Whales

1. Molecular Clock Divergence, By Jessica M. Theodor
ABSTRACT—Molecular clock estimates of divergence times for artiodactyls and whales **vary widely** in their agreement with the fossil record. Recent estimates indicate that the divergence of whales from artiodactyls occurred 60 Ma, a date which compares well with the first appearances of fossil whales around 53.5 Ma, and artiodactyls at 55 Ma. Other estimates imply significant gaps in the fossil record. A date of 65 Ma for the divergence of Suidae and Ruminantia predates the appearance of Ruminantia by over 10 million years, and an estimate of 58 Ma for the divergence of Suidae from Cetacea implies a gap of over 20 million years. Further, although a molecular clock estimate has not been reported, the hypothesis that hippos are the closest living relatives of the whales implies a potential **ghost lineage** for hippos of over 40 million years. There are only two living species of hippos, and their fossil record is sparse, while cetaceans and other artiodactyls are speciose and have rich fossil records. A **40-million-year gap** in the fossil record of hippos could be explained by several possibilities: inadequate biogeographic sampling, taphonomic biases, or undifferentiated primitive morphology. Similarly, a number of possible problems may exist in the molecular data: rate variation in the genes sampled, the low numbers of genes examined, and insufficient age calibrations. In addition, there are potential problems in molecular phylogeny estimation, such as long branch attraction and inappropriate taxonomic sampling. Additional estimates of divergence times among living taxa should provide a broader framework for comparison with the fossil record and provide information to help identify which of these factors are **causing conflict**. Page 39.

2. Molecular tree of extant cetaceans, By Michael R. McGowen
Cetaceans are remarkable among mammals for their numerous adaptations to an entirely aquatic existence, yet many aspects of their phylogeny remain **unresolved**. Page 891

The secondarily aquatic nature of whales and dolphins has inspired numerous phylogenetic studies and prompted **debate** concerning their origins among terrestrial mammals (reviewed in Gatesy and O'Leary, 2001; O'Leary and Gatesy, 2008). No less attention has been given to elucidating relationships among the major groups of cetaceans. Page 891

However, many relationships within Cetacea **remain less certain**, despite multiple efforts to resolve discrete portions of the phylogeny using a diverse array of systematic markers (mitochondrial [mt] DNA [Árnason et al., 1991a, 2000, 2004; Árnason and Gullberg, 1993, 1994, 1996; Milinkovitch et al., 1993, 1994, 1996; Rosel et al., 1995; Montgelard et al., 1997; LeDuc et al., 1999; Cassens et al., 2000; Hamilton et al., 2001; Dalebout et al., 2002, 2003, 2004; Rychel et al, 2004; Sasaki et al., 2005, 2006; Yan et al., 2005; Caballero et al., 2007; McGowen et al., 2008; Xiong et al., 2009], exons, introns, pseudogenes [references in Table 1], transposons [Nikaido et al. 2001a, 2001b, 2006, 2007], and morphology [Heyning, 1997; Messenger and McGuire, 1998; Geisler and Sanders, 2003; Deméré et al., 2008]). Page 891, 892

In addition to this conflict, previous **phylogenetic hypotheses disagree** concerning the branching sequence of the three most basal odontocete clades (Physeteroidea, Ziphiidae, Platanistidae), the exact position of the now extinct Chinese river dolphin Lipotes vexillifer, and the relationships of species within the delphinid, ziphiid, and balaenopteroid radiations. Page 892

In the **absence** of a cohesive species-level phylogeny, there is also a lack of divergence estimates for most cetacean speciation events Page 892

References

1. Molecular Clock Divergence, By Jessica M. Theodor, Journal of Paleontology, 2004, Volume 78, Number 1, Pages 39 To 44

2. Molecular tree of extant cetaceans, By Michael R. McGowen, Molecular Phylogenetics and Evolution, 2009, Volume 53, Pages 891–906