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RECOLLECTIONS

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Once a year, as members of the Society of Vertebrate Paleontology, we make and re-kindle friendships over a very few days, with a number of special colleagues. Persons we remember with warmth, and look forward to meeting again for conversation, related as much or more to their own lives as to our profession. This is particular true of those who show joy and enthusiasm for life in general, as well as for their ongoing professional activities, in the field, the lab, and in their latest plans and ideas.

Betsy Nicholls was one of those persons who added a special light to our society -- one who never lost her youthful enthusiasm for all aspects of paleontological research, kindled at the age of 8 by her first exposure to fossils in the office of Sam Welles at the University of California, and at 12, supported by the encouragement of one of my own childhood heroes, Roy Chapman Andrews. I recall this enthusiasm clearly from a meeting a few years ago, when she recounted the exciting events of discovering, excavating, and arranging for the transport from the wilds of British Columbia of the largest ichthyosaur skeleton ever discovered, with the help of an enormous helicopter and her Japanese colleagues. And she certainly went that extra mile in commuting 270 km each day from her home and family in Calgary to her job as Curator of Marine Reptiles at the Tyrrell Museum, over the last 14 years of her life. And, like a student trapped in a lecture hall at the end of a long day, jumping up at the end of a business meeting of our society to get out as soon as possible for a bite to eat and a chat about the more interesting things in life.

Betsy's research covered a wide range of fossils, including a few papers on dinosaurs, one on a bird (albeit the aquatic *Hesperornis*) and one on a Campanian squid, but most were concentrated on Mesozoic marine reptiles. Her first published paper, on the discovery of the oldest occurrence of a plesiosaur in North America, seemed to set the mold. She covered most of the major groups, except for the primarily European sauropterygians. She was clearly fascinated by the entire assemblage--their functional anatomy, biogeography, ways of life, and relationships. Among the groups she described were plesiosaurs, mosasaurs, turtles, thalattosaurs, and in greatest numbers, ichthyosaurs. For collecting the largest member of this group ever recovered, under extremely difficult conditions, she received the Rolex Award for Enterprise in 2000.

Betsy's widest ranging contribution to the field of Mesozoic marine reptiles was the book, edited with Jack Callaway, *Ancient Marine Reptiles*, published by Academic Press in 1997. This brought together the research of 28 authors, from seven countries, covering nearly all groups of marine reptiles. This book, along with Betsy's many other publications, served to document the level of our understanding of marine reptiles at the end of the 20th century, but also to emphasize both the great importance of this group for our understanding of evolution in general, and to show how little has yet been documented regarding the specific ancestry and nature of interrelationships among the great number of individual lineages.

It is difficult to use the fossil record as proof to substantiate particular evolutionary processes, especially for large scale phenomena, because it is not open to actual experimentation, as is expected in other scientific disciplines. One can hardly expect to repeat the Cambrian Explosion to test Gould's hypothesis (1989) that the early radiation of multicellular animals might have turned out quite differently than it did, as a result of stochastic factors. On the other hand, the evolution of aquatic adaptation in various reptilian clades may be considered a natural experiment. Consider the variables. How many different modes of aquatic adaptation might evolve in relationships to locomotion, respiration, feeding, and reproduction? To what degree were these constrained by the anatomy and ways of life of the many antecedent clades? How many alternatives were achieved in the descendants of a single morphotype? Which is more important, the specific genetics of the ancestor, or the range of possible responses to marine adaptation (in different environments, or in similar environments that are geographically separate)?

However, such investigations require specific knowledge of the closest plausible ancestry of the various lineages, which remains woefully lacking in many cases (Müller, 2004). Moreover, this necessitates recognition of specific ancestor-descendant affinities; sister-group relationships are insufficient to determine the actual sequence of morphological change, which is necessary for determining the tempo and mode of evolution. At present, relatively few relationships have been determined at the level required for evaluating the nature of evolutionary change during their origin from terrestrial predecessors.

For the following taxa, their sister-group affinities have been fairly well established, but not the actual pattern or rate of change between immediate terrestrial antecedents and clearly recognizable common ancestors of the aquatic descendants: 1. The origin of pleurosaurs from among primitive sphenodontids. 2. The three separate radiations of marine turtles; a. Jurassic Plesiochelyidae from primitive cryptodirans; b. Pelomedusidae from ancestral pleurodires; c. the Cretaceous Protostegidae and extant Dermochelyidae and Cheloniidae from early Cretaceous Chelonioidea. 3. Successive derivations of fully aquatic crocodiles; a. Early Jurassic and Cretaceous teleosaurs from ancestral crocodiles; b. the four families of mesosuchian derivatives. According to Hua and Buffetaut (1997), "Unfortunately virtually nothing is known of the nonmarine ancestors of the mesosuchians… and their early histories are therefore very obscure." 4. Mosasaurs from anguimorph lizards.

Moreover, there is an even larger number of aquatic groups for which even the identity of possible sister-taxa remains highly contentious. 1. Ichthyosaurs. 2. *Hupesuchus*. 3. Eusauropterygians (nothosaurs and plesiosaurs). 4. Placodonts. 5. *Helveticosaurus*. 6. Thalattosaurs (Müller, 2004). Also questionable are the affinities of primitive, aquatic eosuchian-grade genera including *Claudiosaurus* and *Hovasaurus* and the broader problem of the ancestry of turtles, themselves terrestrial, but with aquatic descendants. Solution of these problems will benefit from Betsy's description of the descendant groups and her general influence in the field, but will require both the discovery of a host of putative antecedent forms from the Upper Permian and Lower Triassic, and also a very different approach to establishing relationships than the current reliance on global parsimony.

Betsy's research provides a wonderful model for the unbiased investigation of marine reptiles, or any other group of organisms. Go out in the field and collect all the fossils that can be found, no matter how difficult the terrain or the excavation of specimens. Prepare, describe, and illustrate with great attention to the details and significance of anatomical features. Compare with other specimens of the same and related taxa. Evaluate the nature of their adaptation, and their evolutionary history. Cooperate with colleagues, where ever they may be, or whatever groups they may be particularly attached to. Have fun, and spread the joy throughout your discipline.

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