

**Notice of several cases of malformation of the external ear, and of experiments on the state of hearing in such persons, / by Allen Thomson ... Together with an account of the dissection of a similar case of malformation / by Joseph Toynbee.**

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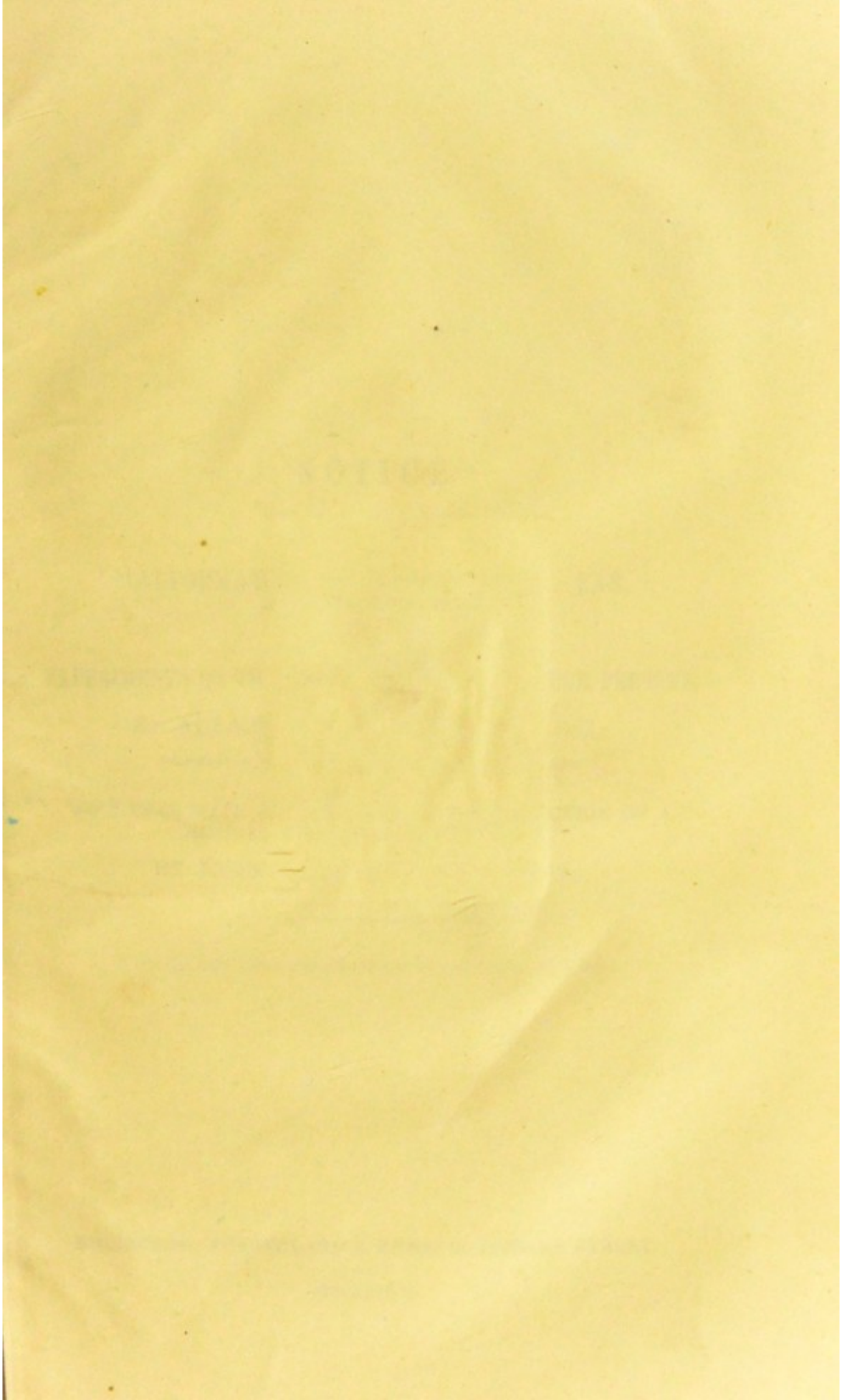
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# NOTICE

OF SEVERAL CASES OF

MALFORMATION OF THE EXTERNAL EAR,

AND OF

EXPERIMENTS ON THE STATE OF HEARING IN SUCH PERSONS.

By ALLEN THOMSON, M.D., F.R.S.E.,

PROFESSOR OF PHYSIOLOGY IN THE UNIVERSITY OF EDINBURGH.

TOGETHER WITH AN ACCOUNT OF THE DISSECTION OF A  
SIMILAR CASE OF MALFORMATION,

BY JOSEPH TOYNBEE, F.R.S., &c., &c.

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[FROM THE EDINBURGH MONTHLY JOURNAL OF MEDICAL SCIENCE, APRIL 1847.]

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## MALFORMATION OF THE EXTERNAL EAR.<sup>1</sup>

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IN March 1843 I saw, along with Professor Miller, a young man affected with congenital closure of the external passage of both ears, and imperfect development of the auricle, and in the course of the same year, I met with two other instances of the same kind of deformity, in a somewhat greater degree. These cases appear to me deserving of notice, both on account of their nature considered as malformations by arrest of development, and from some circumstances with respect to the power of hearing without the assistance of the external and tympanic portions of the auditory apparatus, which the experiments performed upon the three individuals brought to light.<sup>2</sup>

The malformation of the outer and middle portion of the organ of hearing does not appear to be of very rare occurrence. Several varieties of the affection have been described by authors, and a few have been examined by dissection, so that we are not altogether without the means of forming a probable conjecture as to the state of the deeper parts in the cases referred to in the present paper. A specimen of the temporal bone, presenting a very marked instance of this malformation, is preserved in the anatomical museum of the University, and has assisted me greatly in forming an opinion as to the exact seat and nature of the deformity.

Malformation of the external ear with absence or occlusion of the meatus on both sides, does not appear to cause total deafness, even when attended with considerable departure from the natural form and structure of the cavity of the tympanum: in the instances which I have seen, indeed, the deprivation of the power of hearing was not so great as may frequently occur from other causes of apparently a much slighter nature. This manifestly depends on the circumstance, that the malformations in question, are rarely accompanied by any unnatural condition of the essential parts of the labyrinth, which are more immediately concerned in the reception of the sonorous impressions. In none of the three cases to be described, was the defect of hearing originally to such a degree as to

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<sup>1</sup> The following pages contain the substance of a paper read before the Royal Society of Edinburgh in December 1843 and January 1844. (*See the Society's Proceedings*, 1844, p. 443.)

<sup>2</sup> Of these experiments some were performed in concert with Professors Forbes and Miller upon the lad first mentioned.



induce dumbness. An example is recorded in which this was the case, but it may reasonably be supposed, that the malformation in this case affected the deeper as well as the middle and external parts of the auditory apparatus. The instances are not frequent, however, in which deaf-dumbness is caused by congenital malformation of any kind, and it is sufficiently well known to all those who have been connected with Institutions for the deaf and dumb, that in by far the greater number of instances of deafness, either total or to such a degree as to induce dumbness, the affection has proceeded from diseases in early life, such as scarlet fever, measles, and small pox; the inflammatory and suppurative process affecting first the cavity of the tympanum, and being subsequently communicated to some part of the labyrinth. In some of the instances of deafness from congenital affection of the internal ear, dissection has brought to light various degrees of an abnormal condition of the whole labyrinth, or of some of its parts; such as total absence, incomplete canals or cochlea, closure of the meatus auditorius internus, small size or absence of the auditory nerve, &c.

Congenital malformation may exist in any one of the three parts of the auditory apparatus, or in two, or in the whole of them at once. The external auricle is sometimes found deformed, while the meatus and tympanum appear natural; or the labyrinth may be deficient, with a perfect auricle, meatus, and tympanum; but in most instances, an imperfect condition of the tympanum and meatus is attended with malformation of the auricle—a circumstance which, it will afterwards appear, may proceed from these three portions of the apparatus being developed in the fœtus from the same system of parts. One or both organs may be the seat of the malformation of the external ear; and the deeper the parts involved in the abnormal structure, there is the greater probability that both sides will be affected.

There appears to be no good reason for the opinion expressed by Itard, that the existence of malformation of the ear is to be looked upon as a sign of the non-viability of a child at birth. In so far as this malformation, like others, is a sign of general weakness of the constitution, it may be considered as prejudicial; but it is not in itself a source of any danger; and a sufficient number of persons so affected have arrived at maturity in good health, to disprove the opinion now referred to.

I have now to direct the reader's attention to some particulars connected with each of the cases of malformation of the ear that have come under my notice.

The lad, W. B., was first seen by Professor Miller in 1841, when he was thirteen years old. Both he and his friends were most desirous that an attempt should be made, by a surgical operation, to open up the natural passage of the ear. This was scarcely necessary on account of the hearing, for that faculty was not by any means very imperfect.



Mr Miller learned that this boy had given the usual signs of hearing, and had begun to speak, as early as children usually do so; that he had gone to school at the ordinary age; and that, placed in the common class along with other boys, he was able to follow what was said, and to become equally proficient with his fellows in the various elementary branches of education. He joined heartily in the amusements of his school-fellows, and did not appear in play to be inferior to the generality in sharpness or activity. He was also frequently employed by his father, who was a butcher, in going messages, and transacting little matters of business; all of which circumstances proved at once his intelligence, and an amount of the power of hearing not inferior to what might be called a dulness of the perception of sounds. In fact, his hearing was such, that by attention he could join in the conversation of those with whom he was intimate, and that even a stranger could communicate with him by employing slow, distinct, and somewhat loud articulation.

Mr Miller complied with the urgent wish of the lad and his friends, and made an incision in the natural seat of the opening of the meatus upon the right side, on which the auricle and cartilage appeared less imperfect than on the other. He found, however, all the substance exposed by this incision to be dense and imperforate, and nothing perceptible in the slightest degree resembling either a meatus or membrana tympani; and he was satisfied that the operation was futile on account of the wall of bone being complete in the whole vicinity of the ear. Neither did Mr Miller find that there was any difference in the lad's power of hearing whether the wound was open or closed; and he therefore allowed it to heal up.

When I afterwards saw this young man along with Mr Miller, I endeavoured to persuade him to allow me to pass a probe into the Eustachian tube, with a view to ascertain the condition of this passage, which it would be most desirable to know; but I could not overcome his objections to this operation.

With the exception of the very deficient state of development of the auricle, there was no other peculiarity to be remarked in the configuration of the features or head in this lad. His countenance was well formed, both in its upper and lower parts near the jaw, which was by no means the case in the other cases I have seen.

In April 1843, I visited at Falkirk along with Mr Girdwood of that place, and Dr Mercer, a young woman of about sixteen years of age, presenting the same kind of malformation to a greater extent than in W. B., and, along with the local malformation of the ear, considerable imperfection in the shape of the lower part of the face. The lower jaw was remarkably short, its position oblique, and its angle very obtuse; the malar bone was placed far back on the cheek, and the zygomatic arch much shorter than usual.

When this girl was about six years old, Dr Dewar of Dun-



fermline, attempted without success to remedy the defect by an operation on the right side. On making an incision through the integuments, he informs me, something like a membrana tympani was uncovered, and so long as the wound remained open, the girl heard much more acutely than she had done previously; but it was found impossible to keep the opening free during the process of healing, for the new granulations, in spite of all caustic applications, spread continually over the supposed membrana tympani, and finally closed up any passage that had been opened.

This girl was not the only one of the family that was so affected. Dr Mercer has shown me a cast of the head of an infant sister who died in childhood, presenting precisely the same malformation, and I was interested in perceiving that another sister in whom there was not any malformation of the ear, had the same peculiar form of countenance, which I believe to be related to the imperfect development of some of the parts connected with the middle and external ear.

I am inclined to believe that in cases in which the external and middle parts of the auditory apparatus are imperfectly developed, there is a tendency to other malformations about the maxilla and palate. In both the cases already mentioned, there were marks of this tendency in the cleft palate, and deficiency or irregularity of the upper lateral incisor teeth. In W. B. the cleft affected only the uvula, but it was to a greater extent in the girl at Falkirk.

This girl appeared to be possessed of only a moderate share of intelligence, partly from weakness, and partly from her imperfect hearing and consequent want of proper education. Her power of hearing was much less acute than that of the lad W. B., and her choice of language was somewhat limited. She understood, however, what was said to her when it was spoken slowly and distinctly, and she always answered by speech, though rather inarticulately. It ought to be mentioned that there was this marked difference between her case and that of the lad W. B., that she heard much less with the one ear than with the other; indeed she had scarcely any hearing on the side on which the operation had formerly been attempted.

In the third case I have to mention the amount of deafness was greater than in either of the two previous ones. This was Miss R., a lady of about forty-five years of age, residing in Edinburgh, who in her youth had been a pupil of the Institution for the Deaf and Dumb, and in whom, notwithstanding the advantages she there enjoyed from the instructions of the highly zealous and philanthropic Mr Kinniburgh, so well known in connexion with the education of the deaf and dumb, her defective language, and my experiments on her hearing, indicated a very imperfect state of the auditory apparatus. In this lady, however, as in the lad W. B., the hearing, such as it was, appeared to be equal on the two sides.

The form of the imperfectly developed auricles, and the shape of the countenance, presented a remarkable similarity to those of



the girl at Falkirk. The malar bone was thrown so high and far back on the side of the cheek, that the zygomatic arch appeared entirely wanting: the auditory process of the temporal bone could not be felt by the finger; and on the left side particularly, the articular tubercle seemed absent, so that the head of the lower jaw was allowed to project considerably on the cheek.

The sounds of the voice and speech were thick and nasal, and led me at first to suppose that a cleft condition of the palate would be found, as in the other cases; but on inspection the uvula and palate were observed to be quite entire. There existed, however, a remarkable shortness of the vault of the palate from before backwards, which appeared to me sufficient to account for the peculiarity of voice and speech, resembling, in a great degree, that of persons affected with cleft palate.

The same shortness enabled me easily to perceive the openings of the Eustachian tubes through the mouth.

In her youth this lady had been taken to London in order to undergo an operation by Sir Astley Cooper, for the removal of the defect; but entirely without any good result, as no meatus could be found by incision: and I understand that another attempt of a similar kind, made at a later period in Edinburgh, was equally unsuccessful.

The result of experience, in all the cases now mentioned, is decidedly opposed to the propriety of attempting to cure them by surgical operation. All that is known from dissection of other cases, proving the entire absence of the meatus, would lead to the conclusion that no benefit is to be expected from this mode of treatment: and I feel persuaded that it should not be resorted to, unless there are good grounds for believing the meatus to be present, and its closure to be caused by malformation of the integumental part or auricle alone: but I do not believe such to have been the state of the parts in two at least of the cases I have described. Even in the girl at Falkirk, in whom Dr Dewar thought "something like a membrana tympani" was exposed by the operation, it was found impossible to keep this structure free during the process of healing. This difficulty was as fully shown in another case of a similar kind which Dr Dewar had met with, and which he was so kind as to communicate to me at the time when I requested him to furnish me with information respecting the girl at Falkirk. In a boy, ten years of age, Dr Dewar observed "the external ears quite deformed, and the meatus completely closed." This boy heard better in one ear than in the other, and the case appeared to Dr Dewar to be one susceptible of improvement from operation, had not the same causes, as in the other case, interfered to prevent its ultimate success. Dr Dewar removed a portion of the integument from the natural situation of the meatus, and uncovered "a structure which bore some resemblance to the drum of the ear." The hearing was now manifestly improved; the boy started and seemed



alarmed at sounds which previously had passed unnoticed by him : but the growth of granulations, and more especially the tendency which the edges of the divided skin had to approach each other, rendered the operation of no permanent avail. Dr Dewar destroyed these granulations with caustics, actual and potential, but no method, he states, occurred to him at the time of effectually repressing the tendency to reunion ; and the patient was afterwards lost sight of.

I know only of two dissections of the deeper parts in cases similar to those now under consideration. One of these is described by Professor Jaeger, of Erlangen ; the other, which has not, so far as I am aware, been described, is preserved in the Anatomical Museum of the University of Edinburgh.<sup>1</sup> In both of these examples, the malformation affected one side only, and there is a remarkable similarity in the condition of the temporal bone. In both, the labyrinth appears to be quite naturally formed ; the cavity of the tympanum and the bony Eustachian canal exist, but are much smaller than usual : the chain of ossicula differs materially from the natural structure ; being united, in one of the examples, into one straight and simple piece, and consequently assuming very much the form and appearance of the columella of birds or reptiles. The most striking departure from the normal form of the bone, consists in the entire obliteration of the meatus externus, which seems to be connected with the absence of that portion of the temporal bone which forms the tympanic ring and lower side of the bony canal of the meatus, and the extension backwards of the articular or true glenoid portion of the temporal bone to twice its natural breadth. There is a total deficiency, therefore, of what may be termed the tympanic bone, or of that which forms the posterior non-articular part of the glenoid cavity of the temporal bone, intervening between the fissure of Glaser, and the vaginal ridge of the styloid process. Were this part of the bone merely deficient, the cavity of the tympanum would be left freely open below ; but, in the two bones now described, it seems to be closed by the unusual extension of the glenoid or articular portion of the bone backwards.

In reviewing the cases before us, and comparing them with the results of dissection now stated, the following appear to be the most prominent points of deviation from the natural form and structure :—*1st*, An incomplete development of the integumental part of the apparatus, viz. the external auricle and outer part of the meatus. *2d*, The absence of membrana tympani, tympanic ring, and bony part of the meatus, in consequence of the incomplete development of the tympanic bone, or a part of the structure

<sup>1</sup> A third dissection of a similar case has been communicated by Mr Toynbee, since the above was written, and will be found at the end of this paper.



which, in the lower animals, bears that name. 3d, The defective state of the cavity of the tympanum and chain of small bones. 4th, Occasional irregularity or deficiency in the development of the malar, palatal, and maxillary portions of the face.

*Experiments on the State of Hearing, in the above Cases of Malformation.*

Although it is generally understood that sounds may reach the seat of hearing by direct transmission through the bones of the head, more especially when sounding bodies are brought into contact with any of the hard parts, it appears to me that the extent to which sounds may, in this manner, be heard, is usually underrated, and has not been determined with sufficient accuracy.

The history of the individuals affected with congenital closure of the external passage of the ear, whose deformity has now been described, illustrates this mode of transmission of sonorous vibrations in a striking manner, and also exhibits some other peculiarities in the function of hearing, which appear deserving of notice.

In all of the three individuals alluded to, the closure of the external meatus was so complete, as to render impossible the transmission of sounds to the tympanum through air alone. Dissection has shown that, in some similar cases, not only is the outer passage closed, but the bony part of the meatus, and the membrana tympani are absent; and it seems probable that the same state of the parts exists in two at least of the individuals referred to in the present paper. The cavity of the tympanum itself, it appears, is not entirely absent, but its size is reduced considerably below that which is natural. The chain of small bones is imperfectly formed, and wants that disposition which, in the natural state, fits it so admirably for facilitating the transmission of sonorous vibrations from the external air to the fluid of the labyrinth, that is, the abutment of one of its extremities, the malleus, against the membrana tympani, while its other rests by the base of the stapes, on the membrane of the fenestra ovalis of the labyrinth. In fine, it appears highly probable, that in these individuals the Eustachian canal is present, and transmits air into the cavity of the more or less imperfect tympanum.

Yet, notwithstanding this very imperfect condition of the accessory parts of the auditory organ in these three individuals, the power of hearing was considerable; such, indeed, that a conversation could be kept up with them all, and only in one of them with considerable difficulty.

In persons, therefore, affected with such a malformation, the internal ear, or the auditory nerve, as the immediate seat of the sensation, is affected by sounds entirely through the hard parts of the head, whether the sonorous vibrations are communicated



directly to these parts by contact, or, as in common conversation, only through the medium of the air, and their subsequent communication to the hard parts of the head.

In persons in whom the hearing is natural, the external meatus and tympanic apparatus are so much the more frequent and perfect channel of communication of sound to the internal ear, that we are apt to neglect the more direct mode of transmission of sounds through the bones of the head. This last is, nevertheless, constantly in operation, and is the cause of several interesting phenomena of the function of hearing. It is forcibly brought under our notice by the examples of deformity now in review; it also becomes obvious in all those whose hearing is impaired by mere disease of the external passages, without closure; and it may also be made apparent by a very simple experiment, in those whose organs of hearing are perfect.

The experiments I am about to describe are founded upon the fact, that sounds transmitted by contact of the sounding body directly to the head, or other hard parts, appear louder when the external meatus is closed. This fact is rendered familiar to many by the common experiment of suspending an iron rod, or other sounding body, by a cord, which, in passing over the finger, is brought in contact with some part of the head, the ears being closed at the same time by the hands, while the iron is struck against some other bodies; the sounds are thus rendered much more intense than they appear when heard with the meatus open. In using the musical tuning-fork, the following experiments may be more accurately performed:—

Place the tuning-fork, while sounding, in contact with the middle of the top of the head, with the ears open, and it will be heard only faintly; then close the external ears, and the intensity of the sound will appear much greater, indeed almost doubled. If one ear only be closed, the intensity of the sound in the shut ear will appear so much greater, that the sound seems chiefly to be heard in that ear, and this to a remarkable degree; for even if the tuning-fork be applied to the head, close to the open ear (provided it does not touch the external auricle), the sound will appear to travel over to the opposite ear, the meatus of which is closed. We can even trace, by our sensations, the way which the sound seems to take to gain the opposite side. When the tuning-fork, for example, is applied to any part of the skull, at a little distance from the open ear, the sound will appear to travel over the top of the head; but when applied close to the open ear, that is, towards the base of the skull, it seems as if the sensation of the vibration passed through the base to gain the opposite side.

Professor E. H. Weber, of Leipzig, to whom we owe an accurate description of this phenomenon, attributes the increase of sound to the resonance of the confined air of the meatus and tympanum, or to the vibrations established in this column of air, rendered a separate system in consequence of its enclosure. I find



that the increased intensity is still produced by shutting one or both of the meatus, when water has also been introduced to take the place of its air. And this is the case when there is merely water introduced, without the additional use of the soft waxen plugs employed in the other experiments. The explanation of independent vibration of the confined medium might be allowed to apply to water as well as to air; but, although I am not prepared to offer a better, I confess it does not appear to me to account satisfactorily for all the phenomena.

To illustrate fully the relation existing between the transmission of sounds through the meatus, and that through the hard parts of the head in persons whose hearing is natural, let the tuning-fork, sounding as nearly as possible with equal intensity each time, be placed in the following positions—first, with the ears open, held close to one meatus without touching, the most perfect (that is the clearest and loudest) sound will be thus obtained; second, shut the meatus of one or both ears, and hold the tuning-fork close to the shut ear, and its sound will scarcely be heard. Third, shut both ears, and apply the tuning-fork by contact to the vertex of the head, when it will be heard nearly as loud as when close to the open meatus, and it will be heard with nearly equal intensity in both ears. Fourth, shut one meatus only, and when the tuning-fork is applied to any part of the head, a sound of less intensity than in the last case, will be heard, but proportionally so loud in the closed ear, that it requires a considerable effort of attention to enable us to perceive the impression in the other or open ear. Fifth, to render this still more striking, hold the tuning-fork opposite, and very near one open meatus, a loud and distinct sound will be heard; shut the opposite ear, and apply the tuning-fork by contact to the head near the open ear, and the sound is now heard louder in the closed ear than it was before by the open one, and is scarcely perceived in the latter.

In making similar experiments on persons deaf of one ear, from affection of the tympanum or Eustachian tube, an unexpected circumstance was noticed, viz. that the sound of the tuning-fork applied to the head appeared, as in the previous experiments on closing the meatus, much the loudest in the deaf ear. This may not be the case in all such persons, but in four out of five in whom I have made the trial, the result was as I have now stated it; and it can scarcely be held that this greater intensity of sounds felt through the deaf ear was merely the effect of its being unusual.

The study of the partially deaf is of peculiar interest, not only for the physiological elucidation of the functions of the ear, but also practically with a view to the adoption of means for the improvement of hearing in them. I refrain from alluding in this place to the medical or surgical treatment applicable to cases of partial deafness. I shall only make the remark, that it seems probable from recent observations, that the amount to which improvement may pro-



ceed from medical treatment, has been much exaggerated. In restricting myself entirely to the acoustic view of the state of the partially deaf, it is apparent that in case of failure to obtain any improvement by medical or surgical treatment, essential service may still be rendered them by bringing them within the range of hearing through other means.

Dumbness is known usually to proceed from deafness, either existing from birth or arising early in life. The exceptions to this are very rare, and occur only from defective formation of the organs of voice and speech, or from disease of the brain. In the case of dumbness arising from total congenital deafness, sounds can never be associated with ideas, and, consequently, feelings, emotions, actions, and the names of objects, or description of their qualities and states, must find a language in natural gesture, or in conventional written and manual signs. In the second case, that, viz. of total deafness coming on later in life, even if speech shall already have been acquired, it may be gradually lost, in consequence of the want of habit to associate sounds with speech. This occurs only, however, in early life, when the habit of speech has not been fully confirmed. I am informed by Mr Kinniburgh that it rarely happens that dumbness is caused by deafness so late as the tenth or eleventh year, and that the extent to which this may occur will depend very much on the circumstances in which the individual is placed. In those who become only partially deaf, but to such an extent as to incur the risk of becoming also mutes, it seems probable that much of the power of retaining voice and speech, or of regaining it, may depend on a very small difference in the amount of hearing; and I am inclined to think that much more might be done than has yet been attempted, in a certain proportion of such cases, by assisting the hearing through the hard parts of the head, or by other means. Indeed, it seems surprising, considering how long it has been known that in some deaf persons the hearing of sounds is improved by promoting their transmission through the bones of the head, that an apparatus, calculated to facilitate this mode of communication of the sonorous vibrations, has not been employed in place of the ear-trumpet, which can be of comparatively little service to them. The experiments which I have made upon the partially deaf, lead me to divide them into two classes, according as their hearing is in the one set most perfect through the meatus, or in the other, through the bones of the head, a difference which may at once be ascertained by means of the tuning-fork. In those hearing best through the hard parts of the head, it has long been known that the air passages, or accessory parts of the organ principally are affected. In those partially deaf persons, on the other hand, who hear best by the meatus, it appears very probable that in general an affection of the internal ear, or loss of sensibility of the auditory nerve, is the cause of deafness.

In these last, the ear-trumpet is of essential service, by concen-



trating all the weaker vibrations in the passage which is to carry them to the nerve, whose sensations are deadened. In the former the meatus should be closed, and every means ought to be used, as by sounding-boards to collect, and solid elastic rods to conduct, the vibrations to the hard parts of the head.

In connexion with the mode of hearing now under consideration, it is also proper to observe, that the sounds of a person's own voice are heard chiefly through the hard parts of the head, the vibrations being communicated directly to them from the cartilages of the larynx, &c. We accordingly find that one's own voice, like all other sounds arriving through the hard parts of the head, appears louder when the external passages are stopped. The loss of speech, then, in mutes, from deafness, depends in a considerable degree on their inability to hear, and, consequently, to regulate the sounds of their own voices. Hence we find occasionally speech preserved to some extent in persons whose hearing is not sufficiently acute to enable them to follow what is said by others, unless in very loud bawling; and hence, in one of the cases of closure of the meatus before us, that of Miss R., who hears least well of all of them, speech has been retained, while she is habituated to hear few words spoken by others, who find it necessary, in general, to employ the finger signs for the purpose of communicating with her.

By the complete closure of the meatus we reduce our organs of hearing nearly to the condition of that of animals living in water, as fishes and aquatic amphibia; and accordingly when the head is immersed in water, and that fluid allowed to enter the meatus, it is well known that all sonorous vibrations which affect the water externally, and even those at a great distance, are heard with distinctness by the person so immersed.

It might be supposed that in our cases of absence of the meatus and membrana tympani, the individuals heard in the same manner as fishes—but it is not precisely so, for in aquatic animals there is no cavity of the tympanum nor Eustachian tube admitting air into it; while this part of the apparatus is not prevented from acting by the closure of the meatus in ordinary persons; and there is reason to believe the tympanum and Eustachian tube to be also present in those affected with absence of the meatus and membrana tympani. In such individuals, consequently, not only are the auditory nerves of the vestibule, semicircular canals, and cochlea affected by sounds arriving through the hard parts of the head, but sonorous vibrations must also pass from these hard parts to the air within the cavity of the tympanum, and thus affect both secondary membranes, that is those of the fenestra ovalis of the vestibule and fenestra rotunda of the cochlea.

It might be interesting to inquire, here, whether the facts now brought under our notice throw any light on the obscure but most interesting subject of the functions of the different parts of the labyrinth; but it is not very obvious that they do so, unless, in adding



probability to the view taken by Weber, that the cochlea constitutes in all animals provided with a tympanum, that part of the labyrinth in which the greatest number of nervous filaments are most favourably disposed within a narrow space for receiving sounds directly from the hard parts of the head, or mediately from the air of the tympanum affected by the vibrations of these solid parts.

In making various experiments upon the individuals whose history forms the subject of the first part of this paper, a remarkable difference presented itself in the mode of hearing of two of them, viz. the lad B. and Miss R., from what occurs in most other persons.

In almost all those in whom I have tried the experiment, sounds of vibrating bodies applied to the hard parts of the head, like those vibrating in the external air, appear louder the nearer the place at which the sounding body applied is to the seat of hearing. This every one knows is the case with the ears open, and it may be ascertained with great ease when the ears are plugged, by the comparison of any sound of uniform intensity, such as the ticking of a watch, or sound of the tuning-fork applied at different parts of the head, and still more exactly, by the following modification of the experiment.

After the ears have been filled with water and plugged, or simply plugged with soft wax, apply the tuning-fork to the vertex, or some part of the head remote from the ears, and keep it there till the sound is no longer heard, then bring it down towards the meatus, and on applying it to any part nearer the meatus than before, the sound will be again heard, a result which removes any objection to the former experiment, that could be founded on the difficulty of our comparing the intensity of successive sounds, and excludes also the supposition, that the greater intensity which sounds appear to have in the former experiments, is a mental illusion depending on our habitual association of louder sounds with the vicinity of the ear.

It was found, however, in the first experiments made upon the lad B. by Professors Forbes and Miller and myself, and I have since observed the same in Miss R., that sounds were heard loudest not near the seat of the organ of hearing, but invariably upon the vertex of the head.

In a series of experiments performed upon the lad B., in Professor Forbes' class-room, in company with Professors Forbes and Miller, and Dr Spittal, it was found, that the tuning fork was heard best when applied to the vertex of the head,—next best farther back on the middle line or near the occiput, and least well near the site of the external ears. Exactly the same result was obtained in experiments with an organ pipe sounded opposite to these different situations, without its being allowed to touch the head. In repeated trials subsequently made in company with Professor Miller, I found, that while the lad B. heard my watch ticking at a distance of five or



more inches above the top of the head, he was unable to detect its sound at a distance of only half an inch opposite to either of the external ears, and not indeed, till it was firmly pressed upon this part of the head. It was also found, that when the watch was brought into contact with, or pressed upon any part of the head, its sounds were most audible in the situations in which he heard the organ pipe or tuning fork best, that is over the vertex and occiput.

The experiments upon the girl at Falkirk, were not attended with a similar result. She hears best over the site of the ear. But, in this girl it will be recollected, that Dr Dewar when he performed the operation upon her, uncovered something resembling a *membrana tympani*, and that the power of the two ears is very unequal,—circumstances which make me regard her case as in some respects different from those of the lad B. and Miss R.

The only other instance in which I have found the more perfect hearing of sounds conducted directly to the head to be more perfect at the vertex than near the ears, is that of a girl at present a pupil in the Glasgow Institution for the Deaf and Dumb.

This girl was very deaf from birth, but not entirely so. She is dumb, however, or articulates only very imperfectly. Her defect of hearing is of that nature, belonging principally, though by no means exclusively, to the external passages, that she hears sounds through the hard parts of the head which are altogether inaudible by the meatus, and I was surprised to find that she heard both the ticking of a watch and the sound of the tuning-fork better when they were applied to the top of the head than in any other situation.

I could not ascertain that any very obvious disease of the *tympanum* existed in this girl, and I am unable at present to offer any satisfactory explanation of the phenomena observed. In how far a peculiarity in the disposition of the bones of the head may account for it, I would not pretend to decide; but I am more inclined to believe, that the difference now pointed out as existing between the mode of hearing of this girl together with the lad B. and Miss R., and that of other persons, is to be ascribed to some change of the structure of the ear itself. It is possible that it may depend upon both ears being simultaneously affected with an impression of equal intensity when they arrive by the vertex of the head.

The degree to which even weak sounds are transmitted to the ear through the hard parts of the body as well as of the head, in the persons whose history we are now considering, appeared to me remarkable. In the case of the lad B., for example, a watch which had only a weak sound, was distinctly heard by him when it was held in his hand, or was placed on the spine, or pressed on the haunch bone; and in Miss R. weak sounding bodies are heard even when pressed on the ankles. She not only feels the vibrations by the nerves of touch, but also hears the sound of the clock striking in the next room, in this way chiefly through the walls and floor. From habit and cultivation, or from some other cause, sounds are



in this manner more perfectly heard by these individuals than by other persons.

It must be obvious that from the nature of their defect, the persons affected with closure of the meatus, must labour under considerable difficulty in distinguishing accurately different degrees of intensity of sound; but it does not appear that in any of them, there is any want of the power to distinguish its other qualities, as timbre or pitch. The lad B. had a range of hearing, apparently as extensive as that of other persons, he having been tried in Mr Forbes' room, with a range of sounds extending from one very low in the scale to one four octaves above the middle C of the piano-forte, and he was perfectly able to distinguish the pitch of different notes.

The difference in the direction of sounds, he appeared to have very little, if any, power of distinguishing; but this is not more than we should expect, for most persons can tell the direction from which sounds proceed very imperfectly indeed, when the ears are stopped. Our knowledge of the direction of sounds, in fact, depends in a great measure upon our judgment of the difference of intensity with which one or other ear is affected by them; or when one ear only is employed, by the motion of the head till the axis of the open meatus is brought exactly into the direction of the quarter from whence the sound proceeds, when it is heard with greatest intensity. But so completely devoid was the lad B. of any such faculty, that he generally referred all sounds to the direction of the vertex of the head, as the place where he appeared to hear them most intensely.

This remark with respect to the power of distinguishing the direction of sounds, leads me to consider next the history of the persons with closed meatus, in reference to their hearing with one or both ears.

Even in those whose hearing is perfect, the ears exhibit great inferiority to the eyes, in separating or distinguishing sensations, which affect, simultaneously, the organs of the two sides. Dr Wells, founding upon what is observed to occur in vision, imagined that if two different sounds could be heard separately, each one by a different ear, such sounds would not coalesce; but Dr John Gordon, arrived at a different conclusion, and, I believe rightly. The individuals before us, present conditions in which there is almost a total impossibility of the opposite ears being differently affected by simultaneous sounds, so much so, indeed, that the lad B. never appeared to have conceived the organs of hearing to be double, or to have distinguished one from the other. Nor, indeed, was he aware that the seat of hearing was in that part of the head, which is occupied by the internal ear; but was in the habit, when listening attentively, of placing the flat part of his hands upon the sides of his head so as to cover his imperfect ears, and of directing



the top of his head towards the quarter from whence he knew or supposed the sound to proceed.

The lad B. and the other persons similarly affected, hear sounds proceeding from bodies in the air near them (that is not in contact with their head) better with the mouth open than shut; but this is the case with most other persons, and may depend upon two causes. First, that resonance, both of the air in the cavity of the mouth and of the teeth occurs; and second, that the teeth thus become more directly the conductors of sound.

Experiments clearly show that no sounds enter the tympanum by the air of the Eustachian tube, and, I need hardly say, that the gaping of the listener is more the effect of the mental act of attention, during which the muscles of the jaw are relaxed, than connected with any provision for the increase or conduction of sonorous vibrations through the Eustachian tube.

Neither the lad B., nor Miss R., had from their sensations ever been led to regard the ears as the seat of hearing; and from the experiments I have performed, I should be inclined to think that other persons, if their external ears were completely stopped, would not readily form that conclusion, which they are so immediately led to make, from the varying intensity of the sensations in opposite ears which occurs in the common mode of hearing.

When in a person whose ears are natural the external meatus are completely stopped, the sensations of sound appear to affect the whole head, so immediately and equally are they conducted to both ears by the hard parts. Unless, indeed, very marked sounds are made to act close to one or other ear, or unless jarring and painfully intense sounds affect the organ, they are referred indistinctly to the whole head. Our notion, therefore, of the ears as the seat of hearing, or our power of localizing the impressions of sound, appears to depend upon three circumstances. 1st, Upon the varying intensity of sounds that may affect one ear by turning it in different directions. 2d, Upon the different intensity of sounds affecting opposite ears; and 3d, upon painful sensations accompanying sound.

Such pain, however, as is felt from certain sounds, does not probably exist in the auditory nerve itself, but rather in the sensory nerves of the tympanum, and there seems to be a final cause for the existence of these sensations in the increased tension which by reflex action they induce in the membrana tympani, and the consequent impediment they occasion to the farther or too powerful transmission of such sounds to the internal ear. I could not ascertain that such painful sensations had ever been experienced either in the lad B. or Miss R., and I am inclined to think that they do not exist in them, in consequence of the absence of the membrana tympani.

In the concluding part of this paper it is my intention to trace the malformation I have described to its origin, at an early period



of foetal life, in a defect of the development of the middle and external parts of the ear.

In the meantime I beg leave to call the attention of the reader to an account of a dissection of a similar case of malformation, which Mr Toynbee has been so good as to communicate to me, since the publication of the first part of my paper, and which appears to confirm the view I have taken of the nature of the malformation, and deserves particular consideration from the known skill of Mr Toynbee as a dissector, and his very extensive opportunities of becoming acquainted with the morbid anatomy of the ear.



DISSECTION OF A CASE  
OF  
MALFORMATION IN THE EARS OF A CHILD

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(*Read before the Pathological Society of London, January 18, 1847.*)

THE specimen which forms the subject of the present communication was brought before the Pathological Society, by Dr Lloyd, physician to the Aldersgate Dispensary, and at his request I conducted the dissection.

The subject of dissection, was a child born at the seventh month of pregnancy, who died immediately after its birth from hemorrhage taking place from the umbilical cord, which was severed close to the umbilicus by an ignorant midwife.

The external ear consists of a fold of integuments having much the same shape and size as the natural lobe, but it is directed forwards, so that the concave surface which usually looks outwards, is directly applied to the surface of the head, and conceals the tragus which is rather smaller than natural. There are two orifices on the upper part of the anterior surface of this appendage and one at its posterior part; these are the openings of mucous follicles.

The meatus externally is entirely absent, a slight depression in the integuments is the only indication of its usual position. Upon dissection no membrana tympani was discovered, but in its place is a flat surface of bone which presents two fissures, one very narrow and having a direction forwards, and a second three or four lines in length, and from half to three quarters of a line in breadth, which commences at the anterior and inferior part of the other fissure, and has a direction downwards and slightly backwards. This fissure is covered by a membrane. The whole of the auditory ring is absent, so that the mastoid and squamous portions of the temporal bone are only parted by these fissures, the lower of which represents the Glasserian fissure, and the external auditory meatus united into one; and as Professor Allen Thomson has observed in his valuable paper on this subject for the Edinburgh Monthly Journal, the whole of the fossa parotidea is absent.<sup>1</sup>

<sup>1</sup> An examination of the adult skull will show how an absence of the external auditory meatus will produce the relations here described.



The membrane by which the fissure is covered appears to be the analogue of the *membrana tympani*. The zygomatic process of the temporal bone is represented by a small osseous layer developed in the middle of a ligament which extends from the external part of the squamous portion to the orbit; the malar bone is wholly deficient, the external part of the orbital circle being formed by a ligament connecting the superior maxillary and frontal bones.

Upon removing the membrane covering the fissure already described, a cavity was observed lined by mucous membrane; this is evidently the cavity of the tympanum, but very much smaller than natural, so as to appear more like a fissure in the substance of the bone. It measures two lines in its vertical diameter, two lines and a half from above downwards, and about half a line from without inwards. This cavity contains two bones, which are the analogues of the malleus and the stapes. The former consists of a narrow process directed upwards, and a globular body below, from which a process is directed inwards, but it has no connection with the stapes, to which it is superior in its position. The stapes in place of its two crura has a process about three quarters of a line in length, flattened above and below; to the inner extremity the base is attached, which is firmly fixed in the fenestra ovalis; the outer extremity is slightly attenuated, and does not present any surface for articulation. Above the stapes, and having a direction from above downwards and backwards, is the *portio dura* nerve, which is not surrounded by bone,<sup>1</sup> but is in contact with the mucous membrane of the tympanum. The *tensor tympani* muscle is in a natural state; as is also the Eustachian tube which opens into the anterior part of the tympanic cavity. The *stapedius* muscle is absent.

The auditory nerve, the cochlea, vestibule, and semicircular canals appear to be healthy in every respect.

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<sup>1</sup> In several dissections of adult ears, and the specimens of which are in my collection, I have found the external canal for the *portio dura* nerve incomplete. In such cases it is apparent how inflammation of the mucous membrane of the tympanum induces paralysis of the facial nerve, a result which I have more than once observed.



