A treatise on the human ear : with new views on the physiology of the tympanum.

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A TREATISE

ON

THE HUMAN EAR,

WITH

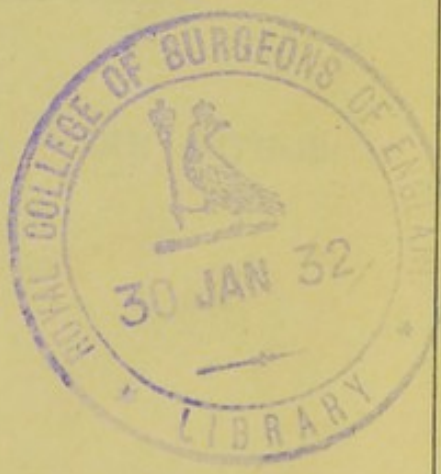
NEW VIEWS

ON

THE PHYSIOLOGY OF THE TYMPANUM.

BY J. W. MOSES, M.D.

MEMBER OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND, &c. &c



"Firmum in vita nihil."

ST. ASAPH: PRINTED AT THE KENTIGERN-OFFICE.

1847.

TO

R. LLOYD WILLIAMS, ESQ. M.D.,

FELLOW OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND;

CONSULTING SURGEON TO THE DENBIGHSHIRE INFIRMARY,

This Treatise is respectfully Dedicated,

BY

HIS OBLIGED AND SINCERE FRIEND,

THE AUTHOR.

PREFACE.

IF I SUCCEED, IN THE FOLLOWING PAGES, IN BRINGING FORWARD EVEN A NEW IDEA ON THE PHYSIOLOGY OF THE TYMPANUM, IN THIS AGE OF INTELLECT, WHEN SO MANY LEARNED MEN, (POSSESSED OF OPPORTUNITIES FOR INVESTIGATING SUCH SUBJECTS, FAR SUPERIOR TO ANY WITHIN MY REACH,) HAVE ACKNOWLEDGED THE DIFFICULTY OF ACCOUNTING FOR THE USES OF THE DIFFERENT MINUTE PARTS CONCERNED AS ACCESSORIES TO THE FUNCTION OF AUDITION, I SHALL REST SATISFIED THAT MY EFFORTS HAVE NOT BEEN IN VAIN.

St. Asaph, N. Wales, March, 1847.

INTRODUCTION.

To ATTEMPT to suggest, or describe any thing new in the structure or functions of the human body, in the present day, when every part has been so thoroughly sifted and scrutinized by the industry of a mighty band of strict searchers after truth, the physiologists of the past and present eras, assisted by the powerful help of the microscope, may be looked upon as presumptuous; and will I have no doubt subject the perpetrator of such rashness to what is called the 'lash of criticism;' and those alone who have smarted from such infliction, can judge of the extreme severity of the punishment, compared with the mildness of the offence.

If a foolish man, in the vanity of his heart, dream even that he is possessed of a new idea, and have the audacity to publish such lucubration, he is at once a victim placed by himself on the altar of criticism and exposed to the peltings of every philosopher, who has written or thought on the same subject, from Solomon downwards. Hippocrates starts at the innovation, shakes his grim beard, and is quoted in an obscure language, as pointing to similar deductions—Celsus is roused from his slumbers, and passages are translated from a dead tongue in which the same views, say they, differently expressed, had passed through his brains near two thousand years ago. "And there is no new thing under the sun, saith the Preacher."

A host of Physiologists, or their ghosts, which are quite as terrible, from the Continent of Europe, including Germans, French, Italians and Russians, start from their graves and assail the unhappy wight, and point with the cold finger of death to their immortal works where the same ideas which are now put forth as new, were published in a different form some two or three hundred years ago. Alas! alas! there is nothing new—there can be no new discovery; so all our toils and midnight watchings are but lone

wanderings through paths, which have been trodden before, by former races of men, whose bodies are now crumbling in their graves, or nourishing the grass of the fields—which to-day is, and tomorrow is cut down, withered and cast into the fire. *Sic transit gloria mundi.*

Notwithstanding these melancholy forebodings, I purpose to offer a theory on the "action of the *membrana tympani*, and the muscles of the internal ear, in connexion with the Eustachian tube, and the important part they perform in the function of hearing; together with the use of the *chorda tympani* nerve, and *tympanic anastomosis.*"

For most of the anatomical details, I am indebted to the Cyclopædia of Anatomy and Physiology.

A TREATISE ON THE HUMAN EAR.

ANATOMICAL SKETCH OF THE TYMPANUM, &c.

THE *tympanum*, or middle ear, is an accessory cavity to the organ of hearing, situated in the internal part of the *pars petrosa* of the temporal bone, and measuring from above downwards as well as from before backwards about four tenths of an inch, and from without inwards about three twentieths of an inch. These measurements will no doubt vary in different subjects. It is bounded internally by the outer wall of the osseous labyrinth, externally by a vibratile, and according to Sir Everard Home, muscular membrane, the *membrana tympani;* and that portion of the temporal bone into which it is framed. Anteriorly a canal, the Eustachian tube, leads from it into the pharynx and posteriorly and superiorly it communicates with the mastoid cells—which are cavities in the mastoid process; all communicating with each other: and in some animals the cells of opposite sides communicate. The cavity of the *tympanum* is traversed by a chain of small bones extending from the *membrana tympani* to the *vestibular fenestra*, the *malleus*, *incus* and *stapes*, not placed in the most advantageous position for conveying sound.—The handle of the *malleus* is fixed to the *membrana tympani*. The *articular* surface on the head of the *malleus*, to the corresponding surface on the body of the *incus*, forming a ball and socket joint, and the long process of the *incus* through the medium of its lenticular process is articulated with the *stapes*, both joints are furnished with small articular *capsules*. These bones are moved by muscles, three attached to the *malleus* and one to the *stapes*. According to Hagenbach, Breschet, and Linke, two muscles only can be demonstrated, and these two are both tensors of the *tympanum*. The connexions of the base of the *stapes* with the *vestibular fenestra* are such as to admit of some degree of movement. The cavity of the *tympanum* is lined by a very delicate membrane of a fibro mucous character, which is prolonged into all its sinuosities and

dependent cavities. The lining membrane of the *tympanum* is continuous through the medium of that of the Eustachian tube, with the *mucous* membrane of the throat.

Very nearly the same accessory apparatus is found in the whole class mammalia. Warm blooded quadrupeds have like the human subject, three ossicula auditus, which on the whole resemble in form those of man, with a few exceptions. (*Class reptilia.*) Turtles, frogs and most species of lizards, possess a *tympanum* and Eustachian tube.—*Class aves* have but one small bone, formed of a branch adherent to the tympanic membrane, and of another terminating in a plate that rests upon the *fenestra ovalis.*

The Eustachian tube in the cetacea opens into the blowing hole.

Fishes, says Sir Anthony Carlisle, are provided with more simple organs of hearing, ordained to inform them of collisions among rocks and stones, or the rushing of water or moving bodies in that element.

The Eustachian tube, is a passage of communication betwixt the cavity of the *tympanum* and the *pharynx.* In length about an inch and a half. Proceeding from the *tympanum,* its first part is an *osseous* canal; the walls of the remainder of it are composed partly of cartilage, and partly of fibrous membrane; in the recent state it is about one-thirtieth of an inch in diameter. The mouth of the tube in the throat forms an oval-shaped fissure, about three-eights of an inch long, bounded anteriorly and posteriorly by prominent swollen edges. The fissure is directed obliquely from above downwards, and from before backwards.

The levator palati and tensor palati muscles by their action will dilate the opening of the Eustachian tube, thereby assisting in the respiratory movement; which I shall point out.

The *tympanum* receives nerves from different sources—from the 5th, 7th, 8th and the 9th pairs of *cerebral* nerves. It has likewise a communication with the sympathetic system.

The fifth pair sends a nerve to the *membrana tympani,* with which the *chorda tympani* in its passage across the cavity of the *tympanum* anatomoses by several filaments. The fascial nerve, the respiratory nerve of the face, gives off a little below the pyramid, a branch to the stapedius muscle.

The pneumogastric nerve, in its passage through the base of the skull, forms a small ganglion, from which springs a nerve which goes to the ear, *ramus auricularis nervi vagi.* This is joined by a filament from the petrous ganglion of the glosso-pharyngeal: it then runs according to Arnold, in a groove in the jugular fossa,

and at last arrives at the aqueduct of Fallopius. Here it divides into three branches, the smallest of which runs upwards in the aqueduct of Fallopius towards the origin of the fascial nerve, and unites with it; the second branch, which is somewhat larger, runs downwards and also anastamoses with the fascial. The third branch gets into the *canaliculus mastoideus* of Arnold, through an opening near the lower aperture of the *canalis chordæ tympani*. It here divides into two branches, one of which joins the posterior auricular branch of the fascial nerve; the other, which is stronger, arrives at the posterior wall of the external auditory passage, gives filaments to the ceruminous glands, penetrates the cartilage of the ear and ramifies on the skin covering its convex surface.

The principal nerve in the *tympanic nervous* anastomosis, is the nerve of Jacobson, or tympanic nerve of Arnold. It extends between the petrous ganglion of the glosso-pharyngeal and the otic ganglion or ganglion of Arnold. To follow it from the glosso-pharyngeal, we find it arises from the upper part of the petrous ganglion, along with another filament which goes to communicate with the ganglion cervicale supremun, and also with the pneumo-gastric. The tympanic nerve enters, by the tympanic canal, the cavity of the *tympanum*. Here the nerve appears near the anterior margin of the *fenestra rotunda*, traverses the groove on the promontory, arrives in front of the vestibular *fenestra*, then enters the proper osseous canal, into which the groove on the promontory is continued superiorly, and which opens on the surface of the petrous bone outside and in front of the hiatus Fallopii. From this the nerve advances between the anterior margin of the petrous bone and the posterior angle of the great wing of the Sphenoid, between the internal muscle of the malleus and the superficial petrosal nerve. There it approaches the nerve of the internus mallei, and proceeds parallel with, and under the name of petrosus superficialis minor Arnoldi, goes to join the otic ganglion. Bidder has discovered a new nervus petrosus superficialis, which, for the sake of distinction, he calls *tertius;* it proceeds from the plexus, accompanying the middle meningeal artery into the cavity of the cranium, passes through a proper fissure in the anterior surface of the petrous bone and under the entrance of the canal of Fallopius into the petrous bone to join the fascial.

The branches given off and the communications formed by the tympanic nerve in the course described, are the following.—

On entering the tympanum, the tympanic nerve divides into two

branches, a lower and an upper. The lower branch gives first twigs to the Eustachian tube, and then passes out of the cavity of the tympanum into the carotid canal, through a passage in the bone, where it anastomoses with the *sympathetic*. The upper branch, the continuation of the nerve, gives a twig to the secondary membrana tympani. According to Varrentrapp, there arises from it, by two roots—a twig, which runs in the inner wall of the cavity of the tympanum, then into the Eustachian tube, the *cartilage of which it penetrates anteriorly, and at last loses itself in the mucous glands around its guttural orifice*. A little higher up a third branch goes to the vestibular fenestra, and, according to Lauth, the tympanic nerve receives, immediately on its entrance into the canal in the upper part of the petrous bone, a *filament from the fascial nerve*. Moreover, the tympanic nerve receives a *filament of communication* from the external branch of the *nervus caroticus* the anterior and stronger branch of the first cervical ganglion of the sympathetic.

From the otic ganglion a nerve goes to the internal muscle of the malleus, ramus ad tensorem tympani. It arises from the upper and posterior part of the ganglion, and runs backwards on the inner side of the middle meningeal artery *to the muscle*.

The auricle and auditory passage derive their nerves from the cervical plexus, from the fascial, from the third branch of the 5th and from the pneumogastric.

The nerve from the cervical plexus is the great auricular nerve, and is distributed to the external parts of the auricle.

The fascial nerve on its exit from the stylo mastoid hole, gives off the posterior auricular nerve, which receives a twig from the *pneumogastric*. The temporal branches of the fascial nerve send filaments to the skin of the anterior part of the auricle, and to its anterior and superior muscles.

The superficial temporal nerve, a branch of the posterior and inferior fasciculus of the third division of the 5th, gives off two branches, nervi meatus auditorei externi, inferior et superior, the ramifications of which are distributed to the integument of the auditory passage and concha. There is one branch, *nervus tympani*, which runs under the upper wall of the osseous auditory passage to the *membrana tympani*, between the layers of which it glides and separates into very delicate filaments, by one or two of which *it anastomoses with the chorda tympani*.

I shall make but few remarks on the physiology of the tympanum as taught in the anatomical schools of the present day.

Savart has made several ingenious experiments on the membrana tympani, with regard to its vibratile power; but unfortunately they were made upon the dead and dry membrana tympani. I must therefore leave my readers to decide whether deductions arrived at by such experiments, ingenious as they have been, can be looked upon as the true physiological condition of that muscular membrane during life. Physiologists appear to be agreed that the action of the only muscles which have been satisfactorily demonstrated are tensors of the tympanum; and that at whatever extremity of the chain of ossicles muscular effort be first exerted, a corresponding effect will be produced at the other.

In experiments or operations upon the membrana tympani, we must never forget that it is a highly vitalized and sensitive structure, plentifully supplied with nerves and blood vessels. What should we think of the anatomist or physiologist, who should attempt to describe the structure or functions of the urinary bladder, from a dried specimen.

A condition essential to the due performance of the function of the tympanum is, that the external air have free access to its cavity.

Voice, says Vitruvius, is breath flowing and made sensible to the hearing by striking the air. That the presence of air is necessary for the production of sound is proved by the experiment first tried by Hauksbee, and repeated by Biot. A bell was made to ring in the receiver of an air-pump, and in the proportion as the air was exhausted it was found that the sound died away,—and it again returned as the air was re-admitted. On the other hand, the bell sounded more strongly when the air within the receiver was condensed, and the greater the condensation of the air, the louder was the sound. Warm air, from its greater elasticity, conveys sound more rapidly than cold. Air appears to be as essential to the organ of hearing, as it is to the organ of voice: vocal sounds are produced by it, which sounds are estimated through it by the ear.

Man being the only animal endowed with language, or the power of communicating his ideas orally to his fellow man, we should, *a priori*, expect to find in him a most perfect organ of hearing; fully developed in all its parts, and susceptible of appreciating the nicest and most delicate impressions—and such is the case.

To make my views of the functions of the tympanum ossicula anditus and muscles, together with the Eustachian tube and mastoid cells, clear, I submit a parallel between the cavity of the

tympanum and the mastoid cells ; and the trachea lungs and cavity of the thorax, both destined to receive air.

PARALLEL BETWEEN THE CAVITY OF THE THORAX AND THE TYMPANUM,

The lungs and cavity of the thorax communicate with the external air by means of the trachea, a tube composed partly of fibro cartilaginous rings, fibrous membrane, elastic fibres, muscular fibres, and lined by a mucous membrane.

The cavity of the tympanum communicates with the external air by means of a tube, the aural trachea, which opens into the pharynx, composed partly of cartilage and partly of fibrous membrane, and lined by mucous membrane.

The air is invited into the lungs, through the trachea by the motion of the diaphragm, intercostals, &c. where it distends the bronchial tubes and air cells of the lungs.

The air is invited into the ear through the Eustachian tube, by the motion of the membrana tympani, which is muscular, and forms the aural diaphragm; regulated in its action by its atagonists, the muscles attached to a chain of bones, and which move with considerable leverage power, like a bell-crank or pump, extending from the membrana tympani to the foramen ovale, where it distends the cavity of the tympanum and mastoid cells, and is essential to the function of audition.

Sir Everard Home, states that he distinctly saw muscular fibres in the membrana tympani radiating from the centre to the circumference, first in the elephant, and afterwards in the ox, and in the human subject. But it is not absolutely necessary, to carry out my theory, that the membrana tympani should be muscular, elastic membrane, or tissue similar to the ligimenta subflava would answer the purpose.

The lungs, diaphragm and thorax muscles, are supplied with respiratory nerves, according to Sir Charles Bell.

The ear and its muscles are likewise supplied with respiratory nerves, in a well marked and singular manner; the Eustachian tube also receives branches.

That air does not force itself uninvited into the cavities or canals of the body, is well known. Why should the Eustachian tube be an exception?—Air does not rush into the male or female urethra although the latter canal is but an inch and a half long, about the same length as the tube to the middle ear; neither does it force a passage into the œsophagus, intestines, nor even into the lungs

themslves, without muscular action; nor does it enter the tympanum without the special action of muscles, and which muscles act in harmony and synchronously with the thoracic diaphragm, and other respiratory muscles. During an inspiration the cavity of the tympanum and mastoid cells receive a fresh supply of air, and during expiration a portion escapes. The muscles attached to the ossicula are the antagonists of the aural diaphragm, which in point of obliquity of attachment is very similar to the diaphragm of the chest.

Witness the birth of a child, and when the first inspiration is made, it is evident that the air does not rush uninvited into the lungs; the descent of the diaphragm is first felt sharply under the hand, the air then distends the lungs, a pause ensues, another action of the muscle takes place, and another distention follows.

Air does not force itself down the œsophagus to the stomach, although passing continually into the larynx. An occasional ball of air may be accidentally swallowed with the food by the muscular action of this tube, but that it is foreign to its function, the unpleasant feeling it causes and its speedy rejection, will prove. Majendie, says, "independently of the faculty of *swallowing* meat and drink, many people are able by means of deglutition to convey air enough into the stomach, to distend it. It was long believed that this faculty was very rare, aud M. Gosse, of Geneva, was quoted as having possessed it in a very remarkable degree. Among one hundred students of medicine, Magendie, found eight who were gifted with this faculty, which may be acquired without much inconvenience. Air becomes hot, rarefies and distends the stomach. In some people it excites a sense of burning heat; in others, a desire to vomit, or very acute pains. Its stay in the stomach is longer or shorter, according to circumstances—it commonly rises up into the œsophagus, and escapes by the mouth or nostrils: at other times it traverses the pylorus, is spread through the whole extent of the intestinal canal, even to the very point of passing out *per anum*." I have known infants at the breast, when the supply of milk was not very abundant, gulp and swallow in their avidity quantities of air, which invariably in a short time causes considerable uneasiness, and the child screeches until it be expelled *per vias naturales*.

The functions of the muscles of the chest are mixed, partly voluntary and partly involuntary: that the muscles connected with the tympanic cavity act in a similar manner, may be observed by the attention being directed to any particular sound—the mouth is partially opened and an inspiration is made and retained for a

moment, thereby fully distending the cavity of the tympanum and its appendages. We listen during inspiration. By placing the extremities of the middle fingers firmly in the external auditory passages, and closing the mouth, a distinct movement of the aural diaphragm and muscles of the auricle may be felt when we inspire quickly through the nose.

Introduce a light probe, (I have used one made of the pith of a rush,) into the external auditory passage, and let it impinge gently upon the *membrana tympani*, not forgetting the obliquity of this membrane, now breathe regularly, and I think a distinct motion may be perceived during inspiration and expiration.

I cannot look upon either of these experiments, as an *experimentum crucis*, for the motion may be confounded with other movements, and the alteration of the positon of the *membrana tympani*, must be very trifling--nevertheless, that such movements do take place I have not a doubt.

During an act of aural inspiration, the tympanic cavity is enlarged by the altered position of the aural diaphragm, which is restored during expiration by the action of the muscles attached to the lever of bones, whose mechanical arrangement is most beautifully adapted to the purpose.

We know that air may be forced into the middle ear, by closing the mouth and nostrils, and at the same time expiring strongly; but considerable power is required even then to effect it, and the disorder which the act causes to audition has been felt by most people.

The admission of air into the tympanum being so important to the function of hearing, we can scarcely imagine the entrance of it to the cavity, and mastoid cells, being left unregulated or to chance; and as it must be renewed at intervals, a portion must be expelled:—consequently, a regular alternation of action becomes necessary; and as the aural trachea merely communicates with the external air during an inspiration performed by the lungs, it must necessarily be associated and act synchronously with those organs; and therefore a nervous communication is indispensable between them.

The casual entrance of air without the action of muscles, supposing the tube, which is an inch and a half long, always to be patent (which is not the case, the orifice being a mere fissure, or rima, and the canal will only admit a fine probe,) would be uncertain and irregular.

What is the use of the extensive nervous communications in and

connected with the middle ear, its muscles, and the Eustachian tube?

I will quote from Mr. Todd, in his conclusion on the physiology of these parts, (*Cyclopædia of Anatomy & Physiology*, vol ii.)—

"It is impossible in the present state of our knowledge, to say what is the office of the chorda tympani, or whether, indeed, it has any office in connexion with hearing; but we may easily conceive that from its connexion with the fascial an irritation of it may excite that nerve. Equally ignorant are we of the function of the tympanic anastamosis."

The respiratory function assigned by me to the tympanum, will at once explain the use of this extensive and hitherto apparently complicated connexion of nerves; that the respiratory act of the tympanum must be associated and synchronous with the pulmonary and general respiratory movement, will clearly point to the use of the chorda tympani nerve and tympanic anastamosis.

That the membrana tympani is not a mere drum for the reception and transmission of vibrations is evident, from many recorded cases, in which it has been destroyed and yet hearing to a considerable extent has existed. In these cases cold air is at once admitted to the cavity of the tympanum, but the nice elastic balance, temperature and regulation of the supply is lost.

"Air is to the ear, what light is to the eye." The destruction of the membrana tympani, would in its injurious effects on audition be similar to those produced on vision by cutting off the eyelids or wounding the iris; an impairment of the functions in either case would at once be the consequence, and might eventually end in a total loss of the sense—Without the guard of the membrana tympani, insects, dust, cold air, &c. would enter the cavity, and the expiratory motion of the tympanum and Eustachian tube being annihilated, there would be no escape for mucus or other accumulations. An artificial membrana tympani, perforated to admit air, would I think in these cases be a protection and service.

The action of the muscles of the small bones will draw the tympanic diaphragm, when at rest, into the cavity of the tympanum, thereby diminishing its size, and forcing air out. The attachment of the stapes over the fenestra ovalis, admits of a more elastic movement than if it were fixed to a solid and immovable bone. The relaxation of these muscles and consequent action of the tympanic membrane, will again restore the parts, and the simultaneous action of the tensor palati muscle, and probably levator palati, will dilate the Eustachian tube and assist the inspiratory effort.

The ear being the principal organ of sense, which guards and protects man, and most animals, during a state of repose; it is

necessary that it should be capable of exercising its function, independently of volition, consequently we find in the tympanum muscles which act involuntarily, and the muscles of the auricle, which in their motions assist the aural diaphragm. have likewise a similar power; and an effort of the will has very little effect on their movements.

Supposing that these small bones had not been placed in an advantageous mechanical position, but that the same motion was indispensable to diminish or enlarge the cavity of the tympanum; what would have been required to compensate for this loss of leverage? A greater amount of vital power, larger and stronger muscles, would then be necessary to effect the movement which is now produced. The design in the arrangement of these parts, has been, evidently, to appropiate as small an amount of muscular fibre as would be compatible with the function required, under an advantageous lever. The muscles traverse bony canals, and it is merely the light tendons which pass into the middle ear to their attachments. The object of this is, I think, obvious; muscle is a bad conductor of vibrations, so are mixed and heterogeneous structures; cartilage and ligaments are, likewise, indifferent conductors —larger muscles would also occupy a larger space, consequently, there would be less air in the cavity.

Such are the conclusions, which I have arrived at on the functions of the tympanum and the Eustachian tube, from the anatomical structure and mechanicism of these minute parts, and by the analogies presented in other organs of the body.

I cannot finish my paper without quoting the following apposite passage from Sir Charles Bell's work on the nerves;—

"If a part, or organ, have many distinct nerves, we may be certain that, it possesses distinct powers, or enters into different combinations, in proportion to the number of its nerves. The knowledge of this circumstance gives new interest to the investigation of this part of anatomy.

"Thus, in reviewing the comparative anatomy of the nerves of the mouth, we shall find, that in creatures which do not breathe, the mouth having only one function to perform—one nerve is sufficient.

"In certain animals, where the face and nostrils have no complexity of organization, it would have no variety of nerves. But on the other hand, when the anatomist employs weeks to dissect and disentangle the nerves of the tongue, throat, and palate, in the human subject, he finds at length, that he has exhibited branches of five different trunks of nerves; and there is no clew to the labyrinth, until he considers the multiplied offices of the mouth in man; that it is a pneumatic as much as a manducatory organ."