

**On the use of an artificial membrana tympani, in cases of deafness, dependant upon perforation or destruction of the natural organ / by Joseph Toynbee.**

**Contributors**

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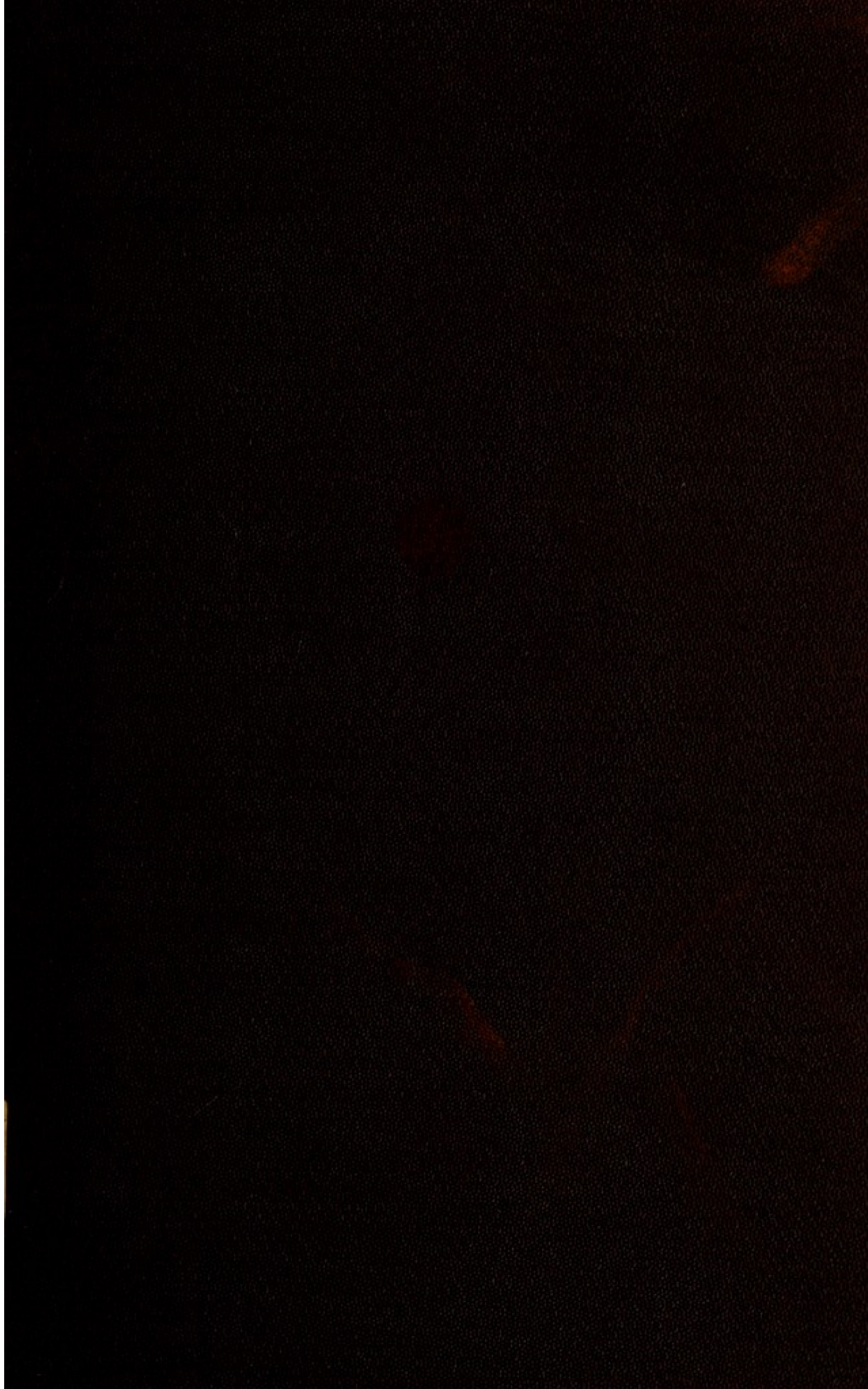
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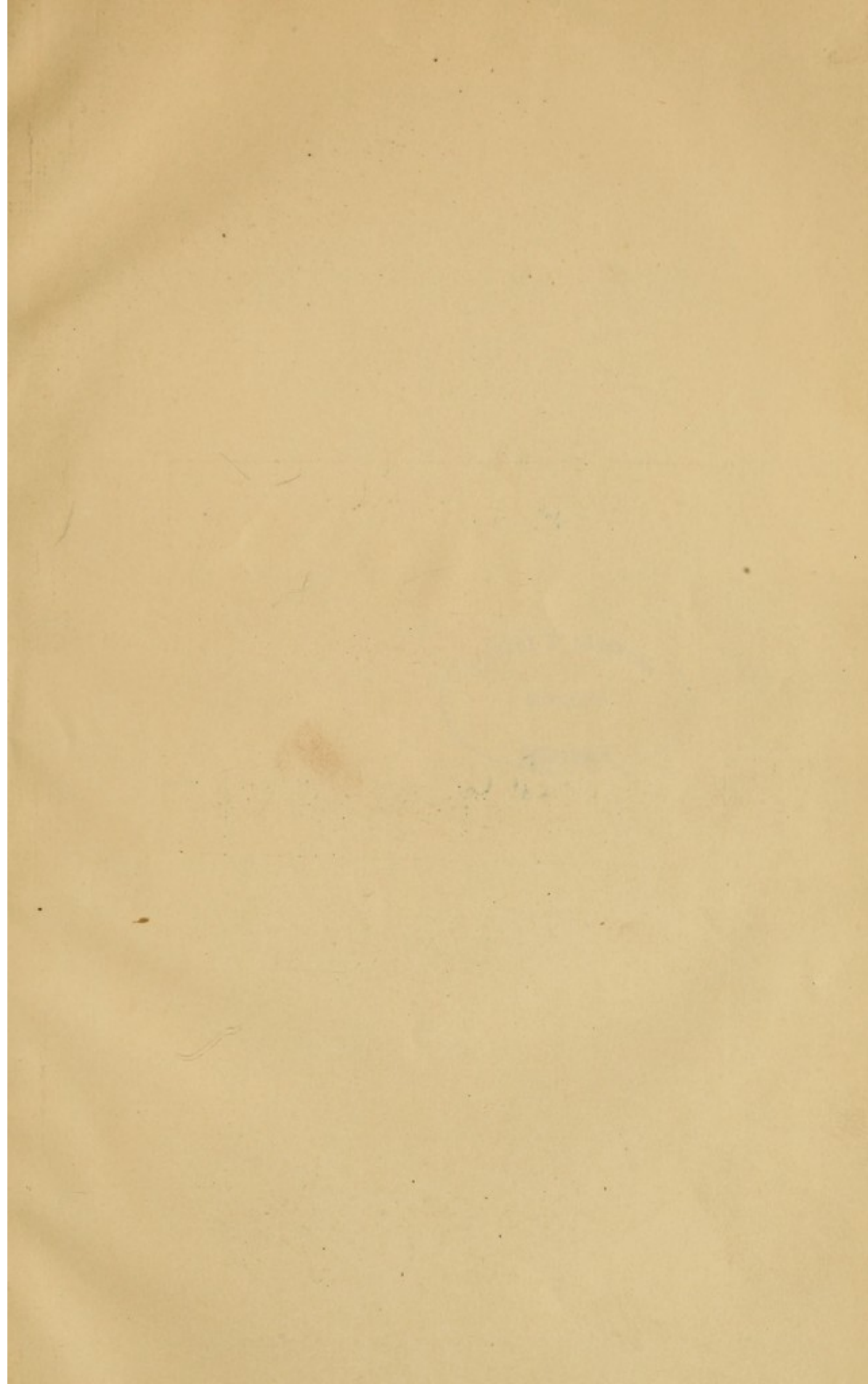


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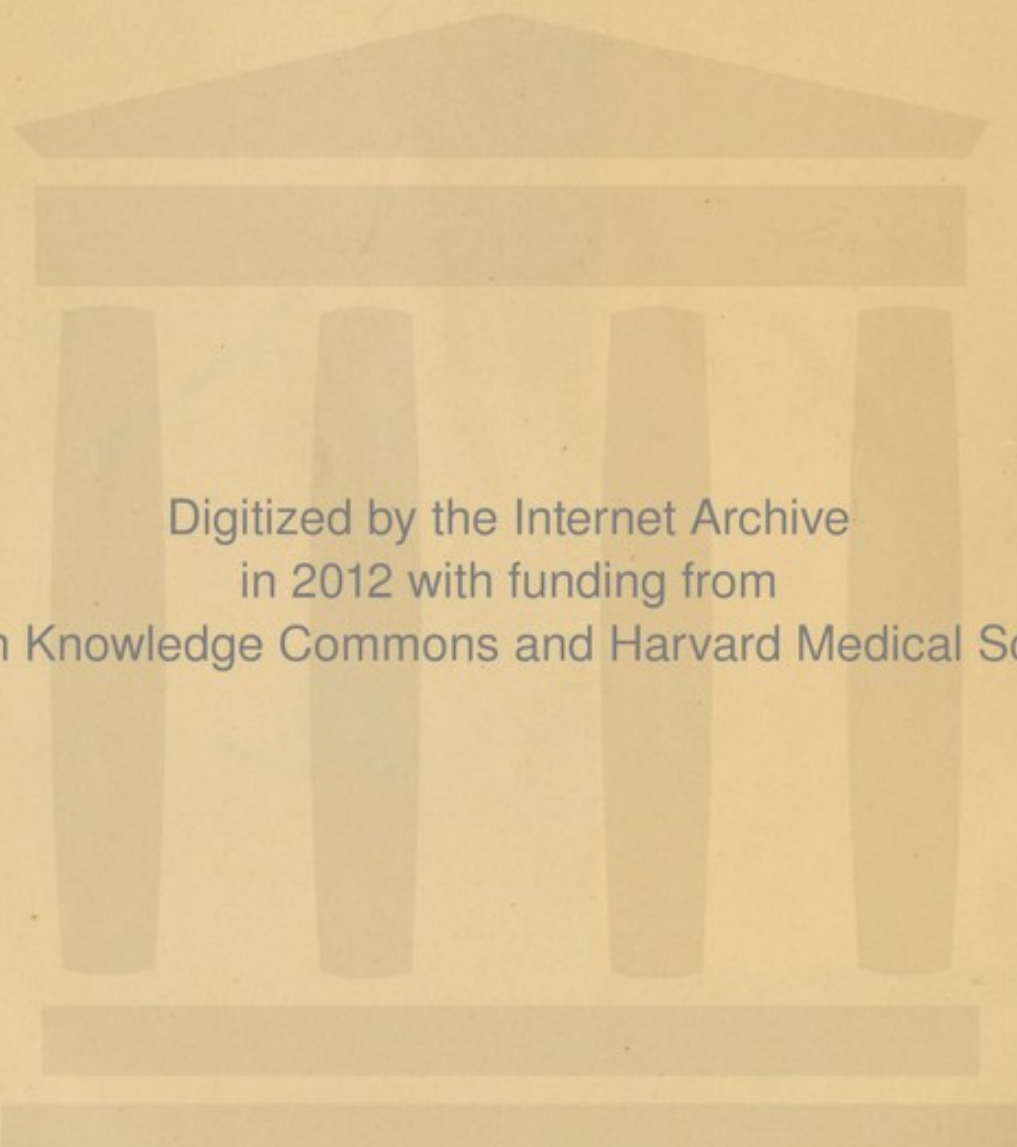
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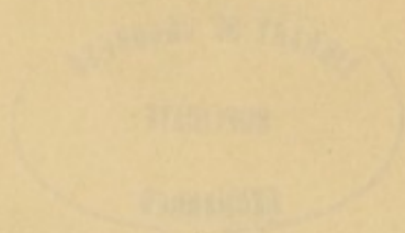






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ON THE USE  
OF AN  
ARTIFICIAL MEMBRANA TYMPANI,  
IN  
CASES OF DEAFNESS,  
DEPENDANT UPON  
PERFORATION OR DESTRUCTION  
OF THE  
NATURAL ORGAN.

BY  
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*Preparing for publication, by the same Author,*

A COMPLETE TREATISE  
ON THE  
DIAGNOSIS AND TREATMENT  
OF THE  
DISEASES OF THE EAR.

P R E F A C E  
TO THE  
S E C O N D   E D I T I O N.

Since the publication of the first edition of the present memoir, I have had frequent opportunities of testing the value of the artificial membrana tympani. The result of my own experience, added to that of other medical men (as shown in the cases appended), is confirmatory of its entire success. Further researches have given additional support to the views laid before the Royal Society, on the action of the muscles of the Eustachian tube, and on the functions of the tympanic cavity—views which first induced me to suggest the practicability of the use of an artificial membrana tympani.

18, Savile Row.

March, 1854.





ON  
AN ARTIFICIAL MEMBRANA TYMPANI.

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It is well known that the partial or complete destruction of the membrana tympani affects, more or less, the power of hearing. In those cases where the orifice in the membrana tympani is small, and the mucous membrane of the tympanum continues healthy, but little inconvenience is experienced: when, however, the orifice is large, and the mucous membrane of the tympanum has become thickened, the capability of hearing is so much impaired that the patient is entirely excluded from the advantages of general conversation.

In the present paper I purpose to describe the results of my attempts to provide a remedy in cases of perforated membrana tympani, by the introduction of an artificial substitute for that important membrane. I shall divide the subject into the following sections:—

I. On the structure of the healthy membrana tympani.

II. On the functions of the membrana tympani, tympanum, and Eustachian tube.



### III. On the formation and use of an artificial membrana tympani.

#### I. ON THE STRUCTURE OF THE HEALTHY MEMBRANA TYMPANI.

In a paper published two years since<sup>1</sup> I demonstrated that the healthy membrana tympani consists of five laminae, which, commencing externally, are as follows:—

- A. The epidermis.
- B. The dermoid layer.
- C. The radiate fibrous layer.
- D. The circular fibrous layer.
- E. The mucous layer, with its epithelium.

A. The *epidermis*, as is well known, forms a *cul-de-sac* at the inner extremity of the external meatus, from whose surface it is easily removed by maceration.



(Figure 1.) In the course of dissecting, I have more than once observed this delicate epidermis to be the only layer remaining over portions of the membrana tympani, varying from a line to a line and a-half in circumference, and yet appearing sufficient to close the tympanic cavity, so as to render the power of hearing nearly perfect. The knowledge of the fact that this delicate layer is occasionally all that is left of the membrana tympani, ought to induce caution in the use of the syringe, as its application may cause a rupture of the epidermis.

<sup>1</sup> On the Structure of the Membrana Tympani in the Human Ear. (Phil. Trans., Part i., 1851.)



B. The *dermoid layer*, as its name implies, is continuous with the dermis lining the meatus, and it is situated between the epidermis and the radiate fibrous layer. It is extremely thin, and is the seat of the exquisite sensibility possessed by the membrana tympani; it also secretes the epidermis. (Figure 2.) The latter, previous to the publication of the paper just alluded to, was supposed to be secreted by the outer surface of the radiated fibrous layer; but there is now no doubt of the existence of the dermoid layer, which is more easily visible in cases of hypertrophy.<sup>1</sup>



C. The *radiate fibrous layer*—hitherto usually described, in conjunction with the circular layer, as “the fibrous lamina of the membrana tympani”—was wrongly considered by Sir Everard Home to be muscular. The fibres of this lamina are attached, externally, to a circular cartilaginous ring, which is received into a groove of the osseous meatus and centrally to the malleus. (Figure 3.) The most attenuated portion of this layer lies between the posterior part of the long process of the malleus, and the circumference of the organ. This lamina is continuous with the periosteum of the meatus.



D. The *circular fibrous layer* is attached to the radiate lamina by fine cellular tissue, and the two

<sup>1</sup> In the specimen from which figure 2 was taken, the dermoid layer was slightly hypertrophied. It is seen passing from the surface of the meatus, and in some degree concealing the malleus.

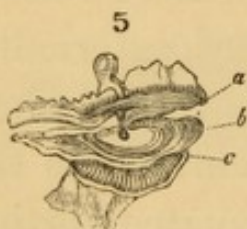


structures may be readily separated. It consists, as its name implies, of circular fibres, which are firm and strong at the circumference of the organ, but



towards its centre become so attenuated as to require care in order to detect them. (Figure 4.) The strong fibres at the circumference form a complete circle, and are attached to each side of the body of the malleus, as well as to the sides of the upper third of the processus longus. The circular fibrous layer is continuous with the periosteum of the tympanic cavity.

E. The *mucous layer* lines the inner surface of the circular fibrous layer. Like the rest of the mucous membrane of the tympanum, it is very thin and delicate, and the epithelium covering it is composed of cells with ciliæ. It will be observed



that of all the laminæ composing the membrana tympani, none are proper to it, but they are continuations of other structures. (Figure 5.<sup>1</sup>)

In order to give a complete idea of the membrana tympani, it is desirable to add, in this place, a few words relative to the *tensor tympani ligament*. This structure is about three-fourths of a line in length, and is attached, internally, to the cochleariform process, and externally to the inner surface of the malleus at the junction of the long process with the neck.

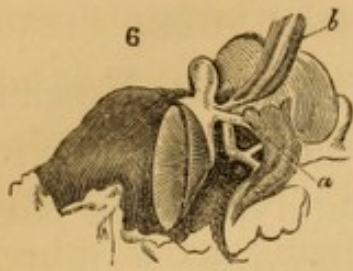
<sup>1</sup> a. The layer of the mucous membrane.

b. The circular fibrous layer.

c. The radiate fibrous layer.



The interior, which is tubular, forms a receptacle for



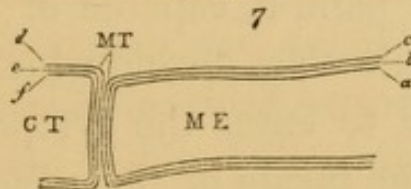
the tendon of the tensor tympani muscle. (Figure 6.<sup>1</sup>) This ligament performs the important function of drawing the membrana tympani inwards,

and thus, by antagonism with the circular and radiate fibres of the organ, which tend to draw the membrana tympani outwards, the organ is kept in a state of moderate tension, and adapted to be acted upon by the tensor tympani and stapedius muscles. In cases of apparently total destruction of the tympanic membrane, the ligament in question still performs the function of keeping the chain of ossicles in a due state of tension, drawing the malleus inwards at the same time that that bone is pulled outwards by the few fibres of the membrana tympani that happen to remain attached to the body of the malleus.<sup>2</sup>

<sup>1</sup> *a.* The tubular tensor tympani ligament.

*b.* The tensor tympani muscle, the tendon of which has been drawn upwards from within the tubular ligament.

<sup>2</sup> The accompanying diagram gives an idea of the relations of the several laminae of the membrana tympani.



*ME.* Meatus externus.

*MT.* Membrana tympani.

*CT.* Cavitas tympani. *a.* The epidermis of the external meatus.

*b.* The dermis of the external meatus.

*c.* The periosteum of the external meatus.

*d.* The periosteum of the tympanic cavity.

*e.* Mucous membrane. *f.* Epithelium.



## II. ON THE FUNCTIONS OF THE MEMBRANA TYMPANI, TYMPANUM, AND EUSTACHIAN TUBE.

During the present year, I have been engaged in some investigations into the functions of the membrana tympani and tympanic cavity, the results of which have been laid before the Royal Society in a paper.<sup>1</sup> In that communication I have shown that, contrary to the usually received opinion, the Eustachian tube does not remain always open, and that so far from allowing an uninterrupted communication between the cavity of the tympanum and that of the fauces, the guttural orifice is always closed except during the momentary action of swallowing.<sup>2</sup> In this latter case, the muscles of the Eustachian tube, the tensor and levator palati muscles, open the guttural orifice of the tube, afford free egress to the mucus secreted by the lining membrane of the tympanum, and allow air to enter or leave the tympanic cavity. The closure of the tube, excepting during the act of deglutition, can be experimentally proved. To those accustomed to descend in a diving-bell, it is well known that the unpleasant sensation in the ears, amounting sometimes to positive pain, is capable of instant removal by the act of swallowing, during which the condensed air being allowed to enter the tympanum and come in contact with the inside of the membrana tympani, the pressure on its outer surface is relieved by being counterbalanced. Again, if an attempt is made to

<sup>1</sup> On the muscles which open the Eustachian tube.

<sup>2</sup> Hyrtl and Wharton Jones had previously stated that the walls of the guttural portion of the tube are in contact.



swallow while the nostrils are closed by the finger and thumb, a sensation of fullness and pressure is experienced in the tympanic cavity, in consequence of air having been forced, during the act of deglutition, through the open tube into the tympanum; and this sensation continues until, by another act of swallowing, the tube is re-opened and the confined air escapes into the fauces. In the above paper an account was given of the muscles of the Eustachian tube in mammalia, birds, and reptiles; and in every animal examined it was quite apparent that the guttural orifice of the tube was closed excepting during muscular action. In some mammalia the tube is opened by the muscles of the palate; in others, by the superior constrictor of the pharynx. In birds there is a common membranous Eustachian tube, into which the osseous tubes open at the base of the skull, and this common tube descends between the two internal pterygoid muscles, to the internal surface of each of which the circumference of the tube is firmly attached by dense cellular tissue; and it is only during certain actions of these muscles that the tube is opened.

Having shown that the guttural orifice of the Eustachian tube in man and animals was closed, except during certain muscular actions, I next showed by a modification of Mr. Wheatstone's experiment, suggested to me by Mr. C. Brooke, that the sonorous vibrations communicated to the bones of the head appear much louder when the meatus is closed, than when its orifice is open. If, for instance, a tuning-fork be made to vibrate, and it be then placed in contact with



the head, the sound proceeding from it will, in a few seconds, cease to be heard; but if, directly on this cessation of sound, the experimenter close the entrance of the meatus in one ear, so as to convert it into a shut cavity, he will immediately hear a renewal of the sound of the tuning-fork; from which it appears most probable that the sonorous vibrations communicated to the external meatus impressed the *membrana tympani* much more powerfully when confined to the cavity of the meatus, than when allowed free communication with the external air. Considering the result of this experiment in connexion with the preceding fact of the ordinarily closed state of the tympanic cavity, it appeared to me highly probable that the sonorous vibrations imparted to the cavity of the tympanum, could only make their due impression on the membranes of the labyrinth, when strictly confined to the tympanic cavity and were not allowed to expend themselves in the cavity of the fauces. This conclusion was strengthened by the recollection that all the walls of the tympanic cavity appear constructed for producing resonance, having an investing mucous membrane of such tenuity as scarcely to be detected, save by the touch, or by the use of a magnifying glass, and also by observing that this peculiar condition of the mucous membrane was restricted to the tympanic cavity itself, and to that portion of the Eustachian tube which forms a portion of the resonant walls of the tympanic cavity.<sup>1</sup>

<sup>1</sup> In a paper published in the *British and Foreign Medico-Chirurgical Review*, No. 21, January, 1853, I have endeavoured to show that a



If the view here advocated be correct, and if, for the perfect performance of the function of hearing, it be necessary that the sonorous vibrations should be confined to the tympanic cavity, it is clear that the analogy usually cited as existing between the musical instrument, the kettle-drum, and the tympanum of the human ear, to the effect that in both, the air within should be allowed to communicate with that without, is incorrect; and it is also evident that an opening in the membrana tympani must, in a degree, diminish the power of hearing.<sup>1</sup> Upon the examination of patients affected with a simple perforation of the membrana tympani, this diminution in the ability to hear can, in fact, always be detected; although, as has been stated, if the orifice be small and the organ otherwise healthy, the difference is inconsiderable.

leading function of the membrana tympani, and the muscles and ossicles of the tympanum, is to act as the analogue of the iris in the eye. The tensor tympani muscle not only, as its name implies, renders tense the membrana tympani but also compresses the fluids of the labyrinth, while the stapedius muscle has a directly opposite action in relaxing the membrana tympani, and in placing the contents of the labyrinth in a state to be affected by the most delicate sonorous undulations. The base of the stapes moves to and fro in the fenestra ovalis, as a piston in a cylinder. There is no doubt in my mind that the fenestra rotunda is the chief medium for the passage of these undulations to the labyrinth, for the chain of bones may be incomplete without the hearing power being affected to scarcely an appreciable extent. Another very important function of the membrana tympani is to form part of the resonant walls of the tympanic cavity.

<sup>1</sup> Müller has shown that for the production of sonorous undulations it is not requisite a small drum should have an orifice for the communication of the air within and that without; and Mr. C. Brooke states that such orifice is only required where the air is considerably displaced, which is the case only in the more simple vibrations of the membranes.



In the greater number of cases, however, where perforation of the *membrana tympani* has existed, other lesions of a serious character have accompanied it—as thickening of the mucous membrane of the *tympanum*; pressure on the membrane of the *fenestra rotunda*; derangement of the articulation of the stapes with the *fenestra ovalis*; or injury to the nervous expansion in the labyrinth. Under any of these circumstances, it occurred to me that as an orifice in the *membrana tympani*, by preventing the sonorous undulations from being concentrated upon the membranous labyrinth, owing to their diffusion in the meatus, might be the direct cause of the diminished power of hearing, so it was probable that increased power would be the result of an artificial stoppage of the orifice.

### III. ON THE FORMATION AND USE OF AN ARTIFICIAL MEMBRANA TYMPANI.

As a consequence of the preceding train of reflection, I was led to attempt the construction of an artificial *membrana tympani*, which it was hoped might serve as a substitute for the natural membrane, so far, at least, as its function of closing the *tympanum* and of rendering its walls resonant was concerned.<sup>1</sup>

<sup>1</sup> My hopes of success were strengthened by the result of some observations I had made upon cases of perforate *membrana tympani*. When these cases are not complicated with any other serious lesion of the organ, it must have been remarked, by others as well as by myself, that the patient, from some inexplicable cause, at times suddenly hears perfectly well, or nearly so. This improved hearing sometimes remains a few minutes only, at others for one or more hours. Having found this improvement to follow the use of a syringe and tepid water, or even of the pocket-hand-



After some experiments I tried vulcanized india rubber and gutta percha, making use of the thinnest layers of them that were procurable. With both these substances I succeeded in making a rude kind of artificial membrana tympani, by cutting a portion about the size of the natural membrane, and passing through it a piece of thread, by means of which and a fine tube it could be passed down to its proper situation. The tube was then withdrawn, and the thread alone left in the external meatus, by which the artificial membrane could be withdrawn at the pleasure of the patient or the operator. The disadvantages attaching to this apparatus were, difficulty of applying it on the part of the patient; liability of the material to be torn by the thread; and unsightliness of the latter hanging down from the meatus. The experiment, however, was sufficiently satisfactory to induce me to request Messrs. Weiss to construct one, the centre of which should consist of two very fine plates of silver, having a diameter of about three quarters of a line, between which the layer of vulcanized india rubber or gutta percha might

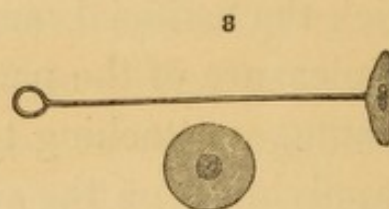
kerchief, I examined the ear in certain patients, after these operations had been effected, and I found in the former case that a bubble of water, and in the latter of discharge, filled up the orifice in the membrana tympani. Upon destroying the bubble, the improvement in the hearing at once disappeared. In one patient I was able to keep up the improved hearing by the use, from time to time, of a solution of gum acacia in water. Upon reconsidering these facts, since I completed the observations upon the closed state of the tympanic cavity, I have arrived at the conclusion that the bubble of water, discharge, or mucilage acted beneficially by again confining the sonorous undulations to the tympanum, and this conclusion has been strengthened by subsequent observations. (See Appendix.)



be placed, and to the outer surface of one of these plates a silver wire was to be attached. The artificial *membrana tympani* made by Messrs. Weiss, from these directions, has hitherto been perfectly successful. As supplied by them, the portion of vulcanized india rubber or gutta percha is about three quarters of an inch in diameter, which leaves sufficient margin for the surgeon to cut out a membrane of any shape that may seem to him desirable, and to leave the silver plate, either in the centre or towards the circumference,

at his discretion.<sup>1</sup> (Figure 8.)

The silver wire is of sufficient length to admit of the



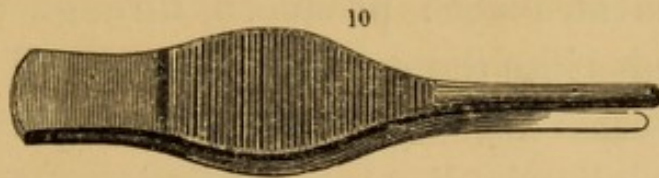
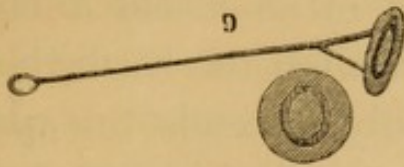
membrane being introduced or withdrawn by the patient, but is not perceived externally except upon especial observation. A second kind of artificial membrane is made by fixing the layer of gutta percha or vulcanized india rubber between two very delicate silver rings from the eighth to the sixth of an inch in diameter; these rings are rivetted together, leaving a portion of the membrane drawn moderately tense in their centre; a margin of the membrane is also left beyond the circumference of the rings, so as to prevent the latter being in contact with and irritating the tube of the ear. To the surface of one of these rings the silver wire is fixed by two branches, and they should be joined so that the outer surface

<sup>1</sup> I now invariably use vulcanized india rubber, not much thicker than ordinary brown paper.



of the rings should look obliquely outwards and forwards instead of directly outwards, thus imitating the direction of the natural membrana tympani. This kind of membrane is often preferable to that previously described, if the meatus is sufficiently large to admit of its passage. (Figure 9.<sup>1</sup>)

A pair of forceps is made whereby the artificial membrane can be more easily introduced and withdrawn. (Figure 10.)



Before proceeding to speak of the mode in which the artificial membrana tympani should be applied, it is necessary to premise a few words on the diseases which usually cause perforation or destruction of the natural membrane, and upon the condition of the structures which remain. The most frequent of these diseases is catarrhal inflammation of the mucous membrane lining the tympanic cavity. It is one of those usually styled *otorrhæa*, of which a more particular account will be found in the paper cited in the margin.<sup>2</sup> This disease generally follows an attack

<sup>1</sup> In some cases, however, it produces a loud noise as if it were too tense; it would, perhaps, be desirable to have it made with only one branch, so that the surgeon may be able to alter the angle of the membrane with the stem, according to the case.

<sup>2</sup> On the Nature and Treatment of those Diseases of the Ear which have hitherto been designated *Otorrhæa* and *Otitis*. Transactions of the Provincial Medical and Surgical Association, vol. xviii. 1851.



of scarlet fever, scarlatina, measles, or any ordinary cold, and it usually occurs in children having a tendency to enlargement of the glands. The tympanic mucous membrane becomes thickened, and secretes so large a quantity of mucus of so viscid a character, that it cannot escape through the Eustachian tube; consequently, it gradually distends the tympanic cavity and presses upon the inner surface of the membrana tympani, a portion of which, generally posterior to the malleus, begins to ulcerate, and an aperture is at length produced, through which the mucus exudes into the external meatus. This orifice is in some cases not larger than a small pin's head, in others it is a line in diameter, while in many cases the entire membrane is destroyed, with the exception of a margin at the circumference about half a line in diameter, which, being composed of the combined fibres of the thickest portion of the circular and radiate laminae, generally remains. This margin is deepest at the upper part. In some rare cases, the long process of the malleus continues entire after the complete destruction of the membrane to which it was attached; but, as a general rule, the whole of this process is gradually absorbed, leaving merely the head of the bone which articulates with the incus, the neck, and the body which receives the attachment of the tensor tympani ligament internally; anteriorly and posteriorly the fibres of the remnant of the membrane are attached, and externally the processus brevis remains. It will therefore be understood that, in cases of so-called destruction of the membrana



tympani, a margin is generally left, to which the body of the malleus remains fixed, and to the inner part of which the tensor tympani ligament and muscle are attached, affording the means by which the small bones and muscles of the tympanum are still enabled to perform their functions. In cases of general *ulceration* of the mucous membrane of the tympanum, which fortunately seldom occurs, the incus is generally discharged, and sometimes the malleus also; but even in these cases, if the attachments of the stapes to the circumference of the fenestra ovalis remain uninjured, the power of hearing may be much improved: should the stapes however be removed, total and irremediable deafness ensues.

The other disease through which an orifice in the membrana tympani is usually effected, is *ulceration of the fibrous laminæ*. The disease itself is commonly the result of inflammation of the dermoid layer, which spreads first to the radiate fibrous and thence to the circular lamina. The laminæ, being weakened by the ulcerative process, fall inwards as far as the promontory, to which they often ultimately adhere, and, when an orifice has been thus produced, its margins are not unfrequently drawn into the shape of a funnel, whose inner part adheres to the tympanic walls. In ulceration of the membrana tympani, proceeding from the dermoid layer, the entire organ is very rarely destroyed, but an orifice merely is produced.

The cases in which the artificial membrana tympani is of the greatest benefit are those where there



is a well defined aperture in the natural membrane, or, if it be entirely absent, where there is simple hypertrophy of the mucous membrane of the tympanum, with or without discharge from its surface. In these cases, it will be found that the organ has by no means entirely lost its power of discerning sounds; as a general rule, the human voice is heard when the mouth of the speaker is situated within about a foot of the patient's ear, and when the words are spoken slowly and distinctly. The diminished power of hearing just noticed, while it entirely excludes the sufferer from the advantages of general conversation, is, however, greatly aggravated when, to the affection of the membrana tympani and mucous membrane of the tympanum, the stapes has become ankylosed to the fenestra ovalis, or the nervous expansions have been injured. In such cases where the patients require to be shouted to close to the ear, the artificial membrane will not prove of any service.

*The Mode of Applying the Artificial Membrana Tympani.*

As in cases of perforation or destruction of the membrana tympani there is so frequently catarrhal inflammation of the mucous membrane of the tympanum, it is obviously important that no foreign substance should be placed in contact with that membrane; and, as there is always a margin of the membrana tympani remaining, the object of the Surgeon should be to keep the artificial membrane external to the latter. After carefully noting the



size of the inner extremity of the meatus to which the natural membrana tympani was attached, the operator should then cut the artificial membrane as nearly of the size and shape of the natural one as possible, taking care at the same time to keep the margin quite smooth and regular.<sup>1</sup> The patient must then be placed with the head inclined to the opposite shoulder, while a strong light is thrown into the meatus, which if liable to discharge should have been previously syringed. The operator will now take the artificial membrane, and, having moistened it with water, pass it, by means of the silver wire, gently inwards, until it has reached what he considers the natural position. This he will ascertain by the occurrence of a faint bubbling sound, caused by the escape of the slightly compressed air beyond it; he will also feel a slight obstruction offered to its further passage by the remnant of the natural membrane. Should he attempt to pass the artificial membrane beyond this point, the patient will complain of pain, which until then had not been felt. The most certain test, however, of the artificial membrane having been properly placed is the sensation of the patient, who discovers, by the sound of his own voice, or that of the surgeon, or by the movement of his tongue and lips, that his hearing has been suddenly much improved.

It will be imagined that great care must be taken to cut the membrane so that it shall fit the inner ex-

<sup>1</sup> In cases where only a small border of the natural membrane remains, it is often desirable to cut the artificial membrane of a size larger than the inner extremity of the tube, so that its edge may turn outwards.



tremity of the meatus with exactness, since if too large it would cause discomfort, and if too small it would not fulfil its purpose of rendering the tympanum an air-tight cavity. It is not easy, in all cases, to fit the artificial membrane exactly to the inner extremity of the meatus, so as not to allow of any communication between the air in the tympanum and that in the external meatus; this is, however, the object which should always be sought to be attained. At first, the patient should be instructed not to use the artificial membrane for more than two hours daily; and, if he complains of an uncomfortable feeling, one hour, or even half an hour, will be sufficient.

It would, perhaps, be expected that the contact of a foreign body, like the artificial membrana tympani, with the wall of the external meatus would soon become intolerable; such, however, is not the case, and several patients have left my room without being able to say, from the sensation in the ear, whether any foreign body were there; many have now worn this apparatus daily, during several months, without having suffered the slightest pain. The explanation of this circumstance may be found in the fact that the most sensitive part of the meatus externus is about its centre, the membrane in the immediate vicinity of the membrana tympani not being so abundantly supplied with nerves: another explanation is that the circumference of the artificial membrane presses with extreme gentleness against the wall of the meatus.

The results of the application of the artificial organ



have been much more satisfactory than I had reason to anticipate. I have already used it beneficially in nearly fifty cases. The substitution of a thin layer of vulcanized india rubber or gutta percha, for so exquisitely delicate a structure as the healthy membrana tympani, would be expected to afford but trifling aid; such, however, is not the case, for among the patients relieved by it most have heard the human voice perfectly across an ordinary sized room, and in one case the voices of boys in the open air were heard at a distance of between one and two fields. Surgeons, who have paid careful attention to diseases of the ear, will not be surprised at the efficient substitute the artificial membrane offers, as they will bring to mind many cases in which the natural organ has been greatly hypertrophied, especially in chronic inflammation of its dermoid layer, with but a very slight diminution of the power of hearing.

The surgeon having ascertained that the artificial membrane is beneficial to the patient, if no pain is experienced, it may be allowed to remain in the ear for a few hours, and gradually increased to the whole day: it is often desirable that the use of the membrana tympani should be preceded, or accompanied, by vesication over the mastoid process, whereby the thick mucous membrane of the tympanum may be rendered more healthy. In all cases, the artificial membrane should be removed at night, and, when there is any discharge, the ear ought to be syringed each night and morning with tepid water.



## C A S E S.

*Deafness for sixteen years, discharge from each ear for six years, aperture in each membrane tympani; power of hearing restored.*

Peter Turnbull, æt. forty-three, formerly in the army, from which he was discharged on account of his deafness, was admitted, under my care, at St. Mary's Hospital, on the 12th of January, 1852. He stated that sixteen years ago, without any other assignable cause than a cold, he became slowly dull of hearing, and five or six years since he perceived a discharge from both ears, which has continued up to the present time. The power of hearing has been gradually diminishing, so that, at present, he requires speaking to loud, close to his head. Upon examination, an aperture between one and two lines in diameter was observed in each membrana tympani, and the mucous membrane of the tympanum, which was the source of the discharge, was more thick and red than natural.

The treatment consisted in keeping up counter-irritation over each mastoid process, and in the use of an injection composed of three grains of acetate of zinc, to an ounce of water. Under this treatment, he somewhat improved, but the hearing still remained so defective that he was precluded from following any avocation. In the commencement of June, I experimented on this patient with the first artificial membrana tympani, composed of vulcanized india rubber, and the good effect was at once decided. When it was placed over the surface of the original membrane, so as wholly to close the orifice, the patient made a movement of his lips, and said, "I hear as differently as possible from what I have done for many years; everything sounds clear!" This patient went away with the artificial membrane in his ear, hearing conversation perfectly. The following morning, he came to my house, saying that he had accidentally moved what I had left in his ear, and that he was "as dull as ever." I replaced the artificial membrane—he again heard well; and being supplied with one which he could introduce or



remove at pleasure, he has worn it during the day, ever since—a space of between three and four months—and he has never complained of pain or discomfort from it. Latterly, he has found the hearing so much improved that he has been able to dispense with the use of the artificial membrane for a few hours daily; but he hears much better with than without it. As a proof of the great amelioration that has taken place, this patient told me that while in the country lately, and using the membrane, he heard voices at a distance, and upon going towards the place from which they appeared to proceed, he found some boys under a hedge, more than a field distant from the spot where he heard them. He is going back into the army.

This patient was shown at a meeting of the Pathological Society of London, in February, 1853; the following is the published report:—"The artificial membranes having been removed, the members of the Society had the opportunity of observing the perforate condition of each membrana tympani. After the removal of the membranes, he could not hear, unless loudly spoken to; but, when he had replaced them, which he did with apparent readiness, his hearing was excellent."—*Medical Times and Gazette*, February 12, 1853.

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*Each membrana tympani destroyed by measles at four years of age. Hearing restored by the artificial membrane. Very sensitive to sounds.*

Miss B., æt. twenty-one, consulted me on November 9, 1853, on the recommendation of Dr. Grindrod of Seaforth, near Liverpool. Her health was good.—*History of case.* At four years of age she suffered from an attack of measles, which was followed by discharge from each ear; this has lasted to the present time, so that the ears require syringing every day. Since the measles, the power of hearing has been so much deteriorated, that it is requisite for her to be spoken to distinctly within the distance of a yard. Upon inspection, it was found that the membrana tympani of each ear had been destroyed, and that the only vestige of it was a very narrow margin. The mucous membrane lining the tympanic cavities was very red, and much thicker than natural; it was covered by a mucous discharge.—*Treatment.* An artificial membrana tympani was introduced into each ear, the effect of which was to improve the power of hearing at once and so greatly, that the patient heard my voice perfectly



well across my room, with my back turned towards her. Ordered to wear the artificial membranes during the day, to take them out at night, and to syringe the ears with warm water twice daily.—13th. Has been wearing the membranes every alternate day, and has heard perfectly while they were worn. Indeed, the only drawback to her comfort has been the circumstance that her friends still speak loud to her, which causes considerable uneasiness in the ears from the very great sound.—16th. Continues to hear well, but has been obliged to remove to a quiet street, as the sound of carriages passing through the street has been annoying. She complains of the “intolerable rustling” of her silk dress, of which she was never before conscious. The patient left London after some further watching, hearing quite comfortably. I received a letter from her in December, from which I subjoin an extract:—“I am thankful to say the improvement in my hearing has increased almost daily, and I now hear general conversation easily, and feel quite a different person from what I did a short time since. I am still sensitive to sounds, but not merely so much distressed with them as I was at first. I found the noise of the organ at church too great the first time I went, and came out almost as soon as the service commenced. I find no pain in my ears, and am in all respects in the enjoyment of good health.”

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*Deafness of twenty years' duration perfectly relieved by the artificial membrane.*

The following particulars of a case about which we corresponded, were sent to me by Dr. Shearman of Sheffield:—“I tried the false drum in one ear, the whole of the membrana tympani had been destroyed, and the cavity of the tympanum so bared to the view, that it was difficult at first to ascertain whether the drum membrane had gone, or was obscured by polypoid, or other growths; however, the probe came down upon the bone. The false drum gave such relief, that the hearing distance was increased from actual contact to twelve, and subsequently to eighteen inches; the patient is now able to manage the contrivance herself.

The other membrana tympani of the same patient is yet so covered with polypous growths, that I cannot make out the precise condition of the drum; however, inflation of the tympanum shows that the membrana tympani is perforated. The deafness in this case is of nearly twenty years duration,



is perfectly removed on the left side, and although the whole of the left membrana tympani is destroyed, the false one acts perfectly."

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*Destruction of each membrana tympani: stricture of the meatus.*

Miss S., æt. twenty-four, not in very good health, states that at four years of age she suffered from an attack of scarlet fever, subsequent to which she was so hard of hearing, as to require to be spoken to distinctly within the distance of a yard. This hardness of hearing is increased during cold and damp weather; has had discharge from both ears, but at present it is only very slight from the left, which is the better ear; complains of no pain, but of a noise. Lately, from not being in good health, has been more than usually dull.

*Examination:* Right ear. The hearing distance of the watch is half an inch.<sup>1</sup> The central part of the meatus is so contracted that it is not more than half its natural size. By means of a very strong light thrown beyond the contracted portion, a portion of the mucous membrane of the tympanum could be detected; there was no appearance of the membrana tympani.—*Left ear.* Hearing distance one inch; meatus contracted like that of the right ear; the membrana tympani was not seen, but in place of it was observed the shining tympanic mucous membrane.

At first sight it appeared that the presence of the stricture would offer an obstacle to the introduction of the artificial membrane, I nevertheless tried a small one to each ear, passing it through the stricture, and then moving it gently to and fro, so as to allow it to recover its plane surface. Having done this, I moved it slightly inwards to the situation of the natural membrane, and immediately the patient found that she heard perfectly all that was said at any part of the room. There was not much difference between the hearing power of the two ears. Care was required in the management of the case from slight tendency to irritation of the meatus, but the patient left me hearing well. In the middle of February, 1854, the mother of this lady being in London, called to thank me for the benefit produced in her daughter's case. She said that her daughter "continued to hear perfectly, and that she was quite an altered person."

<sup>1</sup> I have used the same watch for many years; the natural "hearing distance" is three feet.



*Deafness from scarlet fever during five years. Hearing entirely restored by the use of the artificial membrane.*

Miss G., æt. fourteen, was brought to me in August, 1853, by Dr. Grindrod. Health good.—*History of case.* When between nine and ten years of age, suffered from scarlet fever, since which time has had a discharge from both ears, attended by a diminution of the hearing so as to require to be spoken to loud, near to her. She has lately been to a school at Brussels, where her defective hearing had greatly arrested her progress. Upon *inspection*, it was found that the membrana tympani in each ear was absent, the mucous membrane of the tympanum was thick and red, and poured out a mucous secretion. An artificial membrana tympani was applied to each ear, and the result was so complete a restoration of the hearing power, that the patient could hear all that was said in different parts of a large room. This patient returned to school at Brussels, and in about six weeks afterwards I received a letter from the father, a medical man, from which the following is an extract:—"We have had the most pleasing intelligence from my little daughter at Brussels respecting her hearing. I think I cannot do better than give it in her own words—'I have had three German doctors and one French one to see me, or rather the *artificial membranes*. I am quite a new creature, my hearing is so greatly improved.' The father adds—'This is very satisfactory evidence as to the successful operation of your beautiful invention, after nearly five years' deafness, to an extent that she was unable to hear a word in church the whole of that time.'"

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*Deafness for twenty years from measles and scarlet fever. Greatly improved by the artificial membrane.*

Mr. M., æt. twenty-three, consulted me, December 20, 1853. Health good; no relatives deaf.—*History of case.* At three years of age, had scarlet fever and measles at the same time, accompanied by much discharge from each ear; was totally deaf for some months after the attack, but slowly improved, so as to hear a loud voice spoken near to the left ear; the right ear nearly useless; lately has heard better at times with left ear for two or three hours. To-day, requires to be spoken to loud within two feet of the left ear, and is about the same as ordinarily.

Upon examination of the *right ear*, the meatus was found



to contain a collection of mucus and epidermus, which being removed, the membrana tympani was seen to be white, like paper, flat and thick; posterior to the inferior third of the malleus is a small orifice, about three quarters of a line in diameter, through which mucus oozed from the tympanic cavity. The watch was not heard, even when pressed against the ear; the crack produced by two finger-nails was distinguished.—*Left ear.* The meatus contained a shready discharge; the membrana tympani was absent; the mucous membrane of the tympanum red and much tumefied. Watch heard when in contact with the ear. Although the hearing power of the left ear was somewhat less than in the majority of cases, where there is an absence of the membrana tympani uncomplicated with any other disease, I nevertheless determined to try the artificial membrana tympani, the effect of which was to improve the hearing considerably, although not to the same extent as in the majority of cases.

December 21. Ordered to wear the membrane for four hours.

December 22. Upon the use of the membrane to-day, heard my voice distinctly half across my room.

December 27. Says that he never remembers to have heard so well as yesterday; heard everything that was said at dinner, and his own voice was quite distinct; the sound of the rustling of a lady's silk dress quite astonished him; towards the latter part of the day did not hear quite so well; last night, after removing the drum, was exposed to cold, which caused some pain. Without the drum, to-day could not hear my voice, unless I spoke into his left ear; with it, heard much better, but not so well as yesterday: this arose from the mucous membrane of the tympanum being much tumefied. This tumefaction gradually subsided, and this patient left me a few days after, hearing quite well. He inserts the artificial membrane himself, which requires a little careful adjustment. On one occasion, when he started for a walk in the street, after having inserted the membrane, his hearing was far from good, but as he walked on the pavement, a sudden movement took place in the ear, and he heard perfectly.

In February, 1854, in a letter, this gentleman says, "I have much pleasure in informing you that the artificial membrane continues to be effectual; my friends are much gratified at the improvement you have been able to effect."

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Miss H., æt. seventeen, was brought to me in November, 1853, by Mr. Jeffree, of Lambeth. At seven years of age, had a severe attack of scarlet fever, since which time she has had a discharge from each ear, and is so hard of hearing as to require to be spoken to distinctly in a raised voice within the distance of two yards; she has not been able to hear general conversation. About two years since, a portion of carious bone was removed from the back of each ear.

Upon examination, no *membrana tympani* was observed in either ear, and the mucous membrane of each tympanic cavity was thick and red. The application of the artificial membrane gave immediate relief, and the patient was soon able to wear it during the whole of the day.

The following is an extract from a letter written by the patient, in February, 1854:—"By the use of the artificial drum, I am happy to say that I am now, and have been since I saw you, perfectly capable of hearing at church, and taking part in conversation, with as much facility as if I had never been deprived of the power."

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S. H., Esq., æt. twenty-one, was sent to me by Mr. Fergusson, on December 4th, 1853. Between six and seven years of age, he had an attack of scarlet fever, since which he has had, at intervals, discharge from each ear, attended by so considerable a degree of hardness of hearing, that he is obliged to lean forward whenever he is spoken to, so as to be within a yard of the speaker. Upon examination, the *membrana tympani* was found to have disappeared from each ear; the watch was not heard by the right ear, and at a distance of five inches from the left. By the aid of the artificial membranes, he was able at once to hear me talk across my room, and he soon heard general conversation perfectly. He went into the country, and in the end of January, I had the following confirmation of the persistence of the benefit: "My hearing is quite optional to me; that is, I can hear or not, just as I choose. The artificial drums I use quite well—can put them in or take them out without assistance. My debt of gratitude to you I can never repay."

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Lieut. L., æt. twenty-seven, consulted me on January 1st, 1854. He stated that he had been dull of hearing for fifteen years, especially in the right ear; complains of a singing



noise in both ears, but especially in the right. During the last year, he has been getting worse, so that he is now inconvenienced in society. On examination, the membrana tympani was found to have disappeared from the right ear, and the mucous membrane of the tympanum was red; the watch was not heard, unless in contact with the ear. In the left ear, the membrana tympani was white, like paper, and at its upper part was a small polypus. Upon the application of the artificial membrane to the right ear, the patient heard well at once, although he never remembers to have heard with it before. He was soon able to put it in for himself, and to hear admirably well. At the end of February, he thus wrote:—"I yesterday, by accident, lost overboard the artificial membrane, which I have been wearing since I saw you. I find it now rather uncomfortable to leave off wearing it, and I am sure the hearing has been greatly improved, as, although I have had a bad cold lately, I doubt if any one in my new ship has discovered that I am deaf."

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N. M., Esq., æt. seventeen and a half, consulted me on August 15th, 1853.—*History.* He had measles when young, since which time he has had a discharge from each ear, accompanied by so great a difficulty in hearing, that he requires to be spoken to distinctly within the distance of a yard. Hears somewhat better in frosty weather. Upon examination, a considerable orifice was discerned in each membrana tympani. The mucous membrane of each tympanic cavity is thicker than natural. On applying the artificial membrane to each ear, the hearing power was at once restored; he said that he "heard painfully well, and that his own voice sounded like a trumpet." He soon learned to put the membrane in himself, and he continues to hear quite well. At the end of February, 1854, he wrote from college:—"I have as yet been perfectly able to hear almost every lecture, except those of one professor, who speaks very indistinctly."



## APPENDIX.

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Several writers have alluded to the beneficial results following the treatment of a perforate membrana tympani by means of the introduction of foreign bodies, especially of lint and cotton wool. Thus Itard cites a case in which the deafness was completely relieved by the introduction of a portion of cotton wool to the bottom of the meatus. Deleau speaks of a patient who greatly improved his hearing by the introduction of a piece of wood or the central part of an onion. Mr. Tod describes "the relief derived from the mere introduction of a little lint into the external meatus, in those cases where the membrana tympani has been ruptured or destroyed by disease. So great, indeed, is the improvement which takes place from the application of this simple remedy that patients will frequently appear astonished on being so easily relieved."<sup>1</sup> In the year 1848, Mr. Yearsley published a pamphlet entitled "On a new mode of treating Deafness when attended by partial or entire loss of the membrana tympani; associated or not with discharge from the ear." In this pamphlet, he advocates the application of cotton wool in a moistened state, in cases of partial or entire loss of the membrana tympani, the object of this substance being, as he has subsequently stated, "to support the remaining portion of the membrana tympani, or the ossicula."—*Provincial Medical and Surgical Journal*, August 18, 1852.—With respect to the mode of applying the wool, the following are his instructions:—"A small piece of wool differing in size according to the case, and fully moistened in water, is introduced through the speculum to the bottom of the meatus, and adjusted superiorly, inferiorly, anteriorly, or posteriorly, according to the situation of the perforation, and other circumstances connected with the case; but care must be taken that the entire opening be not covered, otherwise the experiment will not succeed. It is also indispensable to success that the moisture of the wool should be preserved." He also says, "It is far from my wish to discourage the attempts of others to placea right 'these magical bits of wool,' but truth compels me to add that, simple as it may appear, it is an operation requiring the most delicate tact to manipulate with success, which great experience only can confer."

In all cases of perforate membrana tympani, where the introduction of a foreign substance is productive of benefit, I believe it will eventually be proved that such benefit is the result of a partial or complete closure of the orifice.

<sup>1</sup> Anatomy and Physiology of the Organ of Hearing, pages 105-6. 1852.







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The first part of the paper is devoted to a general  
discussion of the problem. It is shown that the  
problem is of great importance in the theory of  
the differential equations of the second order.  
The second part of the paper is devoted to a  
detailed study of the problem. It is shown that  
the problem is of great importance in the theory  
of the differential equations of the second order.  
The third part of the paper is devoted to a  
detailed study of the problem. It is shown that  
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The fourth part of the paper is devoted to a  
detailed study of the problem. It is shown that  
the problem is of great importance in the theory  
of the differential equations of the second order.  
The fifth part of the paper is devoted to a  
detailed study of the problem. It is shown that  
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of the differential equations of the second order.



