number either formed in association with, or subsequently produced by, the self-intersection of lengths of strings; perhaps ≳5 per cent of galaxies should be non-isolated. (Note that even an isolated string will behave differently from a random phase initial perturbation and it will be interesting to see how N-body simulations of galaxy formation are affected.)

Recently, there has been discussion of ways to observe cosmic strings using gravitational lensing effects or to establish the part strings may play in active galactic nuclei[4,21,22]. Out of this may emerge direct methods for resolving whether or not strings are present in today's Universe. Although much remains to be done to see if strings are relevant to galaxy formation, they provide an interesting supplement to exotic particles and provide cosmologists with a mechanism for producing non-random phases which totally alter traditional procedures of calculation. □

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Palaeontology

Consensus on archosaurs

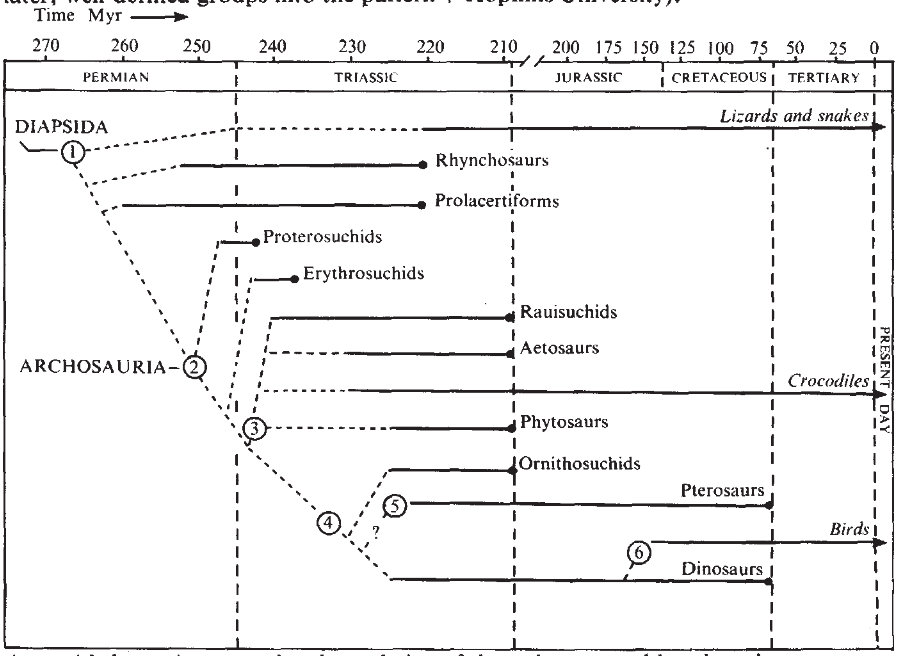
from Michael J. Benton

OBSCURITY shrouds the origins of the archosaurs, those diverse, scaled and feathered forms that include pterosaurs and dinosaurs, as well as the living crocodiles and the birds. Commonly, each line is traced back into a rag-bag group of early archosaurs of the Triassic period (208–245 Myr) called the thecodontians. The archosaurs are thought to have arisen just before the Triassic, but the origin and nearest relatives of the group have been obscure. Clarity and a radical new concensus on some of the issues were the outcome of the 3rd symposium on Mesozoic Terrestial Ecosystems, held at Tübingen, FRG from 6–10 September, 1984.

The reason for the remarkable level of agreement in a hitherto obscured area of evolutionary biology was that each contributor applied the techniques of cladistic analysis to the relationships of the basal thecodontians, and only then slotted the later, well-defined groups into the pattern obtained. Previous analyses had relied upon the assessment of general resemblances and the time sequence of the fossils in an attempt to pinpoint ancestors. The cladistic technique assumes that it is very unlikely (but not impossible) that we shall ever find an ancestor, and it concentrates on identifying nearest relatives — sister-groups — by an analysis of shared derived characters.

The radical new conclusions that were reached at the Tübingen meeting are best explained by reference to the numbered sequence on the summary tree below.

(1) The archosaurs form part of a larger group, the Diapsida, which also includes the living lizards and snakes[1,2] (for a dissenting view, see ref. 3). Within the diapsids, the nearest sister-groups to the archosaurs are the rhynchosaurs and the prolacertiforms[1,2] (J. Gauthier, University of California, Berkeley and G. Paul, Johns Hopkins University).



A tree (cladogram) representing the evolution of the archosaurs and based on the consensus of opinion at the Tübingen meeting. The tree is set against a timescale based on the known fossil record. Note the change in time scale at 200 Myr, which gives greatest emphasis to events in the Triassic.

(2) The early Triassic archosaurs — the Proterosuchidae and the Erythrosuchidae — are much more primitive than all later archosaurs, and are placed as basal sister-groups within the Archosauria; the later forms split into two major lines, one leading to the crocodiles, the other to the dinosaurs (M. Parrish, University of Chicago; Gauthier).

(3) The 'crocodile line' includes several specialized thecodontian groups of the middle and late Triassic: the superficially crocodile-like fish-eating phytosaurs, the snub-nosed herbivorous aetosaurs, and the carnivorous rauisuchians. The first crocodiles are known from the late Triassic. They were long-limbed lightly-built terrestrial forms, that evolved aquatic specializations after the extinction of the phytosaurs.

(4) The dinosaurs, as we currently understand that term, form a monophyletic group — that is, they all evolved from a single common ancestor, which was a late Triassic dinosaur. This important conclusion was agreed by Gauthier, Paul[5] and Parish, as well as by D. Norman (University of Oxford), P. Sereno (American Museum of Natural History), and myself. Already in the 1970s, several palaeontologists had suggested that the dinosaurs were a monophyletic group[4,5], but this view had not been widely accepted. The new consensus is that the dinosaurs were a single group of advanced archosaurs sharing a number of derived characters of the limbs that were related to the animals' particular kind of upright stance (see *News & Views, Nature* **310**, 101; 1984).

(5) More controversially, Gauthier and K. Padian (University of California, Berkeley) argued that the pterosaurs — the extinct flying reptiles — were the closest sister-group of the Dinosauria. Pterosaurs had forearms, bodies and heads specialized for flight but their hindlimbs are apparently very dinosaur-like.

(6) Finally, there was much more agreement than seemed possible a year or so ago (see *News & Views, Nature* **305**, 99; 1983) on the relationships of the birds. This was touched on briefly at the Tübingen meeting, but was discussed in greater depth at a special meeting devoted to the 'early bird' *Archaeopteryx* held in Eichstätt, FRG. Nearly everyone now accepts that the birds arose from the dinosaurs, and from the bipedal carnivorous dinosaurs (the theropods) in particular. There was little support for the alternative view that the birds sprang directly from the Triassic thecodontians, or from a crocodile-like ancestor, and the discussion was more about which theropod family was most closely related to the birds. □

1. Benton, M.J. *Symp. zool. Soc. Lond.* **52**, 575 (1984).
2. Evans, S.E. *Zool. J. Linn. Soc.* **82** (in the press).
3. Gardiner, B.G. *Zool. J. Linn. Soc.* **74**, 207 (1982).
4. Bakker, R.T. & Galton, P.M. *Nature* **248**, 168 (1974).
5. Bonaparte, J.F. *J. Paleontol.* **50**, 808 (1976).

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