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EAR BONES OF *NOTOTHERIA* AND ALLIED ANIMALS.

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If we pass in review the osteology of the ear bones of the Kangaroo, the Wombat, the Native Bear, etc.. and then turn to the *Nototheria*, we get an interesting series of departures from a common type, which latter we may assume began by manifesting a fairly normal development of the bones, in the region of the ear. Just what that ancient type was need not at present detain us, our work being rather that of showing how the bones have developed, dwindled, coalesced, and otherwise altered, as the several groups of marsupials, above named, followed their special lines of evolution. In so doing, are we to regard each group as being a law unto itself expressed, once and for all, or did the several changes become analogues of those passed through by other creatures (not of necessity marsupial) in other parts of the world? Although perfectly aware of the fact that this subject is not popular with modern biologists, we think that work along these lines is worth attempting, and will eventually be found useful.

THE POSTULATED ANCESTOR.

It cannot be too much to assume that in the hypothetical type the following characters duly obtained:—

1. That the par-occipital bounded the occiput.

2. The mastoid portion of the periotic was wedged between the par-occipital and the post-tympanic.

3. That the post-tympanic was well developed.

4. That the tympanic was a bony ring, at the surface of the skull, if anything nearer to the post-tympanic than to the post-glenoid.

5. That the post-glenoid was a well-marked process.

KANGAROO.

1. The par-occipital is a long and well developed process, but does not strictly bound the occiput, the shorter, truncated mastoid forming the outward cranial extension.

2. The mastoid strip is in evidence.

3. The post-tympanic has coalesced with the mastoid element, but its tympanic over-arch can still be seen.

4. The bony ring of the tympanic occupies the centre of the otocrane, and reaches backward and forward, by solid extensions of its bony substance.

5. The post-glenoid is short and stout, and is slightly embraced by the tympanic, and that to a greater or a lesser extent in individual skulls.

From the hypothetical type, then, we here note the following departures, being the sum total of the evolution of the external (bony) ear of the Kangaroo:—

1. The par-occipital has grown in thickness, by the addition of a moiety (upon its inner side) from the mastoid, so that it now forms the inner half of the process.

2. The mastoid has bounded the skull by a truncated process.

3. The post-tympanic has retained its original characters, more mesiad than distad.

4. The tympanic has grown, to compensate for the reduction of the post-tympanic, and most likely altered its direction.

5. Owing to the changes just noted, the post-glenoid has become more directly associated with the tympanic.

THE TASMANIAN WOMBAT.

In this marsupial we may observe:—

1. The par-occipital has been forced mesiad, and does not, by a long way, bound the occiput.

2. The mastoid forms a mastoid process, actually bounding the skull.

3. The post-tympanic is in-stepped, and forms the median boundary wall of the occiput, and is thin and knife-edged in structure.

4. The tympanic surrounds, without touching, the post-glenoid, but is more closely associated with the post-tympanic. In young animals, however, it is central, showing that the change of direction is relatively recent.

5. The post-glenoid is a well-marked process, but excavated by air cells.

The changes thus manifested show that in its evolution the wombat has:—

1. Dwarfed the par-occipital, and driven it mesiad.

2 & 3. Produced the mastoid and post-tympanic.

4. Altered the tympanic to meet the condition of enlargement (by means of air cells) of the whole region of the ear.

5. Retained, but re-adapted, the post-glenoid.

The needs that stimulated these changes were met in a somewhat different way in the Hairy-nosed Wombat of South Australia, in which animal the tympanic has retained its central position, by throwing out extensions to meet the post-tympanic, and the post-glenoid. The latter process has dwarfed to the merest semblance of its former greatness, the enlarged tympanic, and the enormous air cells being, at present, the chief features of the ear.

These changes in Wombats amount to as much or indeed rather more variation from the assumed type as we found among Kangaroos.

THE NATIVE BEAR.

1. The par-occipital bounds the occiput, and is a direct outgrowth from the ex-occipital, receiving nothing from the mastoid.

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These changes in Wombats amount to as much or indeed rather more variation from the assumed type as we found among Kangaroos.

THE NATIVE BEAR.

1. The par-occipital bounds the occiput, and is a direct outgrowth from the ex-occipital, receiving nothing from the mastoid.

2. The mastoid unites with the post-tympanic in a knife-edged upper bounding wall.

3. The post-tympanic strongly over-arches the tympanic.

4. The tympanic is a slightly marked tube recessed into the central portion of the bony ear.

5. The post-glenoid is large and dilated by air cells into an extensive chamber easily half the size of the true bulla—which latter is enormous.

Comparison with the hypothetical type (6) will show the following retentions and variations:—

1. The par-occipital must be almost, if not quite, a replica of the type.

2. The mastoid has also varied little.

3. The post-tympanic strongly over-arches the ear, and retains much of its original importance.

4. The tympanic ring has dwarfed, and become recessed, but still retains its central position. It embraces the post-glenoid, and presents a surface to the post-tympanic and mastoid.

5. The post-glenoid is large, and dilated extensively by air cells, forming, in fact, a chamber half the size of the enormous bulla (as already said), the whole of which are departures from the type.

THE TASMANIAN PHALANGER.

1. The par-occipital is removed mesiad.

2. The mastoid, which bounds the occiput, is to all intents and purposes a large air chamber. Ventrad it extends to and coalesces with the true bulla, and the tympanic, as well as with the par-occipital.

3. The post-tympanic is also a large air chamber extending without a break across to the squamosal portion of the zygoma.

4. The tympanic has coalesced with the surrounding bony elements of the ear, a slight notch alone indicating its separation from the post-tympanic.

5. The post-glenoid is well defined forward, but backward is ankylosed to the edge of the tympanic ring, which latter is very thin.

In Cook's Phalanger the variations are as follows:—

1. The par-occipital is long, as in the assumed type, but does not quite bound the occiput.

2. The mastoid extends well up the skull, and early coalesces with the other bony moieties of the ear.

3. The post-tympanic is not separate from the other squamosal elements, but unites with them to bound extensive air chambers.

4. The tympanic is more ring-like, and stands out farther, than that of the other phalanger.

5. The post-glenoid is thin, and has coalesced with the tympanic; in fact, the whole area is a mass of air cells, through which the tympanic ring penetrates.

Having thus passed in review the several expansions, contractions, and suppressions of the bones of the ears of those marsupials that chiefly interest us in our quest, we can see that every important change of life they were called upon to meet wrote a well-defined record upon their otocranes.

Wombats, adapting themselves to a fossoral life, altered the whole character of the ear in some such way as that noted above, while the hairy-nosed race developed specific variations from the generic variant. What is true of the wombats is true of the whole group just passed in review, and, accordingly, when we come to deal with the *Nototheria* we may reasonably expect to encounter similar changes, and once having found them, to use them, if so required, for taxonomic purposes.

NOTOTHERIUM MITCHELLI.

If we had to change the ear of any existing Tasmanian marsupial into one similar to that of *Nototherium mitchelli*, the ear most easy of such a conversion would be that of *Trichosurus vulpecula*. To accomplish the change it would only be necessary to bend forward the mastoid process, and ankylose it to the post-glenoid. As already pointed out (P. and P. Roy. Soc. Tas., 1920, page 108), our studies led us to conclude that the ear of *N. mitchelli* had been formed by an equal blending of the post-glenoid, post-tympanic, and mastoid processes, together with a coalescing of the tympanic ring, until the whole represented a solid bony mass, and these extended researches among allied marsupials (that

show changes rung upon every moiety of the bony ear) render this statement as feasible to-day as it was then The absence of a series of immature skulls of the giant marsupial render it at present impossible to absolutely check the steps in this evolutionary process, but as we said in our paper *(loc. cit.)*, the ear of *Nototherium tasmanicum* was a stage nearer the primitive condition, as will now be duly shown.

NOTOTHERIUM TASMANICUM.

Not being called upon to thicken up the skull to support a fighting weapon of appreciable size, this creature shows specific differences about equal to those that obtain between the common mainland wombat and that of the hairy-nosed form of South Australia.

All the elements of the bony ear can be traced, and their several dispositions are as follows:—

1. The post-glenoid has bent backwards, and fuzed with the post-tympanic.

2. The tympanic ring can still be traced.

3. The post-tympanic has coalesced with the post-glenoid, their union forming (distad) a bony process.

4. The mastoid still shows as a blunt process—it and ex-occipital bound the occiput.

5. The par-occipital, which is a massive process, is removed mesiad some 50 mm.

This amount of variation, between the two animals named, is great, as is usually found among specifically distinct marsupials.

And now let us re-ask the question: Do these changes among marsupials agree at all with those found among their non-marsupial analogues? Let us see.

DINOCERAS MIRABILE (MARSH).

In this animal the following conditions obtained:—

1. The par-occipital was dwarfed.

2. The mastoid strip of the periotic appeared upon the surface.

3. The post-tympanic was large, and bounded the auditory meatus.

4. The tympanic was recessed, and seemingly was more foraminal than tube-like.

5. The post-glenoid was a large and powerful process. In *Dinoceras laticeps*, there is a marked tendency to blend the ear bones into a solid mass.

In *Tinoceros ingens* (of Marsh) everything posterior to the auditory meatus is fused into a bony unit, a condition that apparently supervened upon the evolution of the fighting bosses. These several studies teach us that with the incoming of fighting habits, the variations of the otocrane are markedly similar, be the animal a more or less Tapir-like Marsupial, evolving weapons of offence, a Titanothere, or an ungulate, destined to become a true Rhinoceros. If we carefully weigh up the possibilities, however, that present themselves to us, as the results of any such sequence as that we have been dealing with, the conviction grows that mere environmental stress will not account for all the conditions met with. In other words, we think that evolving races of animals follow a more or less orderly sequence, plus, and minus, local conditions, for one of which biological factors we used the term "Rhinoceros Trend" in our former papers to this Society. The hasty rejection, by early evolutionists, of the law of "correlated modifications" was an unwise step, for what was really wanted was a wider and more literal use of it, rather than its elimination as a mere superficiality.

"Parallel Evolution," and similar terms, are shorn of much of their force if nothing exists behind them, as a *vera causa*, but environmental pressure. The few notes here presented are but a portion of a much larger collection made by us, including a comparative series from the existing ungulates, but space forbids their inclusion into the present text. We might also have followed out the ratios of environmental effect upon the otocranes of the marsupials named, with a view to estimating the amount of the unaccounted for balance, had conditions of publication so favoured us.

LITERATURE.

1884 Monograph of the *Dinocerata*, U.S. Geol. Survey. Vol. X., 1884, by Prof. O. C. Marsh.

1920 Studies in Tasmanian Mammals, living and extinct, P. and P. Roy. Soc. Tas., by Scott and Lord.