

MATTERS ARISING

Origin of mammal-like reptiles

KEMP¹ has recently hypothesized that "the synapsid [mammal-like reptile] skull evolved from a limnoscelid-like skull rather than from that of a romeriid, and that the temporal fenestra of the mammal-like reptiles evolved directly from the remnant of the crossopterygian hinge line". This disagrees with the widely accepted theory that the Protorothyrididae (Romeriidae), a group of small reptiles with unfenestrated skull roofs, include the ancestors or near-ancestors of the Pelycosauria, the earliest synapsid or mammal-like reptiles²⁻⁴. Both Kemp¹ and Reisz^{5,6} have recognized that the protorothyridid skull is advanced in some cranial features compared with pelycosaurids and, hence, could not be ancestral to the primitive pattern of early synapsids. Kemp's hypothesis replacing a protorothyridid ancestor with a "limnoscelid-like" ancestor also seems invalid.

Kemp uses the common occurrence of a large supratemporal that contacts the postorbital, and a large tabular that contacts the paraoccipital process of the opisthotic, as the basis of his hypothesis. These, however, are primitive tetrapod characters present in virtually all primitive amphibians and reptiles. Thus they have no phylogenetic significance in the context of synapsid origins. The proper methodology for developing a theory of phylogenetic relationships of any group of organisms is to study the distribution pattern of morphological characters among a whole range of generally similar organisms so that a determination of whether a particular character is primitive or derived may be made (only derived characters are of any significance when trying to deduce phylogenetic relationships). Because Kemp has failed to do this, he has been badly misled by phylogenetically insignificant primitive characters.

The thesis that the synapsid temporal fenestrae evolved directly from a remnant of the crossopterygian hinge-line between the skull roof and cheek is untenable. There is no evidence that any true cotylosaur, including seymouriamorphs or diadectomorphs (limnoscelids belong to the latter group⁷) or primitive reptiles, ever had a cardinal line of weakness (or hinge) between the skull roof and cheek in the living animals. The presence of such a feature in the above animals is an old misconception based on the fact that post-depositional crushing tends to concentrate forces along the sharp angle between the skull roof and cheek leading to breakage of the bone or suture. The only known skull of *Limnoscelis* is compressed dorsolaterally so that the bone has broken in this region to give the impression of a

hinge, or line of weakness. As Heaton⁸ has noted, this often happened in captorhinomorphs as well, where there was a solid wide suture between the skull roof and cheek. The only known specimen of *Romeriscus*, a possible limnoscelid on which Kemp placed much emphasis, is so poorly and incompletely preserved that it cannot be used as the basis of a major hypothesis.⁹

Hypotheses on the origin of the Synapsida based on the development of the temporal fenestrae¹⁰ are inappropriate because these are not restricted to them (lateral temporal fenestrae are present in mesosaurs, bolosaurs, diapsids and some millerosaurs) and because fenestration is only one aspect of the development of the synapsid skull. Any hypothesis of the origin of the synapsid reptiles should be linked to the structural innovations seen in the braincase, occiput, adductor chamber, mandibles and dentition as a whole, because these changes gave rise to a morphological complex that is unique among higher vertebrates.

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1. Kemp, T. S. *Nature* **283**, 378-380 (1980).
2. Carroll, R. L., *J. Paleont.* **43**, 151-170 (1969).
3. Clark, J. & Carroll, R. L. *Bull. Mus. comp. Zool. Harv.* **144**, 353-407 (1973).
4. Carroll, R. L. *Forma et Functio*, **3**, 165-178 (1970).
5. Reisz, R. R. *Univ. Kansas Paleont. Contrib., Vertebrata* (in the press).
6. Reisz, R. R. in *The Terrestrial Environment and the Origin of Land Vertebrates* (ed. Panchen, A. L.) (Academic, London, in the press).
7. Heaton, M. J. in *The Terrestrial Environment and the Origin of Land Vertebrates* (ed. Panchen, A. L.) (Academic, London, in the press).
8. Heaton, M. J. *Bull. Okla. geol. Surv.* **127**, 1-84 (1979).
9. Baird, D. & Carroll, R. L. *Science* **157**, 56-59 (1967).
10. Reisz, R. R. *Bull. Mus. comp. Zool. Harv.* **143**, 27-62 (1972).

KEMP REPLIES—Reisz and Heaton's criticism of the use of primitive characters to demonstrate phylogenetic relationships ignores my specific disclaimer that I was proposing any particular relationship between limnoscelids and synapsids. My object was simply to suggest that the character-state of the temporal region of the skull of the direct ancestor of synapsids resembled that retained in the limnoscelids, for example, and not that of romeriid or protorothyridid reptiles. Of course any hypothesis about the phylogenetic relationships of synapsids to particular tetrapod groups would require a comprehensive study of the distribution of derived characters of the whole skeleton. It was for this reason that I

carefully avoided any taxonomic implications at all, and indeed the possibility of a primary sister-group relationship between romeriids and synapsids is nowhere excluded.

The exact nature of the connection between the skull table and cheek of *Limnoscelis* is difficult to determine from a single, damaged skull. Even if the 'hinge-line' is merely the consequence of distortion, as Reisz and Heaton now claim, the similar manner of breakage of the two sides of the skull, between the table and the cheek, suggests nevertheless that this line was weak. So also does the fact that the suture between the post-orbital and squamosal is continued posteriorly in a straight line by the suture between the supratemporal and squamosal to the hind margin of the skull. My contention that the synapsid temporal fenestra appeared within this suture line remains unaffected, even if the contact between the respective bones was rather firmer than supposed. There would still have been a thin layer of connective tissue between the bones, as in the case of any suture, which could have expanded, eventually forming the temporal aponeurosis.

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Growth rings in dinosaur teeth

THERE are several difficulties with Johnston's interpretation of the growth rings he has observed in dinosaur teeth¹. The first problem is whether the rings are annual. Such growth rings are found in living and fossil ectothermic vertebrates, but in the bones, not the teeth, which are replaced frequently in most non-mammalian vertebrates². The teeth of crocodiles are replaced at intervals of 8-16 months³, making it impossible for more than two annual rings to occur within any given tooth. There is no evidence that replacement ceases during adult life, nor that the rate was substantially different in fossil crocodylians. Data on the manner and rate of tooth replacement for dinosaurs are limited, although evidence suggests multiple replacement and rapid turnover².

Dinosaurs and crocodiles would be expected to share some similarities in hard-tissue deposition and to differ from mammals, for the ancestors of archosaurs and mammals were separated perhaps as