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Thesis.

On the Comparative Anatomy of the Organ of Hearing in Man, & in the Lower Animals.

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The complexity, and the marvellous delicacy of adjustment in the various parts constituting the Organ of Hearing in man is extreme. No one beforehand could by any possibility have imagined that there existed so many different Structures, each of them designed to contribute their share to the framework necessary to carry on this most important function; possessed of exquisite organization; and lying deeply buried, and covered up from view in the Petrous subdivision of that small Temporal Bone, which contributes to the formation of the wall of the Cranial cavity.

And, most assuredly here, if anywhere, the rich fields of exploratory investigation lie hidden, and concealed from the Observer, & that in attempting to study the Internal Ear, were there not the most scrupulous care, a rude and unskilful hand might easily shiver into a hopeless mass of destruction, at once, this delicate Organ; in profound unconsciousness

that more had been done than to crumble away some unimportant laminæ of bone, scarcely seeming to differ at all in appearance from any other osseous substance. This danger of injury would be all the greater, owing to the extreme density of the texture which surrounds those exquisite structures contained within. The Auditory Organ in Man may be naturally subdivided into 6 parts: viz.ª

I. The External auditory meatus; extending from without as far as the Membrana Tympani.

II. The cavity of the Tympanum; together with the Ossicula Auditûs; membranes; nerves; and foramina; and muscular apparatus; which it contains.

III. The Vestibule and its Contents.

IV. The Semicircular Canals.

V. The Cochlea.

VI. The Internal auditory Meatus.

The purport of this paper is not so much to give a description of the Anatomy of the In=ternal Ear of man, as to consider this Organ in its relation to the Homologous or Analogous organs corresponding to it in the

lower animals. Before doing this, however, a few prefatory remarks may be made.
It may be here laid down as an axiom, that whilst all the above specified parts of the auditory organ have their own proportionate value, and importance, it is The Vestibule that constitutes its essential and indispensable portion. At the same time it must be fully allowed that the Semicircular Canals, The Cochlea, The Small Bones of the Cavity of the Tympanum, the Tympanic Cavity and membrane, and external passage leading to it, as well as the Eustachian Tube, and all the complex arrangement of nerves and foramina, as well as the air-passages of the Mastoid cells are decidedly required, also, to perform their respective offices, in order that we may have, in full completeness, that perfect, and wonderfully elaborated structure, which the Ear of Man in truth is.
From the assemblage and conjunction of all these complicated organisms in direct apposition, and connected as they are with the nervous force emanating from the cerebral

substance within, which judges, by these means, of every varied sound presented to it from without; results that vital process, and capacity, to which we give the name of the auditory function. It is from the contact of the special nerve-substance from the cerebral centres designed for this purpose, with sound arising from the external world without, and penetrating into the recesses of these wonderful, and almost microscopical caverns in the Petrous portion of the Temporal Bone, that we discover our competency to appreciate sounds the most varied, and diverse from each other; as the shock produced by the roar of cannon, or, on the other hand, the delicate brush upon some material substance in its flight, made by an insect's wing.

It must be a most striking fact to every one that such a capacity should exist, and be exercised from moment to moment so uninterruptedly, except in those intervals of rest to the organ, which are afforded it in the periods of sleep. The perfection of the Organ of Hearing, like that of the Eye,

is so great, that it attracts to itself no observation in any greater degree than we should think of the pane of glass through which we were viewing a magnificent range of scenery - Constantly recurring, we cease to take note of phenomena which are not at all, on this account, less surprising. In Man, the Organ of Hearing has received its highest and most perfect form of development, and all the different parts of the Internal Ear present, when taken togeth, the highest degree of intricate arrangement. As we descend however in the scale of living beings, we find a greater and greater tendency towards the simplification of this organ, and towards the assumption of the rudimentary condition, and its complexity steadily decreases, step by step, until at length we find the very simplest form present - Thus all the rest of the Mammalia are immensely inferior to Man in the powers of intelligently appreciating sound. The Birds have a still greater inferiority of organization, as compared with the Mammalia; the Reptiles again,

as compared with Birds; and the Fishes, as com=
=pared with the Reptilia, whilst still lower, we
find the same steadily increasing inferiority, as we pass
downwards, through the remaining subdivisions of
the Animal world, in the Mollusca; and Articu=
=lata; down to the Radiata; where it may be, we
possess the first germs of those powers in regard
to sound, which in the higher animals become
so strikingly intricate and complex. It seems
as if the amount of development had been, as
respects the lowest grades of creatures restricted
to that which is seen in foetal life in the
Mammalia, where the auditory apparatus takes
origin in part of the open cephalic vesicles,
(or vesicle of the Medulla Oblongata,) which protrude
on either side. The vesicle itself remains per=
=manent as the 4th. Ventricle - as the protrusion
increases, the auditory sac becomes pear-shaped,
and connected with the central mass only
by a pedicle whose canal gradually closes up.
The cut-off sac is the vestibular cavity, and the
pedicle is the auditory nerve, and at first there
is no vestige of either cochlea, semicircular canals,
or Tympanic apparatus, but the condition resembles the per=
=manent form of the organ of Hearing in the Cephalopoda; and

the lowest Fishes.

It may be advisable to regard this organ, first, in the lowest forms in which we are able to discover it, and proceed gradually upward; but before doing this, a few general remarks may be made - When complexity of organization is spoken of, an objector might enquire whether the fine appre=ciation of the faintest sounds in the feline tribes, in the hare, and in some of the aves, is not even more marked than in man himself, it may be; and this would appear to be an argument militating against the deterioration of the auditory organ amongst the lower Mammalia - To this, the answer may be given, that when we reflect upon the fact that man is endowed with a brain immensely preponderant in both size, and capacities, and capabilities, over that of any other animal whatever, this fact alone would warrant the statement that man as possessed of such a brain, must also possess with it a marked superiority in regard to selection, and discrimination, over every other animal, as regards sound, and that none of the animals can be compared with him, with reference to the perfec=tion of this organ - for it is not alone the power of delicate sensibility to sound; but <u>combined with this</u>,

the
intellectual ability to judge, and educe, by means
of mind, results, from what he hears, with transcendant
skill - In the same way, quickness of vision, or
rapidity of muscular movements in some animals
far surpassing what man could be competent for,
is not to be taken as a proof that the eye, or ear,
of these creatures, is superior to the corresponding
organ in the human races; for these latter have
superadded to mere organisation, the powers of
mind, and reason. - But as we
descend to lower forms of life than these; we meet
with organs, that are in themselves, as lying open to
our investigations, manifestly and absolutely
inferior to those of the higher animals. For
example, if we compare the gills of the fish with
the lungs of man, or the foot of the common house-
-fly, with the foot of the Mammalia, we find the
most marked inferiority of the Organ itself in the
fish, and in the foot of the fly which acts by me-
-chanical suction - It may be repeated then
here, that the Vestibule is the essential part of the
Organ of Hearing; And it may be also mentioned
that the Cochlea is first met with in a rudimentary
form, among the Squamigerous Reptiles; that it
is the last addition made to the Labyrinth; and

that in Birds it becomes still more complex, although only rudimentary yet, and that it is most highly developed in Man. If certain portions of the auditory organ are investigated as to frequency of occurrence in the animal kingdom, the Semicircular Canals will be found the most common; next the cavity of the Tympanum; and last of all the Cochlea. Of all the Ossicula Auditûs, the Stapes is the most persistent, and essential. It alone remains in Birds and Reptiles when the others have either disappeared, or have been reduced to mere cartilaginous pieces. A tympanum exists, as has been alluded to, in a greater number of instances than a Cochlea. All the Fishes, with the exception of the Herring, have bones analogous to the Tympanic Ossicula. The Cochlea, and the Semicircular Canals, are the localities in the nerve-expansions derived from the Portio Mollis, where the Brain takes cognizance of external impressions of sound, which reach these parts, intensified by the action of the chain of Bones, in the Tympanic Cavity, which end with the movements of the foot of the Stapes in the Foramen Ovale - the perilymph around, and the endolymph within the membranous labyrinth filling the Semicircular membranous Canals, and the

interiors of the Sacculus Communis, and the Sacculus Proprius, as well as the two Scalæ, the Vestibular and Cochlear, modifying the Vibrations of the Ossicula, and the Otoconites within the Membranous Labyrinth, all act harmoniously in concert and perform their functions in a way, of which we can only very inadequately conceive. The Vibrations arrive in two opposite directions through the two Scalæ; passing from the Tympanum through the Foramen ovale, and through the Foramen Rotundum. Besides these general statements, what can be more wonderful, when we view its minute structures, than the Cochlea itself? Late discoveries in regard to it by Corti, Köllikes, and Claudius; of which Professor Goodsir has lately given us such an extremely interesting account, in the Edinburgh Medical Journal, for December, 1855. Pp. 563-565 are most remarkable - Dr Thomas Young as there quoted states that the Cochlea is "a Micrometer of Sound," and the discoveries of the entrance of the two sets of terminal nerve-filaments into the Rods of Corti by the distinguished men alluded to, who have entered into such laborious researches as to the Lamina Spiralis, shew how wonderful the parts contained within the Cochlea are.

It would be out of place to enter here at greater length into the details on this subject, given in the striking papers referred to; and the next inquiry must be what are these otoconites which are found in the sacculus proprius, and communis of the Vestibule? The apparently unimportant material composing the on when investigated, as to the purpose, which it subserves, is found to be an element of no small moment, in the auditory economy. To such an extent does an analogous element prevail throughout the whole extent of the animal kingdom that it is found, in almost every instance, from man down to the Cephalopoda, to be present. In man, the otoconites consist of a congeries of minute crystalline particles of carbonate, and phosphate of lime, held together by an animal substance. In some cases these concretions of the above two salts are found in powdered aggregations; as in Birds; Reptiles; and some of the Chondropterygious Fishes; in other animals, they are possessed of almost stony hardness, as well as in several of the osseous Fishes; and in the Sturgeon. In the Fishes; and the Mollusca, they receive the name of Otolithes. from ὠΰς, auris; and λίθος, lapis. They are well seen

in the Cod, and the Haddock. Some have erroneously considered otolithes, as the analogues of the tympanic bones. As we pass downwards in the scale of animal life, we find the Monotremata, especially the Ornithorhynchus, possessing not only a species of bill, like the Birds, but an auditory organ also closely resembling that possessed by Birds. In Reptilia, the Cochlea is first met with; descending still lower, viz. to the Fishes, the Cochlea disappears entirely; and the labyrinthic cavity, as in the Haddock, is often open to the general cranial cavity; and still going down in the scale, we find that the lowest Cyclostomatous Fishes do not possess Semicircular Canals at all; and that there is little superiority possessed by their organ of hearing, over that of the Cephalopodous type, among the Mollusca; amongst which last, as well as amongst Articulata; the organ is represented by a mere sac containing fluid, and a concrete body, viz. an Otolithe. Among the Insecta, it is supposed that the antennæ have to do with hearing; and in inferior forms of life & those of a very low type of organization, mere neural expansions may subserve auditory requirements;

without assuming the form of any definite organ. We shall look a little at the Auditory Function, as found in the different great classes of the Animal world.

Radiata.

Here we have a sort of incipient Organ, designed for the appreciation of sounds; if we may trust the Statements of Mr Dallas in "Orr's Circle of the Sciences." "Organic Nature." Vol II. Page 250. He remarks about the Oceanic Octona, one of the Medusæ, that the marginal Tentacles of this Creature terminate in a small bulb, in which the Microscope reveals the presence of Otolithes; which he believes, can be for no other purpose, than to enable it to judge of sound. There does not seem to be any reason to doubt the correctness of this; and if true, it is the more remarkable that we should have in the same part of the body the presence of another organ of special sense, viz: Vision; for he describes minute dots, in close approximation to these Otolithes, which it seems to be admitted by all, are really eyes; and which have, in consequence, had given to them the

name of Ocelli. Thus low in the scale of living beings, do we find the rudiments of special organs, which in the higher animals, become elaborate in the highest degree.

Articulata.

Sub class I. Insecta.

There has been considerable difficulty in ascertaining the true locality of the auditory organ in Insects - of the fact of their possessing one there can be no doubt, for we know that they are attracted towards each other, in some species at least, by a peculiar humming sound, which they have the power of producing. Swammerdam believed that its seat was in the Blatta orientalis, at the base of the Antennæ. Rawdolphi believed that a certain vesicle, at the base of the jaws of the bee, was its auditory organ - Strauss-Durckheim was of opinion, that in the cockchafer, it resided in the bases of the Antennæ - De Blainville thought certain vesicles placed at the sides of the body, and covered by a membrane, were its seat. The nerves distributed to the Antennæ have often a ganglion at their base; and are divided into many branches,

almost after having entered them. The antennæ are often too short to subserve the function which has been assigned to them by some Naturalists, viz.t that they are organs of touch; whilst for hearing, their structure would be admirably calculated, by becoming sensible of the pulsations of the surrounding atmosphere

Sub class II. Arachnida.

As to the Arachnida, we know nothing definite as to what part of the body is the seat of this function, if it exists.

Sub Class III. Crustacea.

In this class of the Articulata, the organ of hearing is perfectly well made out. It exists behind the second pair of the Antennæ, or upon the first basal articulation of the antennæ themselves. In the River Crab is found, in this situation, a small bony tubercle, pierced at its summit by a round opening, upon which an elastic membrane is expanded. Scarpa speaks of this as analogous either to the Membrana Tympani, or to the Fenestra Ovalis. The interior of the cavity, is filled with fluid,

into which passes a branch of the nerve to the Antennæ. above this tubercle, there is one of a glandular appearance; which from its close approximation, may with much probability be thought connected with the transmission of sound. In many of the Brachyura, this membrane does not exist; but in lieu of it, is found a small osseous disc moveable. In the Maja, and others, occurs a broad bony plate posteriorly, detaching itself at a right angle, and running up to the glandular organ alluded to above. Near its base this lamellar extension, is pierced with a large oval opening, covered by a mem=brane; and near to this, the nerve seems to terminate. Muscles move this plate, like the arrangement in the Ossicula of the higher animals; and render the membrane tense, so as to modify the effects of sound. M. Savart in his "Recherches sur les usages de la Membrane du Tym=pan", has made many interesting experi=ments on this subject; and he says, that the long rigid stems of the Antennæ them=selves, contribute to the intensifying of the vibra=tions of sound, which, without this, would not be capable

of being perceived. In the Vermes Articulata, hearing exists, though its special locality may not be known. M. de Quatrefages has detected, in certain Annelida, auditory capsules, with otolithes, as among the Mollusca. In Lucifer, there is a single spherical refracting otolithe contained in a little sac; very much as found in the Gasteropoda. In Palæmon, the anterior extremity of the sac is enveloped in pigment granules, and on the side opposite the fissure is placed a series of pairs on which is found a large ovoidal otolithe. In the Macrourous Decapodous Crustacea; Dr. A. Farre mentions (Philosophical Transactions) a curious modification of the auditory apparatus. Instead of a calcareous otolithe; particles of siliceous sand are found in the interior of the sac which is placed in the usual situation in this class of animals. This sand rests on the extremities of a row of hair-like processes projecting into the interior of the sac, these contain a row of cells, which are probably nerve vesicles. This sac is connected with the cephalic ganglia by a nerve-trunk,

distinct from that which supplies the Antennæ; and forms a plexus around the sac. In many of the Decapoda, besides the Lobster, there exists a Belly covering completely over the whole joint, except at the valvular orifice.

Mollusca.

Among the Dentricata; Prof^r. Eschricht considers that two remarkable vesicular bodies found in connexion with the single nerve ganglion in Chelyosoma; (one of the simple Ascidians,) belong to the function of hearing. Probably the single, or double tubercular body, described by Savigny, in various Ascidians, is the same. Auditory bodies are still plainer in the Salpa. Huxley says there exists a strongly transparent vesicle, attached to the nervous ganglion, and containing four hemispherical bodies, with black pigment spots, on their outer surface; whilst a conical depression in the outer tissue, leading towards this, is for the purpose of bringing it into relation with the surrounding medium. (Philosophical Transactions. 1851. P. 571.) Among the Lamellibranchiata, a pair of similar vesicles are found at

the base of the foot; either sessile upon the pedal ganglion, or connected with it by nervous pedicles. These contain otolithes, which execute continual vibrating, and rotatory movements. In the Gasteropoda, these organs are found a little more advanced, in connection with the pedal ganglion, which is connected with the sub-oesophageal portion of the nervous collar, or connected with a pedicle. In Nudibranchiata they occupy a higher position; though still accompanying the pedal ganglia; which in these animals, are found united with the cephalic ganglia, above the oesophagus. In the Heteropoda; the auditory organs seem connected with the cephalic ganglia. But it is in the Cephalopoda that the organ of hearing has been found in its greatest perfection amongst the Mollusca; in the subdivision of the Di-branchiata. It consists of a vestibule, containing fluid, and an otolithe; but possessing neither Semi-circular Canals, nor Cochlea. In the Cuttle-fish, the double cavity is of a somewhat square shape, with a sacculus

and nerve to it, every where closed, except at the entrance of the nerve. From their internal surfaces project into the interior, several ob= =tuse processes of a soft elastic texture, which support the sacculus - These projections seem to represent what, in the higher animals, become Semicircular Canals; Cochlea; &c. The Otolithe in the Sepia, is of a transparent white, and of an irregular flattened figure, having four projections. On the surface of it looking to the parietes, The surface is convex, and smooth; the opposite one is concave, and irre= =gular. In Octopus Vulgaris, the Vestibules have nearly spherical cavities walls are smooth; otolithes hemispherical; and are white on the attached side; yellow on the opposite one - The Auditory nerve divides into three branches. In Eledone cirrosa, the otolithe is shaped like a limpet-shell; pink on the sides; and of a British hue internally. In all the Deca= =poda; except the Cuttle-fish; the Carbonate of Lime which the otolithes contain is the only earthy substance entering into the composition of these animals. In the Cepha= =lopoda, the auditory Sac of each side is

connected with the cephalic ganglia, only by the Auditory Nerve. The sac itself contains an otolithe of irregular form, lodged in a cavity which is hollowed out of the cartilage, which supports the nervous centres. This is an arrangement which evidently foreshadows the "sense-capsule" in the Vertebrata. From the Mollusca we have next to pass on to a class in which the organ of sound presents a considerable advance on the preceding forms.

Fishes.

In the Fishes, this organ become more highly developed as we advance from the lower groups of Fishes, to the higher; varying in organization, from the presentation of the Vestibule alone, (as in the case of Sepia among the Mollusca, and having no higher development,) to the most perfect forms found amongst this great class; the lowest in position, amongst the Vertebrata. In the Fishes, the rudimentary representatives of the Semi-Circular Canals are found in the Occipital Bone. E.H. Weber has divided the Fishes into groups, as regards the organ of Hearing; 1. In the Lamprey, (Petromyzon)

this organ is the least developed. It is enclosed in a plain ovoid cartilaginous receptacle, situated on each side of the Skull, external to the posterior cartilages of the Cranium. Nearest to the Cranium, there are two openings, the inferior is the larger, and oval. The organ is closed with a firm elastic membrane. The superior opening is very small, and gives passage to the auditory nerve. There is no other opening into its cavity, but the two mentioned. It is filled by a membranous sac containing watery fluid. This sac is divided by folds into several compartments. On its wall, the auditory nerve spreads out, in the form of pulp. In the Lamprey therefore, we have neither an otolithe; nor the sac of the otolithe; nor the Semicircular Canals; excepting we may consider that two curved folds of the vesicular membrane may represent the latter. Weber makes his second group, of those Fishes having no separate cavity for hearing, from the Cranial. This latter is the ear possessed by most of the Fishes. It is found in the Osseous Fishes, and in the Branchiostegous, & Chondropterygious Fishes.

all these Fishes, have a very large cavity of the Cranium; a small part of which only, is occupied by the brain. This cavity answers the place of a bony labyrinth; and is filled with fluid, which in fishes is thick, and viscid. The organ of hearing is placed at the base of the Cranium. In this second group, Fishes possess 1st. a membranous Vestibule. 2nd. a sac of the Otolithe. 3d. Membranous Semicircular Canals. The membranous Vestibule varies considerably in form. It contains an Otolithe.; the Ampullæ of the Semicircular canals open into it. The sacculus is very large in Fishes. The sac of the Otolithe is generally placed beneath, and contiguous to the membranous Vestibule, & is divided into two portions ordinarily, by a septum. The anterior compartment is the larger. In the Eel tribe, a membranous sac is lodged in the commencement of the Spinal canal which opens into the Vestibular cavity, near the entrance of the posterior Semicircular Canal. All the Fishes, excepting the Lamprey tribe, have three Semicircular Canals. In the Murena

Anguilla, the anterior, and Posterior Semicir=
=cular Canals, rise above the brain, towards the
vertex, and approach those on the opposite
side - In the Mate there are two orifices,
answering to the meatus auditorius Externus.
They lead, after a winding course, into the mem=
=branous Vestibule - Cretaceous matter is found
in both the sac, and sacculus. The Osseous
fishes are destitute of External auditory
passages. The cyclostomi present very
interesting features of approximation to the
Foetal Structure of the auditory organ in the
mammalia - In Myxine, this organ is extremely
simple; and in Bdellostoma likewise; con=
=sisting of a capsule of elliptical shape; a
membranous vestibule inside; and a single
Semicircular Canal - Otolithes are not found
in the Cyclostomi. There is no vestige
at all of an auditory organ found in
the Amphioxus. In Lepidosiren there is
a large Labyrinth, three Semicircular Canals,
& two otolithes.

Reptilia -

Here we take a sudden start upwards in
the development of the Ear. Previously we have

no trace of a tympanic cavity, but now we find the occurrence of a distinctly marked one, in the higher subdivisions of this Class together with a Membrana Tympani, interposed between the Vestibule, and the External Ear. The Tympanic cavity is absent in the Selachydea; and in the Tailed Batrachia; and Ophidia; and both Integument, and Muscles, are continued over the Ear externally. The Tail-less Batrachia have ordinarily a membranous tympanum. They, as well as the Ophidia, and also the Chelonians, and Saurians, have a columella, and Operculum; which last closes the Fenestra Ovalis. The Columella rests upon the Operculum by its broader end, and to its outer extremity a piece of Cartilage is attached, which in its turn adheres to the Membrana Tympani. They have Eustachian tubes also, sometimes opening into the middle of the Pharynx by one common aperture. The small cartilage mentioned as adhering to the membrana Tympani, may represent the Malleus; the Columella, the Incus; and the Operculum, the Stapes. Two muscles are found in the Tympanum in the Reptiles viz.t the

Tensor Tympani, and the Stapedius. In Typhlops and Rhinophis, there are no ossicula auditus. The Bufo Igneus; and Rana Cultripes; Sala=
=manders, and Chirotes; have no tympanic cavity, nor strictly do serpents, possess one either. In Acontias the Columella is wanting. In Pseudopus the Membrana Tympani is covered over by integument, and muscles. The cartilage answering to the Malleus is tripartite in the Crocodile; round in Chelonians. The Reptilia have no external Ear, but in the Crocodile there is a fold of the integument which contains a bony plate, which can be closed at will. All the Reptilia have a bony labyrinth separated from the cranial cavity. The sac within the Vestibule en=
=closes a friable crystalline chalky substance, & sometimes harder bodies. A cochlea is absent in the naked Amphibia, but is found in all the Chelonians. It is found in its most rudimentary form in these latter, as a rounded cavity containing a sac. In the Sauria and Ophidia, the Cochlea is a hollow cone, and includes a double car=
=tilage clothed by a membrane analogous to the Lamina Spiralis, which divides it into two com=

=partments, communicating at the apex. Its
apex is directed to the medial line of the Cranium.
The auditory nerve expands upon it. In Lizards,
and also Crocodiles, there are three Semicir=
=cular Canals. The position of the Tympanum
in the Crocodile is towards the upper part of
the cranium. In the Chelonia, the Tympa=
=num is divided by a constriction separating
the external, from the internal portion; which
last is prolonged backwards. At the bottom
of the Tympanum, a canal leads to the
Fenestra ovalis. In general among the
Saurians, the walls of the Tympanic Cavity
are partly membranous. The Eustachian
Canal is very short.

Birds.

The Birds possess a Hearing Organ very
closely analogous to that of the Higher Reptiles,
such as the Crocodile. They possess the
Labyrinth of a very large size, and have
generally, no external ear like that of Mam=
=malia. The owl is provided with a large
crescentic membrane; and the Ostrich, and
Buzzard, as well as the Owl, can raise cer=
=tain feathers around the external meatus, for

the purpose of collecting sounds; though the name 'External meatus' is hardly to be applied to the ear of a bird; as the bony meatus is very shallow indeed. The Membrana Tympani is very delicate - It is convex externally, thus differing from the mammalia. The cavity of the Tympanum is widest at the External part, & communicates by two foramina analogous to the foramen Ovale, and Rotundum, with the Internal Ear. In Birds there is an extensive system of intercommunication of cells, within the bones. Thus, from the back of the Tympanum a passage leads above the foramen magnum, in the substance of the occipital Bone, to the middle line, where a similar arrangement meets it from the opposite side. From the anterior part of the Tympanum, the cells of the bones and anterior parts of the Cranium are connected. A third foramen passes to the cells around the Labyrinth, which is itself of very compact bony substance, but owing to the loose osseous structure around it, the Labyrinth is easily separable for examination. The place of the Ossicula Auditus, are supplied by one Ossiculum,

the Columella. or Bacillus; so called, from its elongated shape; and by two Cartilages; an ex=ternal one, triangular; often provided with a long process, corresponding to the Malleus; and a second smaller one, analogous to the Incus. The columella is frequently found to be broader inferiorly, and is sometimes found to possess two crura, which approximates it still nearer in resemblance to the Stapes. It is moved by one muscle, as in the case of the Pelican, the Raven, &c. It then resembles the Stapes Bone of the Kangaroo. In Birds we find the Eustachian Tube very large, and osseous. In the Swan a single aperture is found for this opening behind the Posterior Nares; as the Tubes of each side previously to opening, unite into one. The labyrinth consists of vestibule, Cochlea, and three Semicircular Canals. Of the latter, the superior one is the largest, ex=cepting in the case of the Insessores, where it is the smallest of all. The horizontal canal is the smallest. The cochlea in Birds resembles that of the Crocodile. It consists of a short os=seous tube, slightly curved, the concavity looking backwards. It is divided by two

Cartilages, united by a membrane into passages, analogous to those of the Scalæ Vestibuli, & Cochleæ. The Thickened margin of the membranous zone of the Lamina Spiralis in the human ear, corresponds to the cartilage of the cochlea of the bird with its Vestibular Tympanic Scalæ. In the membranous sac of the Vestibule, powdered masses of crystallized Phosphate of Lime are found. The Struthious Birds shew a closer resemblance to the Reptilia by possessing a Cochlea very small in proportion with the other parts.

The Mammalia.

From the Birds we advance to this great division of the Animal Kingdom of which man is at the Head, and here we find again, a more settled and established advance on all the preceding groups. The most important part of the auditory organ, the Labyrinth, manifests ordinarily throughout the Mammalia, a general harmony, and accordance, with the same parts in Man. The Mammalia are characterized by the development of the Lamina Spiralis of the Cochlea; The Cochlea itself; The three Ossicula; & Membrana

Tympani; and Tympanic Cavity; together with all parts contained in the Labyrinth - The auditory organ is completely surrounded by dense osseous substance, but in the foetal state it is not yet impacted in this way, but a resemblance is found to exist between this state and the permanent condition of the organ, in certain inferior states of it - thus we find, for example, that in the foetal period the external Semicircular Canal is free in man, resembling at this time the permanent state in the dog, and hare; but that afterwards, it becomes entirely enclosed in with compact bone. The Semicircular Canals; and the vestibule, and concretions contained, are closely similar in the Mammalia generally to what they are found to be in man, with here and there exceptional cases. A few of the most remarkable instances of diversities may be noticed here. These diversities are extremely interesting to trace, and it is always assumed that the Organ of Hearing in Man is the Perfectly Developed Organ, for illustrating the same organ in every other Creature, owing, in a great degree, to the great

mass of Cerebral power, with Which, he alone is endowed. In the Monotremata in the case of the Ornithorhynchus is found the closest resemblance to the Division of the Aves; which we have just left. It has a small columella, or imperforate Stapes, articulated with a triangular Bone which Meckel says represents the Incus. In the Marsupialia also, the form of the Stapes represents the Columella to some extent; as in the Perameles; or for half its length as in the Kangaroo, where it divides into two short crura before reaching the base. This form occurs in the Sloth also. The Stapes is very widely modified. In the higher orders of apes; in the Elephant, the Mole, the Hedge-Hog, & Bat, there exist only trifling deviations from its form in Man - its opening being larger, or smaller, and its crura, or its head, elongated, or shortened. In some of the Rodentia, and Insectivora, as for example, the Marmot, the Mole, and the Squirrel; and the Rat; a branch of the Carotid Artery, the Arteria Ophthalmica, and Maxillaris; and in the case of Cheiroptera, the Middle Meningeal artery, runs through the Stapes, and the cavity of the Tympanum.

Between the two Crura of the Stapes, the Artery is protected from injury by a bony ring which as a kind of bar, supports the Stapes, thus preventing its passing too far into the large foramen Ovale, which in the Cheiroptera is of great size. In the Stapedius muscle of the Ox, and horse, there exists a small Lenticular bone. In the Seal, the branches of the Stapes are very thick, so as nearly to shut up the opening; which indeed is the case completely in the Walrus; the Dolphin; and the Whale; in these three last, an entire occlusion of the aperture has taken place. The Stapedius and Tensor Tympani muscles seem, as in man, to be always two in number. In the Ornithorhynchus, and Mole; the Semicircular Canals are very large; and project into the Internal cavity of the Cranium. As regards the labyrinth; interesting varieties are found. The Vestibule is almost wanting in the Cetacea. The Semicircular Canals in Cats; in the Cheiroptera; and in the Viverridæ; have a curve like that of the segment of a circle. In the Horse; they form a parabolic curve. And in the Camel; goat; & Myrmecophaga.

Subrata; they form an ellipse. In the Antelopes; and some Edentata; a Spiral - In the Cetacea they are small, less than in the common Field-Mouse; and they form the segment of a circle. The Dromedary possesses the largest Canals; after these, in order, come the Seals. The Canals usually open into the Vestibule by five mouths, but this is not a constant thing. The Amphibia present also considerable variations in dimension, and locality - generally there are three - in the Sloths only two. The cochlea is that structure which differs the most widely, in the number of turns it makes. In Whales, and Dolphins, it has only 1½ turns, and is very large, presenting thus a striking contrast to the very small Semi-circular Canals which the Whale possesses. In Delphinus Delphis, the Cochlea is actually larger than in the largest Mammalia living upon the Land. Its turns are all on one level. In the Hedge-Hog, the Cochlea turns 1½ times; in the Seals, twice; in the Chamois, the same. Most of the Ruminant Animals such as the Horse, and many Edentata, have not quite two and a half coils. The same

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is the case in Man, in the apes, and Cheiroptera
In Cats; Dogs; Bears; and many of the Carni=
=vora; there are three turns of the Cochlea. In the
Pig; Squirrel; and other Rodentia; there are
nearly four, and in Coelogenys Paca; nearly
five turns. As a contrast to this the Echidna
and Ornithorhynchus have only a single half
turn, and thus they approximate to the form
in the Aves. In the Seal the Foramen Rotun=
=dum is four times as great as the Foramen
ovale. The Tympanic cavity varies very
much also. In man, and in the apes, it is
quite buried in the Petrous Portion, but in
the other orders, we have a peculiar Tympanic
Bone, variously formed in different Orders.
In the Whales it is separated from the smal=
=ler Petrous Bone, and attached to the Cranium
by ligament. It is very large, and densely
hard. In the Ruminants, the cavity of the Tym=
=panum is irregularly shaped, and somewhat
angular. In the Sheep it is very large. In
the Rabbit; as well as in many other Rodentia;
and Carnivora; there is a clearly marked
Bony bulb projecting outwards, at the base,
and towards the side of the Cranium. This is

very large in Dipus. A bony tympanic ring, frequently imperfect superiorly, often exists externally. In the Sloth the cavity of the Tympanum passes into the arch of the Zygoma. The Membrana Tympani may be drawn inwards, or outwards, or horizontal, as in Moles; or approaching to Vertical, as in Man. The Eustachian Tube in the Horse, and Ass, is united with an air-sac, within the fauces. The three Bones of the Ear, can be ordinarily recognized. In the Apes of the Old World, they have the form they possess in Man. In America however they differ more widely. For Example. the Opening into the Stapes is very generally small. In the Squirrel, and the Rodentia, they can be recognized. The Handle of the Malleus is very variable. In Carnivora it is long. In the Sloth broad. In the Rodentia it is often like the Blade of a Knife. In the Chrysochloris, a supplementary bone is interposed between the Malleus, and Incus. In the Whale, the Malleus is almost triangular.

Thus it has been endeavoured to

trace upwards from the rudimentary appearances, in the lowest living organisms in which they occur, of an organ of hearing to the gradual and more per-fect development of the organ in the higher races, in which we find it approaching most nearly the structure which it assumes in man himself.

Some have ingeniously endeavoured to institute a comparison between the respective component part of the organ of vision and the ear, but there must be always more or less of fanciful analogy in a very extended attempt of this kind.

There does seem however to be a sort of parallel between the functions of the Iris, as forming a kind of Shield to prevent the access of too great an amount of light at the back part of the eye, at the expansion of the optic nerve upon the retina, and the Membrana Tympani of the External Ear, forming, besides its other uses, a sort of modifying screen for preventing the too great intensity of sound from reaching the auditory nerve in too undue a measure, and providing for some abatement of the force of the vibrations of sound from without.

Much more might have been said upon the whole subject of the

respective auditory organisms in different classes of living beings, but in conclusion, it may be briefly added that in each several form of animal life where this organ exists at all, it is adapted to subserve the special phase of organization which it is found to accompany in the creature formed to exist either in the air, or in the water, or in both, (as in the case of the Amphibia,) and is modified in the most elaborate manner to suit the ever varying circumstances in which its exercise is required.