords a ground for the conclusion that the parts of the mucous membrane of the throat in which its fibres terminate possess also the sense of taste. It may easily be conceived that only those fibres of the nerve passing to the tongue are provided at their inner and terminal extremities with the indispensable apparatus (known as taste bulbs) for the reception of the impressions and their conversion into the sensations of taste, while the rest are simply adapted to the transmission of the sensation of touch. According to W. Krause these taste bulbs follow the distribution of the glosso-pharyngeal nerve.

I shall now point out most of the peculiarities of the gustatory organs. Every one must have observed, either in himself or others, or else in the tongue of the ox when it has been prepared for food, that the upper surface of the tongue is not smooth, but rough; though in man the unevenness is so slight, that to the unaided eye this surface presents a velvety appearance, while in the ox it is so rough, both to sight and touch, as to resemble a rasp. Each of the little projections, which occupy it, appear under the microscope as a very composite organ, on the whole of a quiet, regular form. We distinguish, according to their outline, three varieties of these projections: the *fungiform papillæ*, the *filiform* and *conical papillæ*, and the *circumvallate papillæ*, to all of which the general name of papillæ is given. The first

FIGURE 2. Papillary Surface of the Tongue, with the Fauces and Tonsils. (Sappey.)

1, 2, circumvallate papillæ; 3, fungiform papillæ; 4, 5, filiform and conical papillæ; 6, glands and glandular recesses; 7, tonsils; 8, tip of the epiglottis; 9, frenum epiglottidis.

are found especially on the upper surface, on the point of the tongue; the second are distributed over the whole of the member; the third occur only towards its base, where they are arranged upon its surface to the number of from ten to twelve, in the shape of a V. If the tongue be stretched as far as possible out of the mouth, this V and the flattened eminences which form it, placed at intervals and surrounded by a sort of foss, may readily be seen. A more exact description of these three varieties of projections will not, I think, be without interest.

As they are merely elevations of the outer coat of the coat they consist of the same two membranes with that coat, viz.: an outer cov-

ering, called the epithelium, and the proper mucous membrane. The epithelium consists of cells multifariously superposed on one another, the uppermost layers of which become dried into flat and angular little scales, while the lower are moist and roundish. By the use of the tongue the former are continually worn off, and may be observed with the microscope as a constant ingredient of the saliva, which they render turbid; to repair this loss new cells are always forming below. The layers thus constituted are destined undoubtedly to furnish protection to the underlying mucous tissue, which contains the fine and easily-wounded vessels and nerves, just as in the external skin the epidermis, which is similarly composed, serves as a protective covering to the cutis. The accompanying figures, representing a section of the different varieties of papillæ magnified, may serve as the groundwork of a more exact description of each. In figure 3 is represented the section of a filiform; in figure 4 that of a fungiform; and in figure 5 a vertical section from a calve of the circumvallate papillæ. In all of

FIGURE 3.

FIGURE 4.

FIGURE 5.

them the part designated *a* represents the epithelium, consisting of squamous and cellular layers; that marked *b* the underlying mucous membrane. It will be seen at first sight that the epithelium in neither form invests the subjacent mucous membrane as a glove does the finger, so that the outer surface of the former shall present an exact impression of that of the latter. In the filiform papillæ it will be observed that the epithelium has a number of long antennæ-like excrescences, giving the papillæ the appearance of a brush, while in the others this covering is extremely smooth, notwithstanding the inequalities of the underlying membrane, *b*, whose surface exhibits in each example a number of successive and rather narrow eminences of a sugar-loaf or conical form. What purpose the antennæ of the first form subserve it is possible to conjecture; but, as regards the regular elevation of the proper mucous membrane, their presence alike in each of the three kinds of papillæ, as well as the circumstance of their existence likewise in the outer skin, leads to the conclusion that wherever they occur, whatever otherwise their diversity, the physiological significance which they bear must be the same. Now as the microscope shows us that, as regards the outer skin and in part the mucous membrane of the tongue, the finest branches of the blood-vessels and the terminal extremities of the nerves of taste, etc., are found in these little eminences, the inference is obvious that this peculiar formation of the surface is imposed on account of the organic contents of the eminences, providing, as it does, suitable receptacles in the periphery for the ends of the vessels, and especially the nerves, and securing their regular distribution over the surface. We may conceive that it behooved that the ends of vessels and nerves should closely approach the outer surface at regular distances from one another, which purpose, indeed, might have been attained had these minute organs penetrated at certain intervals from the mucous membrane into the loose strata of the epithelium; but then they must have wanted a sufficiently stable involucrum to protect them against the pressure and continual wasting of the shifting elements of that covering. Now, such a protection is supplied by the enveloping projections of the mucous membrane which enter into corresponding cavities of the epithelium. I am aware that this teleological mode of considering anatomical arrangements as directed to a predetermined end, and contrived with a view to attaining that end, will at present be received in many quarters with entire repugnance; wherefore I shall not here further insist upon it. Enough if the preceding examples should serve to show how well this manner of viewing the subject is adapted to lead us to an understanding of such arrangements. The clearest method of explaining

natural as well as artificial mechanism is, in my opinion, that which bases itself upon teleological principles; how far the employment of teleology for purpose of demonstration may be justified is another question.

Returning to a consideration of the papillæ, I remark that, for a proper conception of them, attention should be especially directed to the delicate structure of the small secondary projections of the mucous membrane, with a view to seeking therein the ends of the nerves and apparatus of sensation. But hitherto all efforts have been fruitless, nor has research in this direction been rewarded with any degree of certainty. Neither in the filiform, nor fungiform, nor circumvallate papillæ has success attended the attempt to explore the ultimate destination of the nerves which direct their minute filaments with extreme intricacy towards the surface, to follow them into the interior of the superficial projections of the mucous membrane and there detect a difference of arrangements which might guide us to a decision respecting a difference of functions. However probable the supposition that the filiform and fungiform papillæ contain the ends and apparatus of the nerves of touch; that the circumvallate, on the other hand, which occupy the centre of the seat of taste and are outwardly so strikingly distinguished, contain those of the nerves of taste (taste-buds), we are now able to furnish anatomical evidence for that supposition, and indeed to establish conclusively thorough physiological experiments. Even the peculiarity of external form of these latter papillæ is not a riddle; then we cannot exactly explain what purpose is subserved by their division into a roundish central elevation, *a*, and an annular periphery, *b*, separated from one another by a distinct *c*. If we ventured to assert that this fossa furnishes a sort of reservoir in which the solutions of sapid objects are received in order, by longer contact with the sensitive surface, to take more full effect on the extremities of the taste-buds or nerves of taste, while the passage of those solutions over free surface might be too rapid for distinct perception, we again advance a conjecture for which much proof can be alleged.

Nothing remains for me to say further, therefore, but to wait until, by persevering and patient observation, some deeper insight into the secret mechanism of the organs in question shall be vouchsafed, and material be thereby furnished for physiological interpretation.

A few more of the most recent and closer studied anatomical and histological facts of what we know upon the gustatory organs will be, no doubt, most acceptable. Quain, Arnstein, Drosch, Grélin,

Friedrich, Hönig, Schmid, Lenhossek, Niemack and Tuckerman,* all these combined researchers in this branch of study teach us all that I am going to relate regarding the minute new points in connection with these organs. To begin with again, by way of recapitulation partly: The gustatory organs are represented by certain patches, or groups, of peculiarly modified epithelium cells, which are lodged in the thickness of the stratified epithelium of certain parts of the tongue and pharynx. These groups of cells have in mammals a bud-like arrangement, and have, therefore, been termed *taste buds*. They occur in man at the sides of the papillae vallatæ of the tongue, forming a zone around the papillæ, and also upon the opposed wall of the vallum. They are also found on the fungiform of the papillæ of the back and side of the tongue, extending to the lip, and here and there in the epithelium, covering the general surface of the same parts of the organ. They are especially numerous over a small area just in front of the anterior pillar of the fauces (*fimbria lingue*). The area usually displays four or five longitudinal folds, or elevations, of the mucous membrane, and appears to represent a much better defined oval laminated structure, which is found in a similar situation in the tongue of some mammals (*e. g.*, rabbit), and which is known as the *papilla foliata* (Figure 6).

FIGURE 6. View from above of the Rabbit's Tongue Showing the Papillæ Follatæ. (E. A. S.)

Flask-shaped organs, similar to taste buds, were discovered by Leydig in fishes in certain parts of the skin, and they also occur in the mucous membrane of the mouth and throat in those animals. In amphibia the taste organs take the form of patches of modified epithelium cells, set on the surface of certain *papillæ* of the tongue. The structure of the taste buds is most easily studied in sections of the papilla foliate of the rabbit.

*The entire minute anatomy herein described has been taken from the various authors named. To "Quain's Anatomy" I am much indebted for some descriptions used on the cells of the gustatory organs.—AUTHOR.

FIGURE 7. Vertical Section of a Foliate Papilla of the Rabbit, Passing Across the Follum. (Ranvier.)

p, central lamina of follum; *v*, vein; *p'*, lateral lamina of follum; *g*, taste bud; *n*, sections of nerve-bundles; *a*, serous gland.

FIGURE 8. Section Through one of the Taste Buds of the Papilla Folliata of the Rabbit. (Ranvier.) Highly magnified.

p, gustatory pore; *s*, gustatory cell; *r*, sustentacular cell; *m*, leucocyte containing granules; *e*, superficial epithelium cells; *n*, nerve-fibres..

Taste buds have been compared in general form and appearance to the leaf buds of a plant. They are flask-shaped bodies, the base of the flask resting upon the corium of the mucous membrane, and the apex projecting towards the free surface of the epithelium, and emerging between the ordinary flattened surface cells of the stratified

epithelium. The cells of the stratified epithelium are adapted and applied to the outer surface of the taste bud, and form a sort of adventitious capsule for it. The most superficial cells may even be perforated to allow of the access of the apex of the taste bud to the free surface. In any case the apex does not quite reach the surface, but is approached from the surface by a small opening, the gustatory pore. Into this a bunch of fine hairlets, prolonged from the gustatory cells of the taste bud, is seen to project.

Every taste bud contains two kinds of cells, termed respectively the *sustentacular* and the *gustatory* cells. The *sustentacular cells* (Figure 9, *b*) are long and spindle-shaped, tapering to either end.

FIGURE 9. Cells from Taste Buds of Rabbit. (Engelmann.)

a, four gustatory cells; *b*, two gustatory and one sustentacular cell; *c*, three sustentacular cells.

They form a complete envelope to the taste bud, being fitted together like the staves of a barrel; these surface cells are flattened from within out. Other sustentacular cells lie within the taste bud amongst the gustatory cells, extending from apex to base of the taste bud.

The *gustatory cells* closely resemble in general appearance the olfactory cells of Max Schultz. From the nucleated body of the cell, which is somewhat bulged, two processes extend. One, the peripheral, is nearly straight, and passes to the gustatory pore, where it ends in a cilium-like projection, the *taste-hair*. The other process, the central one, passes towards the base of the flask; it may be fine and varicose, and often bifurcated or even further branched, and, according to G. Retzius and Lenhossék, it ends in a free extremity or extremities, and not, as was formerly thought, in continuity with the nerve-fibrils which pass to the taste bud.

Each taste bud receives a small bundle of nerve-fibres, derived, at least in the case of those of the papillæ vallatæ, from the glosso-

pharyngeal nerve. The nerve fibres lose their medullary sheath as they enter the organ and are continued as axis cylinders which end by ramifying amongst the gustatory cells (*intrabulbar ramification*) Figure 10), without, as has been just stated, coming into actual continuity with these cells. A number of nerve-fibrils also pass into the enclosing capsule of stratified epithelium and end by ramifying between the cells of that epithelium (*peribulbar ramification*, Figure 10, *p.*). These peribulbar nerves are believed to be nerves of general sensibility and not gustatory.

FIGURE 10. Ending of Nerve fibers in and around Taste Buds of Rabbit: Golgi Preparation. (G. Retzius.)

Section of the glosso-pharyngeal nerves in young animals is followed by atrophy of the taste buds after some time. The taste buds of the anterior part of the tongue appear to be supplied by the chorda-tympana nerve.

When a comparison is made of the modes of arrangement of sensory cells and nerve fibres in the different organs of special sense, we find that our knowledge in regard to the gustatory organs is still imperfect. It has usually been supposed hitherto that the central processes of the gustatory cells are prolonged into nerve fibres, and, if this were the case, these cells would come into the same category with the olfactory cells of the nasal mucous membrane. But according to the most recent observations, the central process of the gustatory cell is not continuous with a fibre of the glosso-pharyngeal nerve, and the connection of the gustatory cells with the fibres of that nerve is indirect

and not by continuity. If this is so, the arrangement in the gustatory organ would appear to be somewhat similar to that which obtains in the general integument and in the auditory organ. (Fig. 11).

FIGURE 11. Diagram Showing the Mode of Termination of Sensory Nerve Fibers in the Auditory, Gustatory, and Tactile Structures of Vertebrata. (After G. Retzius.)

[CONTINUED IN NEXT NUMBER.]