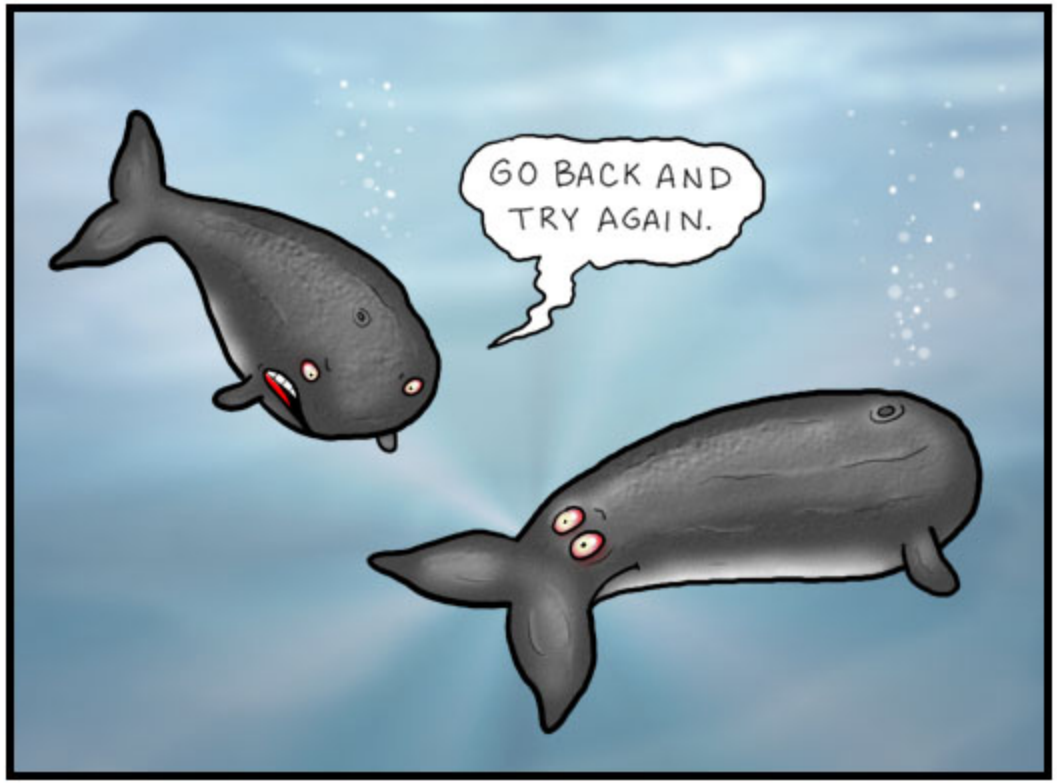
The Evolution of Whales

Geology 331

DOCTOR FUN

7 Feb 2006



The Mis-evolution of Whales

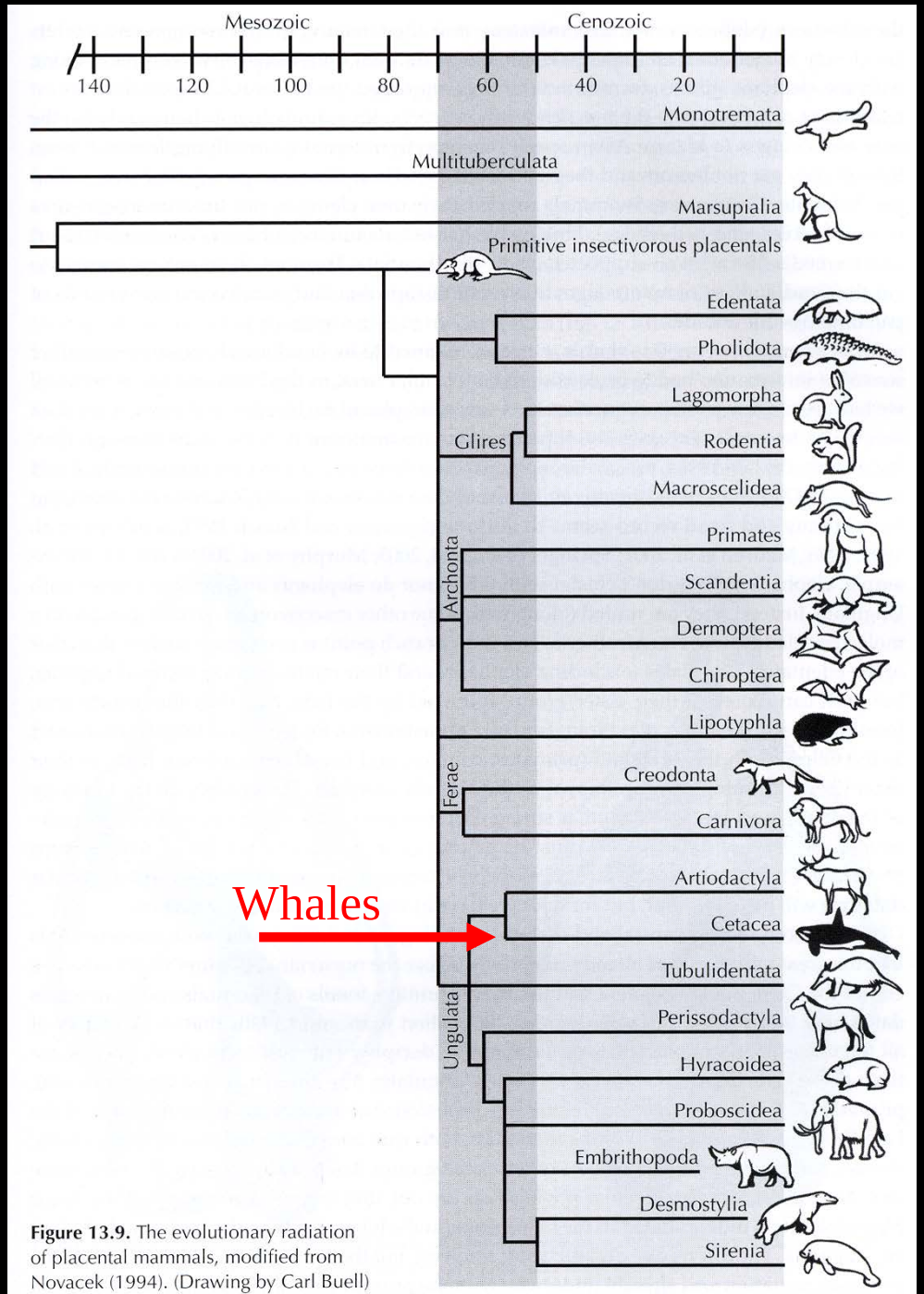
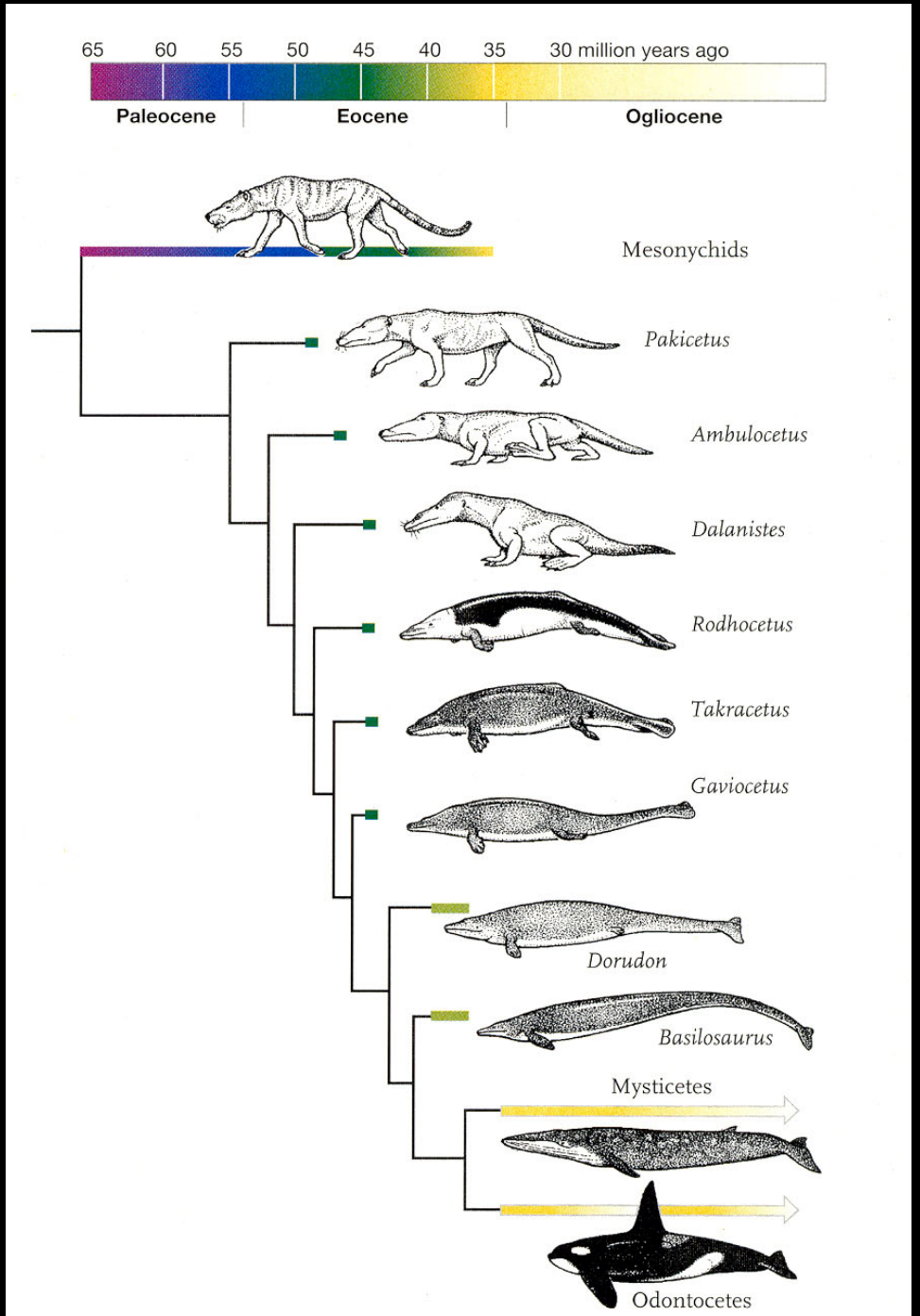


Figure 13.9. The evolutionary radiation of placental mammals, modified from Novacek (1994). (Drawing by Carl Buell)

Prothero, 2007

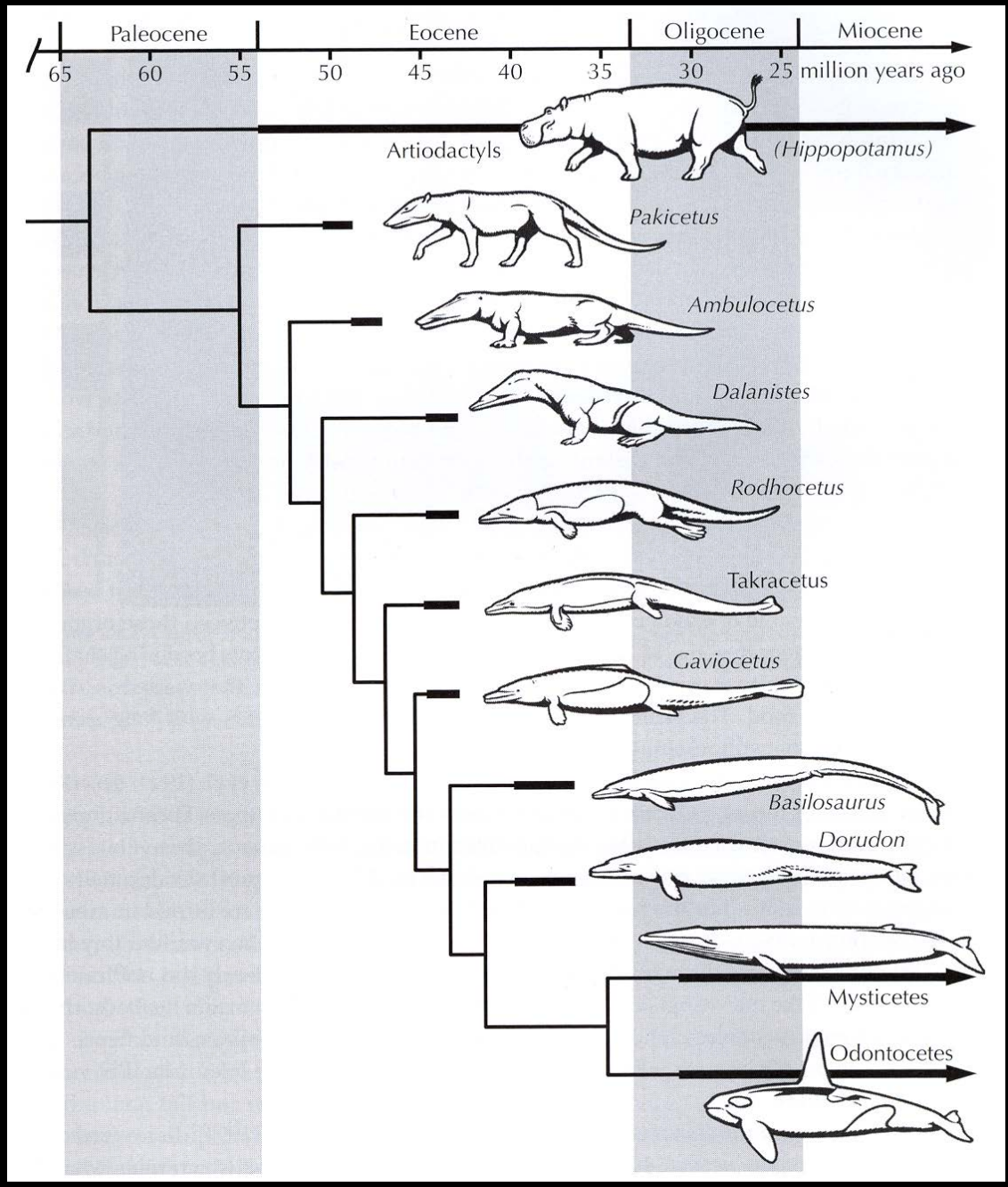
Evolution of Whales

1990s



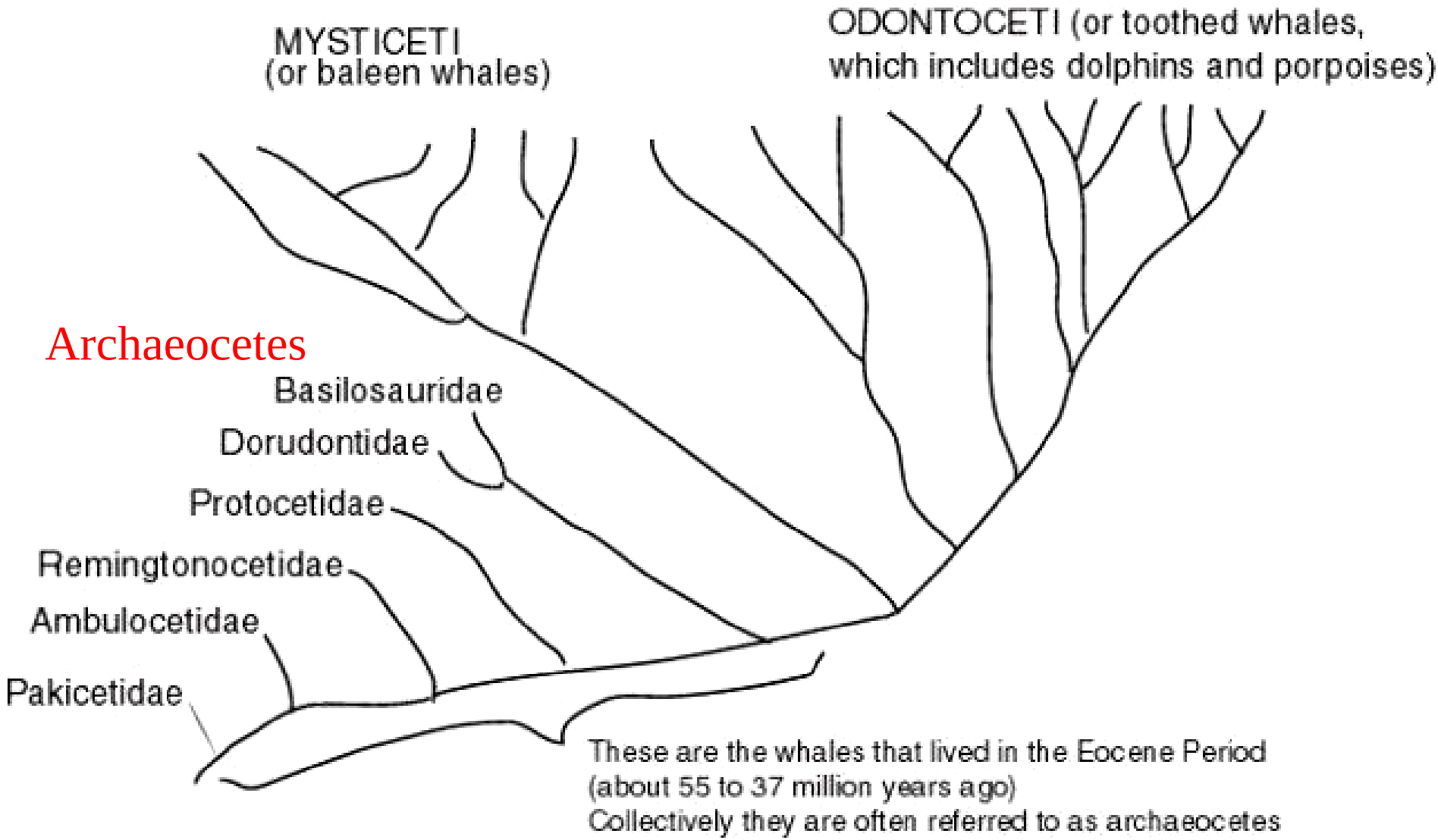
Evolution of Whales

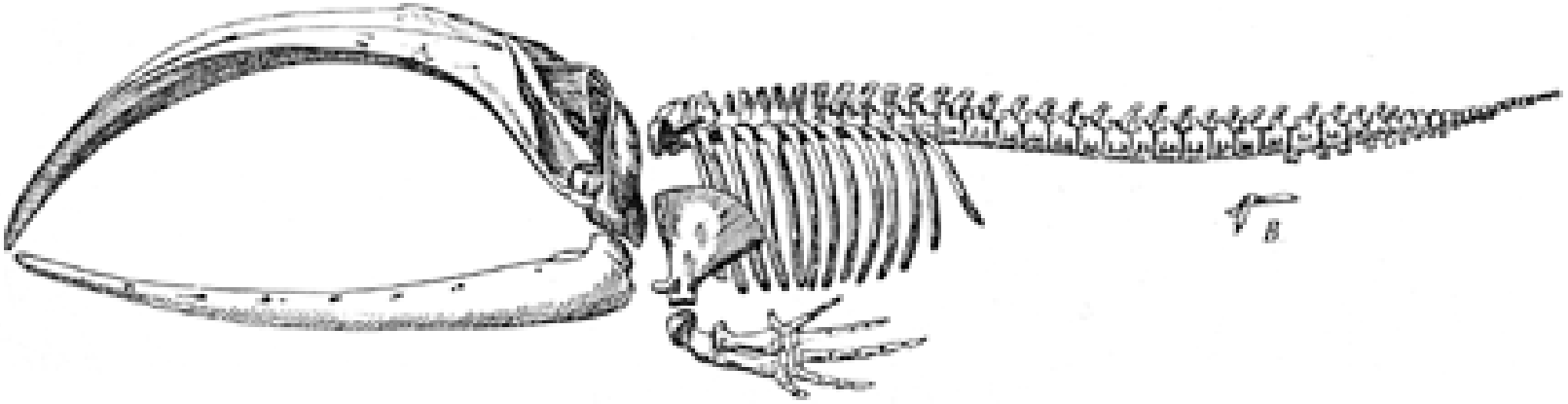
2000s



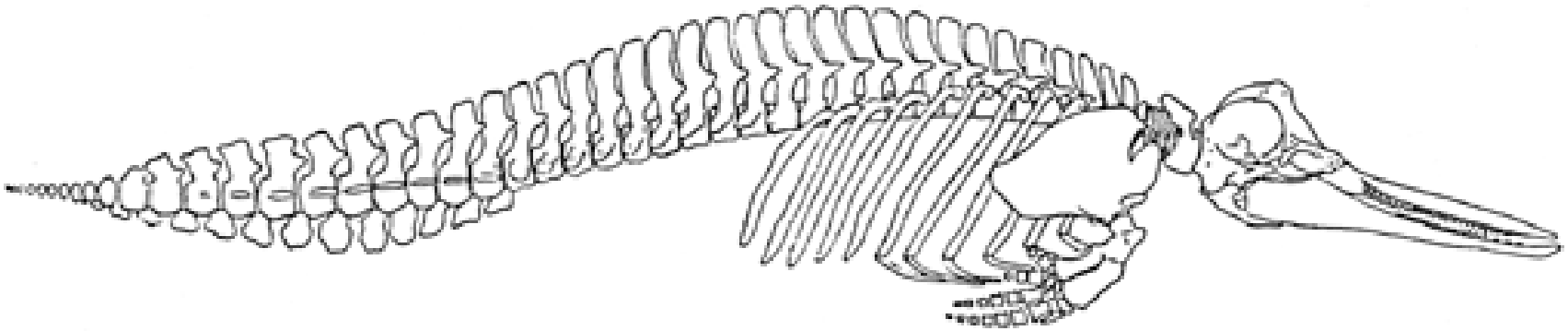
Prothero, 2007

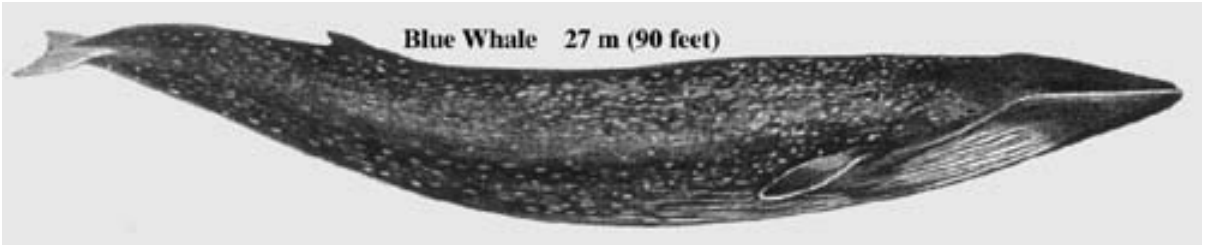
A family tree of Whales (CETACEA in Latin)

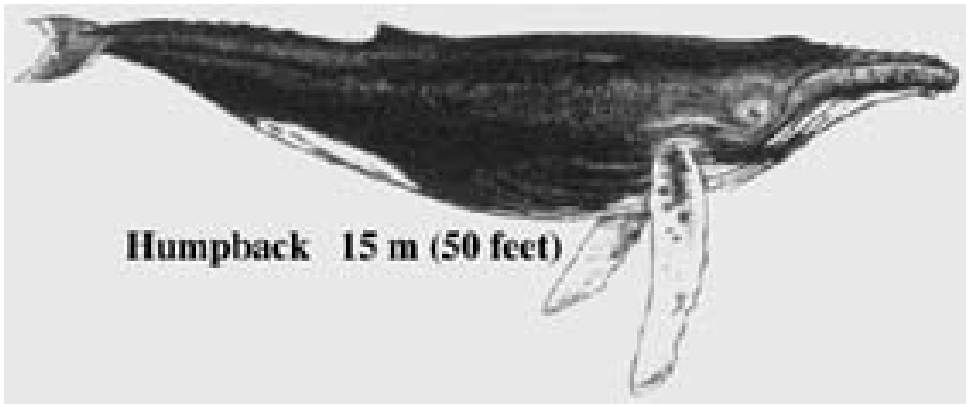


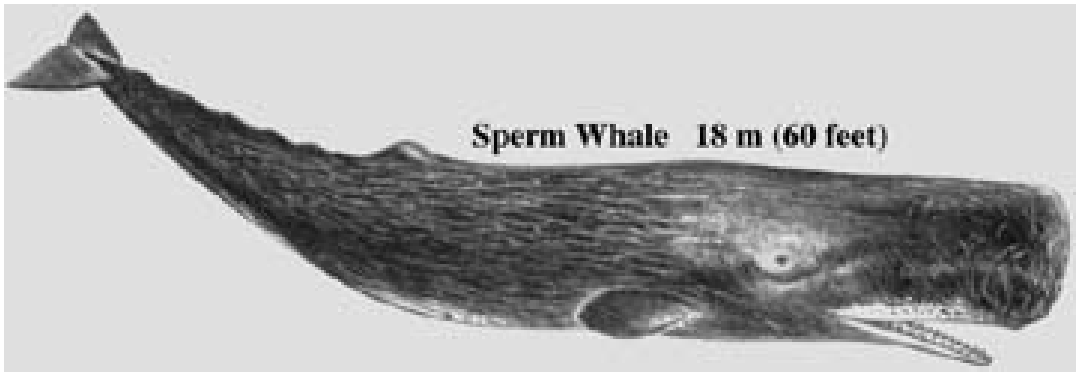


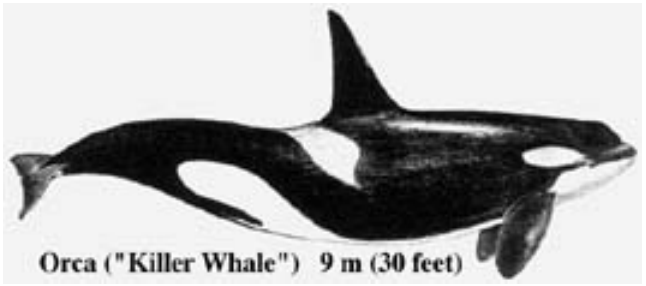
The two major groups of living whales: Mysticetes (baleen) and Odontocetes (toothed)







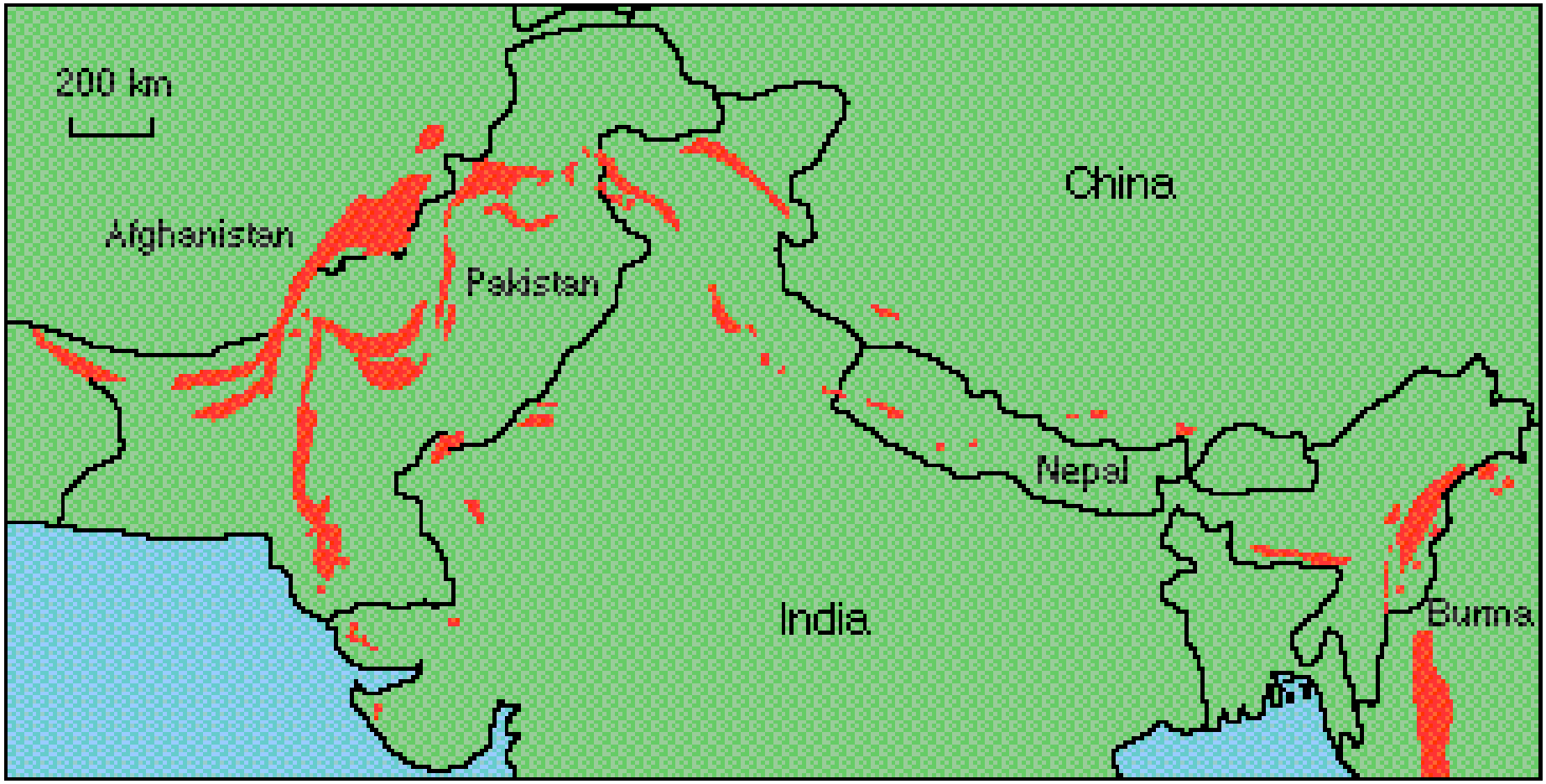




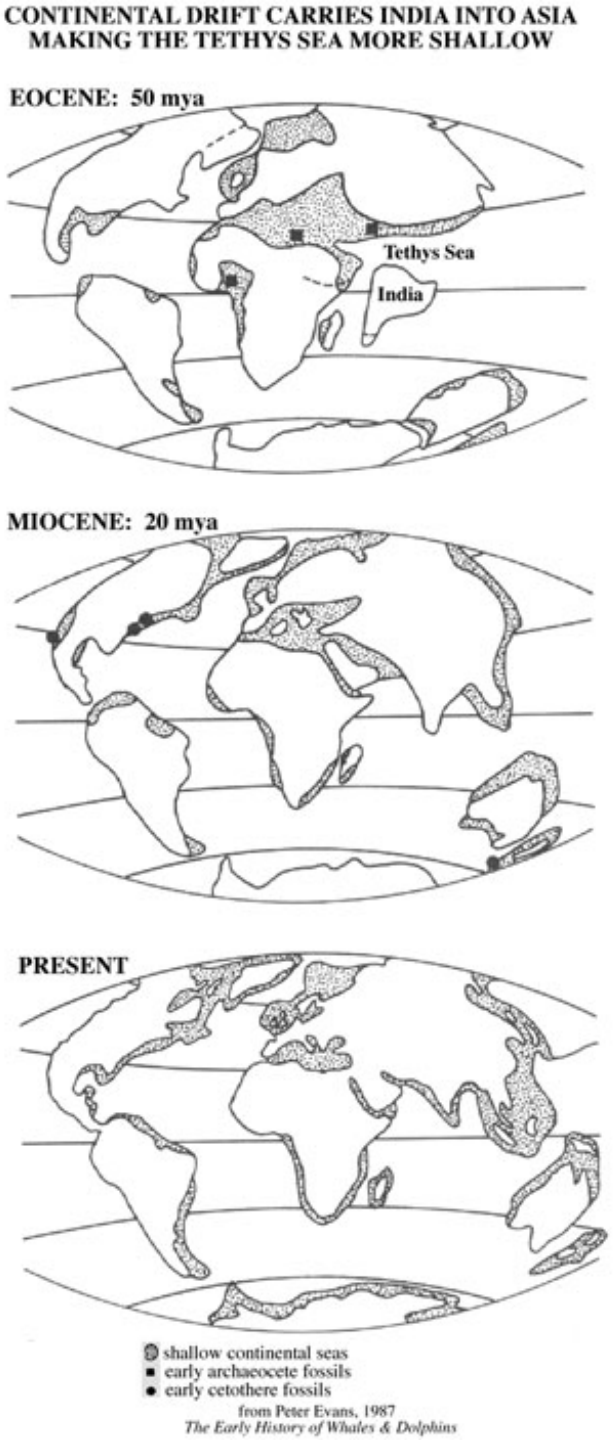
Blue Whale, Humpback Whale, Sperm Whale, and Killer Whale

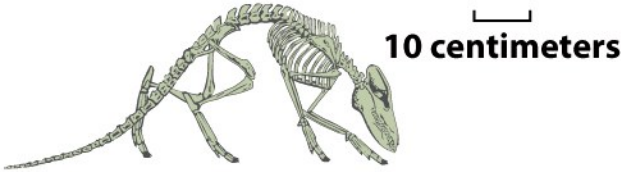
Whale baleen

Tertiary Outcrops Yielding Fossil Whales in Asia

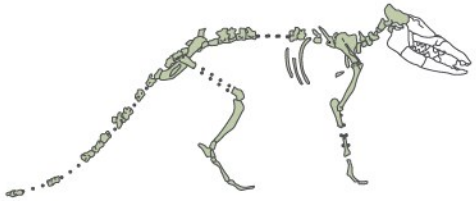


Closing of the Tethys Sea during the Cenozoic

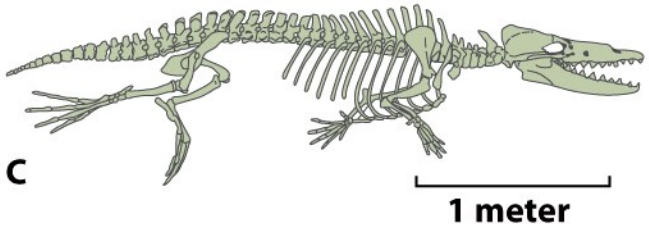




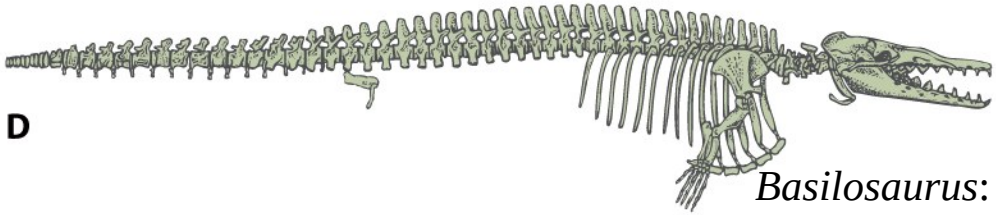
Indohyus: 48 MY old



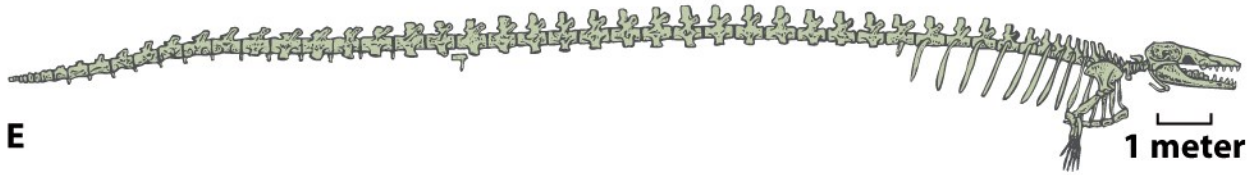
Pakicetus: 50 MY old



Ambulocetus: 49 MY old



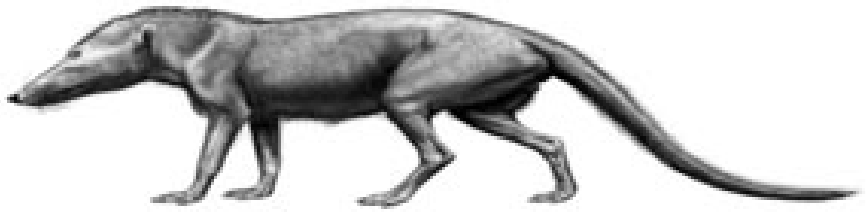
Basilosaurus: 37 MY old



Dorudon: 35 MY old

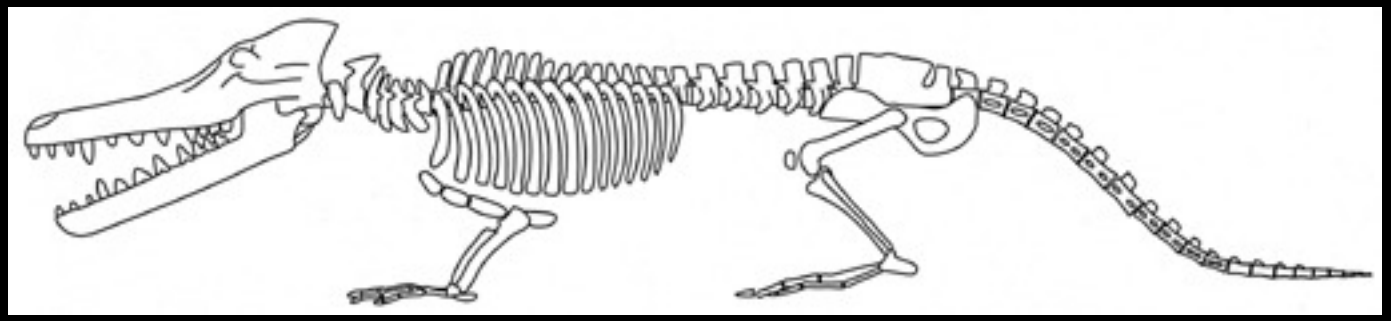
Figure 7-17
***Earth System History,* Third Edition**

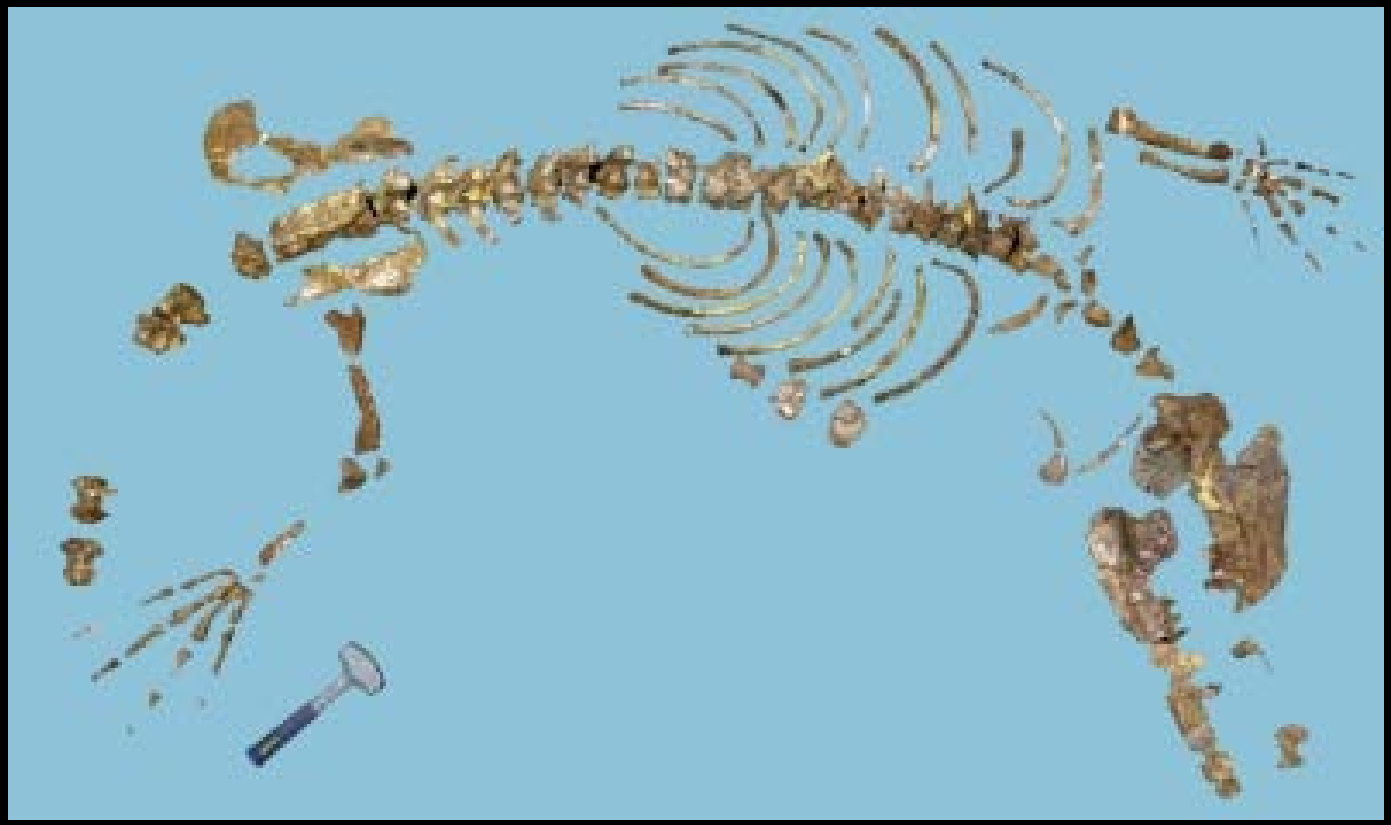
Pakicetus:
50 MY old



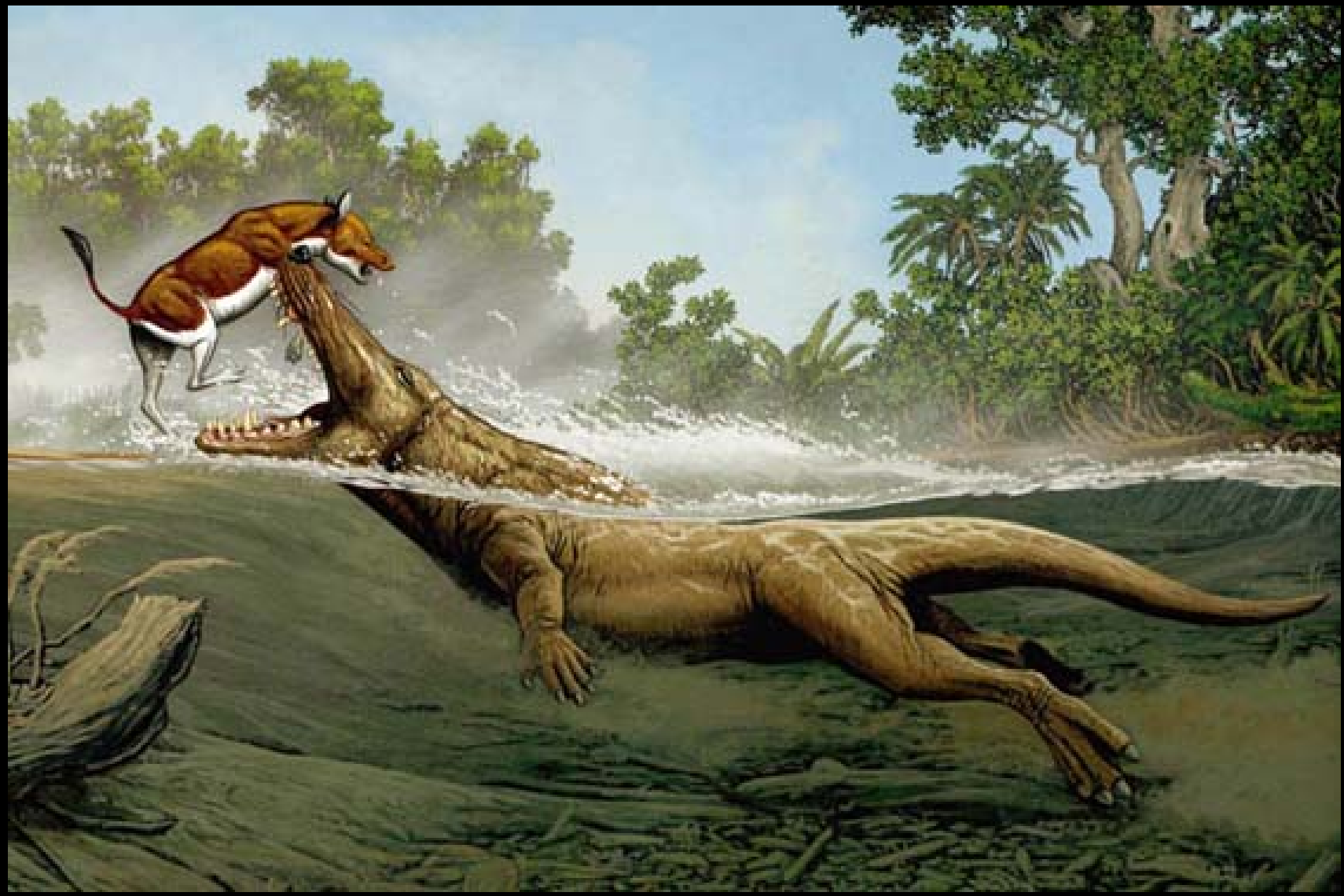
Size comparison with
a modern coyote skull

Ambulocetus: 49 MY old

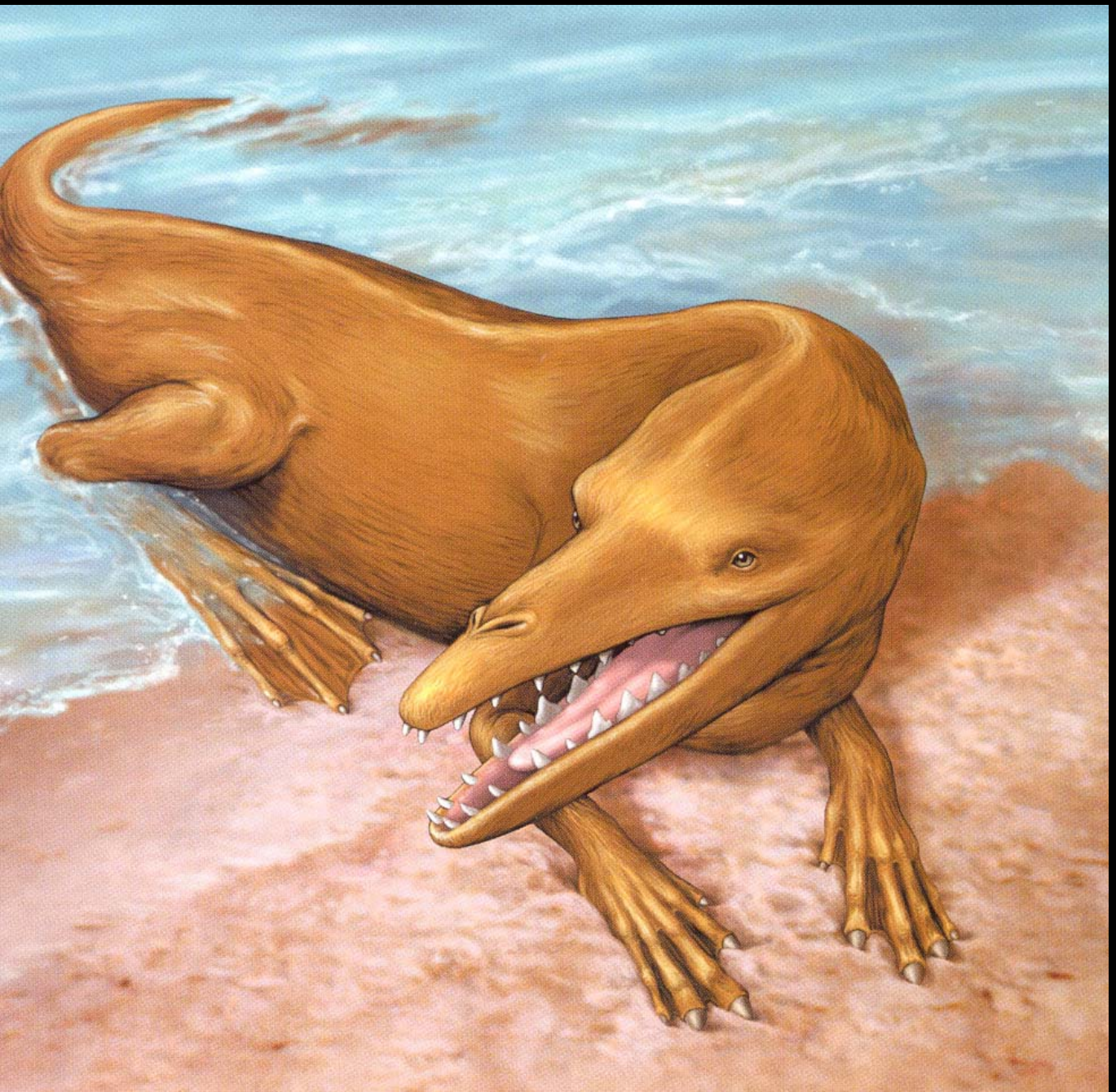




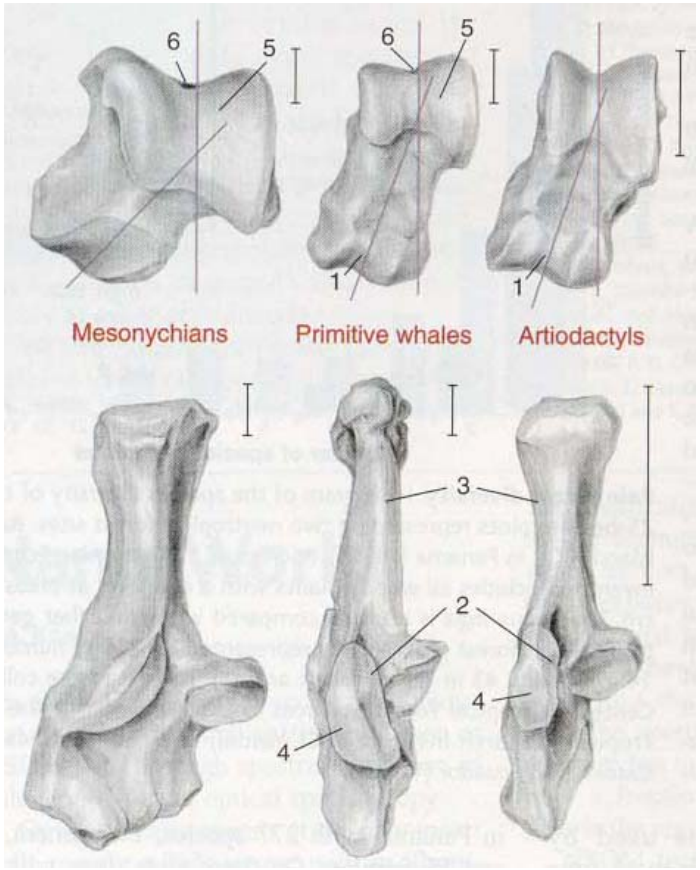
Ambulocetus in action



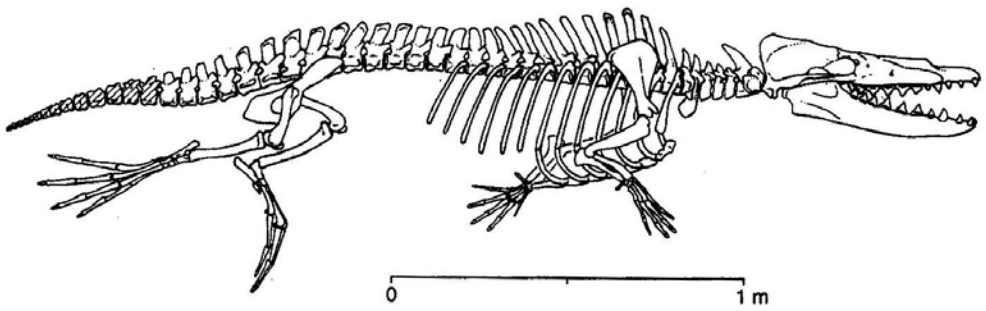
Reconstruction of the fossil whale *Ambulocetus* from the Eocene of Pakistan (~ 49 million years ago). *Ambulocetus* was discovered in 1994. In this artists reconstruction, *Ambulocetus* is shown living like a crocodile, hunting land mammals near the shore.

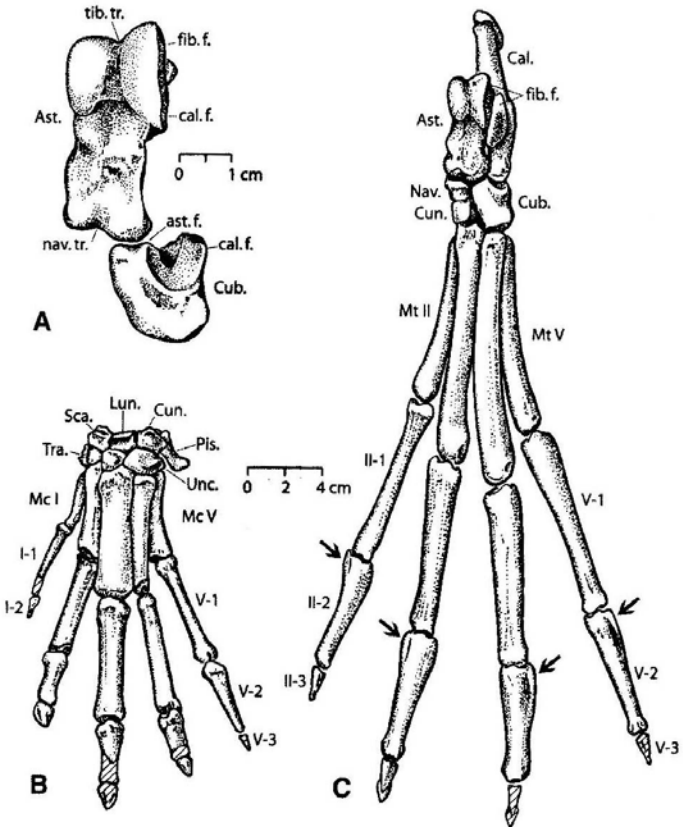


Rodhocetus:
46 MY old



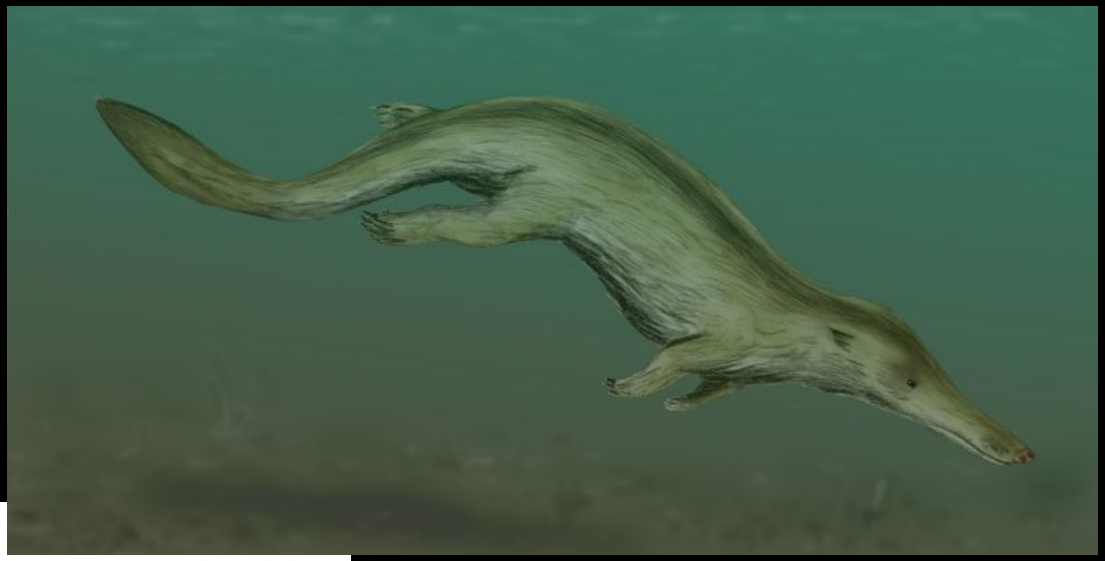
The ankle bones of *Rodhocetus* are more similar to artiodactyls (even-toed ungulates) than the traditional mesonychian ancestor.

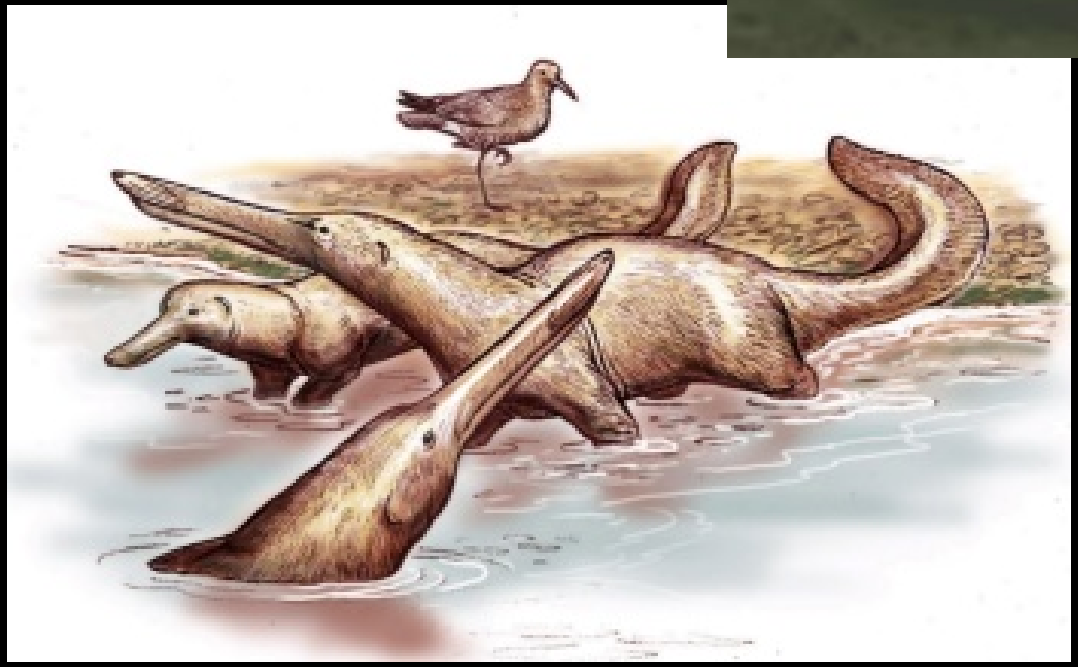


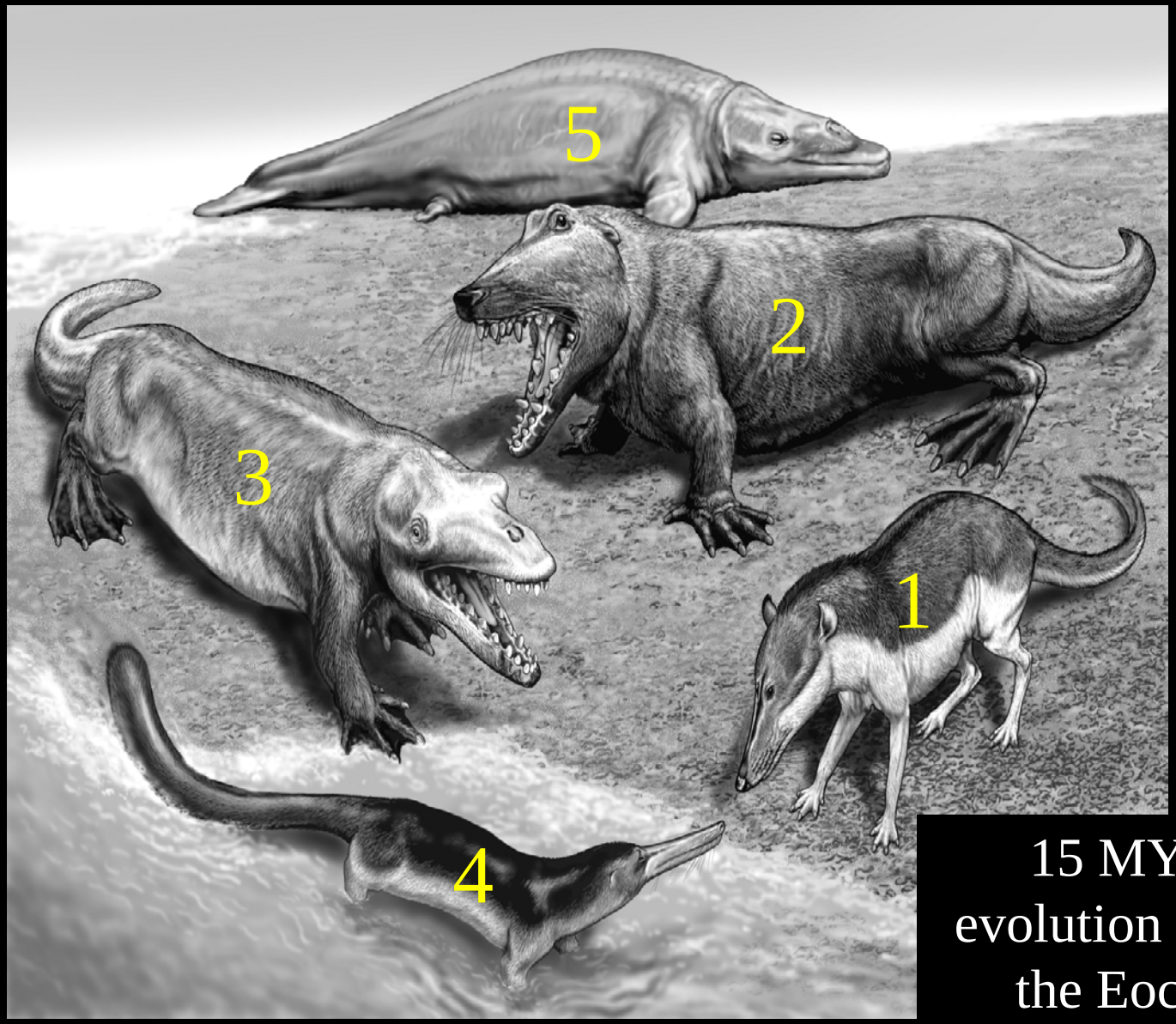


Ocean Hall, Smithsonian Institution

Kutchicetus: 45 MY old



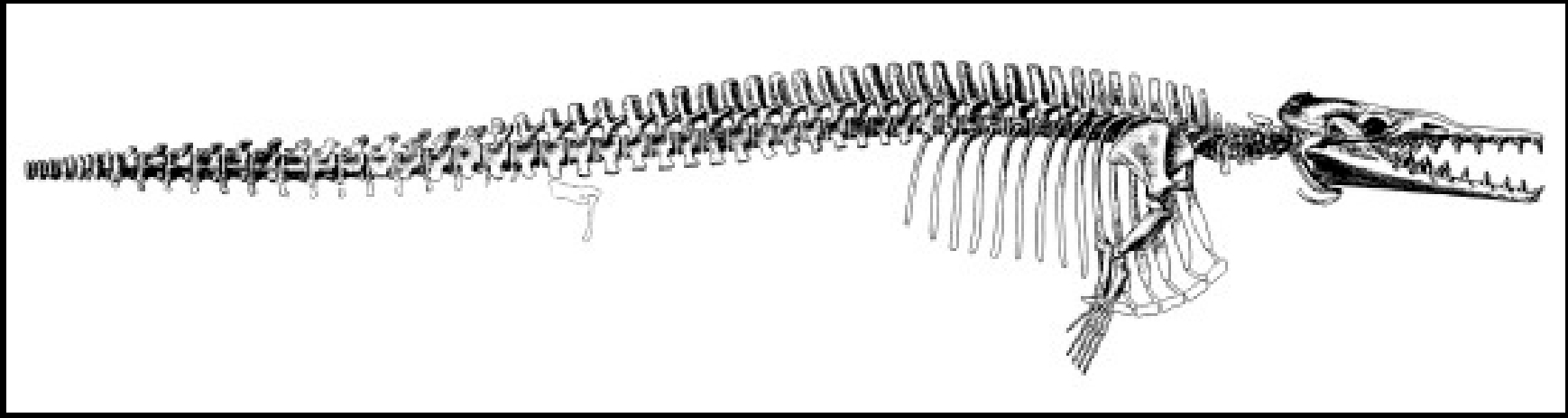




15 MY of evolution during the Eocene

Evolutionary Order: 1, *Pakicetus*; 2, *Ambulocetus*; 3, *Rodhocetus*; 4, *Kutchicetus*; 5, *Dorudon*

Basilosaurus: 37 MY old



Ankle, foot, and toes of *Basilosaurus* excavated in Wadi Hitan, Egypt. The foot as shown is approximately 12 cm long. Photograph ©1991 Philip Gingerich.

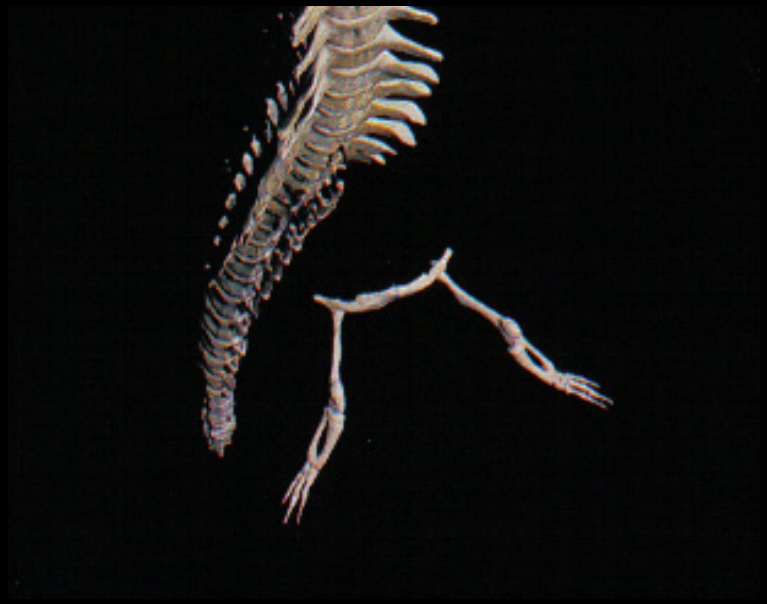
Phil Gingerich’s work on fossil whales

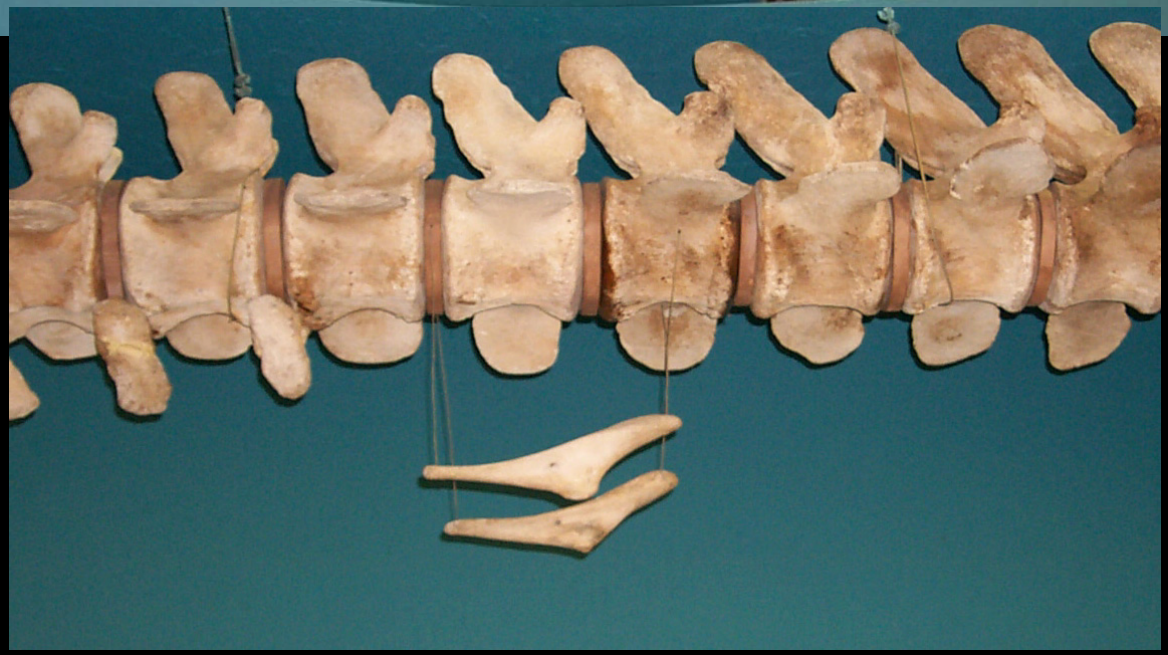
http://www.youtube.com/watch?v=I2C-3PjNGok

Dr. B. Holly Smith working at the base of the tail at a *Basilosaurus* excavation in Wadi Hitan, Egypt. We are particularly interested in this part of the skeleton because this is where the reduced hind limbs, feet, and toes are found. Photograph ©1991 Philip Gingerich.

Virtually complete skeleton of *Dorudon* excavated in Wadi Hitan, Egypt. Note the retention of hind limbs, feet, and toes like those found in *Basilosaurus*. The skeleton is approximately 5 m long. Photograph ©1998 Philip Gingerich.

Dorudon from the late Eocene of Egypt

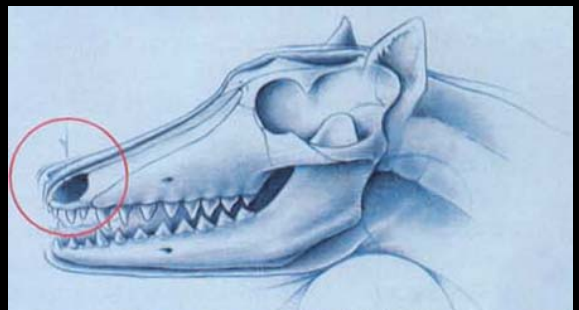




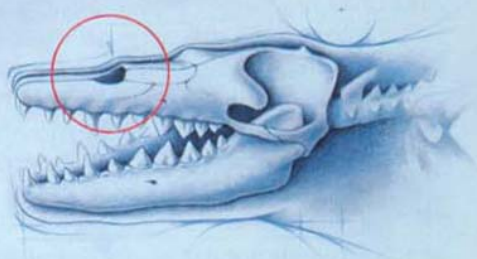
vestigial
whale
hips

Dolphin with extra fins in position of rear legs, Japan 2006

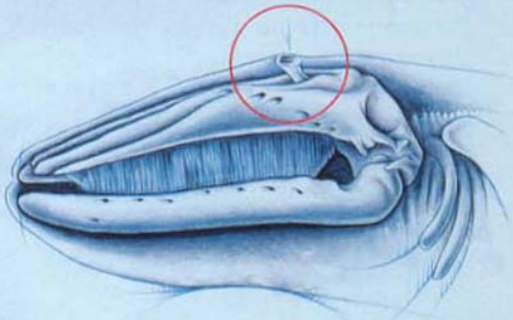
Evolution of nasal opening in whales



The ancient, amphibious whale *Pakicetus* had a land mammal's nostrils at the end of the snout.

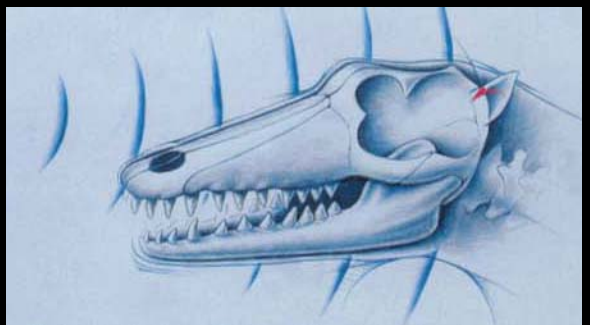


Rodhocetus swam the seas; its nostrils were higher on the skull, intermediate to those of its ancestors and modern whales.

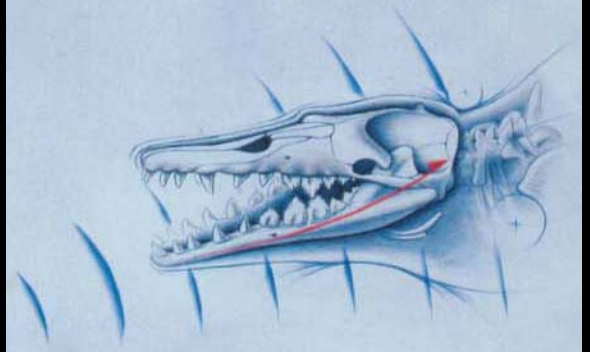


A modern gray whale's blowhole allows it to break the surface, inhale, and resubmerge without having to stop or tilt the snout up.

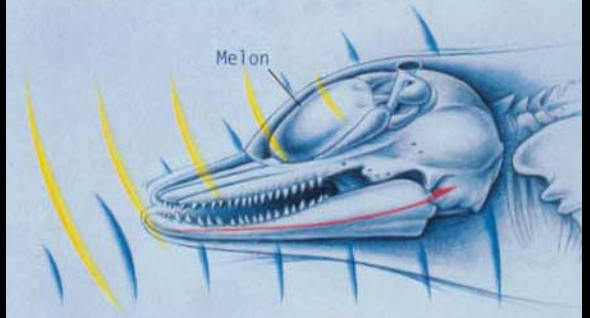
Hearing in whales



Though more aquatic than *Pakicetus*, *Ambulocetus* still heard directly through its ears.



Sounds were transmitted to the middle ears of *Basilosaurus* as vibrations from the lower jaw.

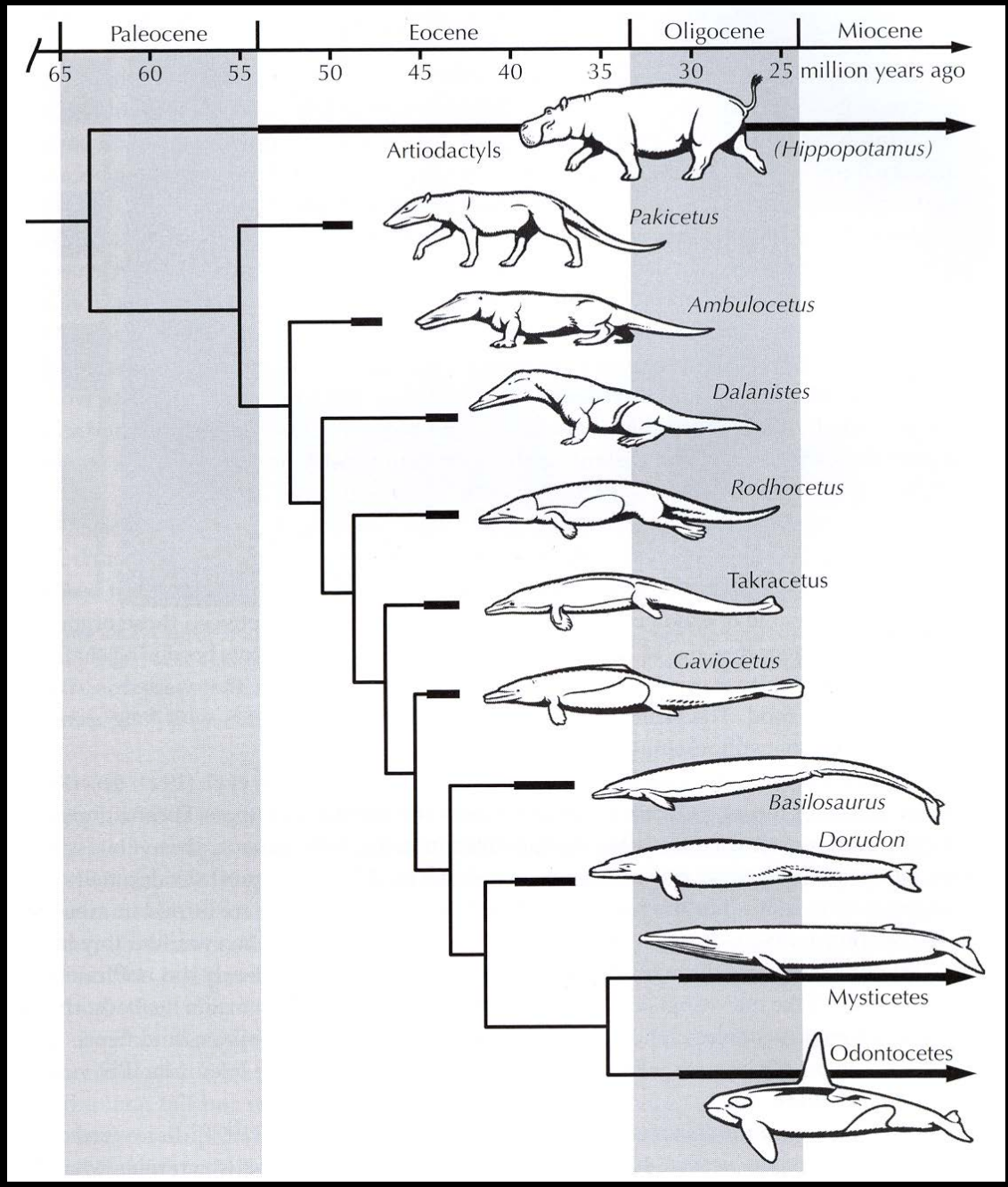


Modern toothed whales echolocate: The melon directs sound at an object, and the lower jaw receives the echoing reply.

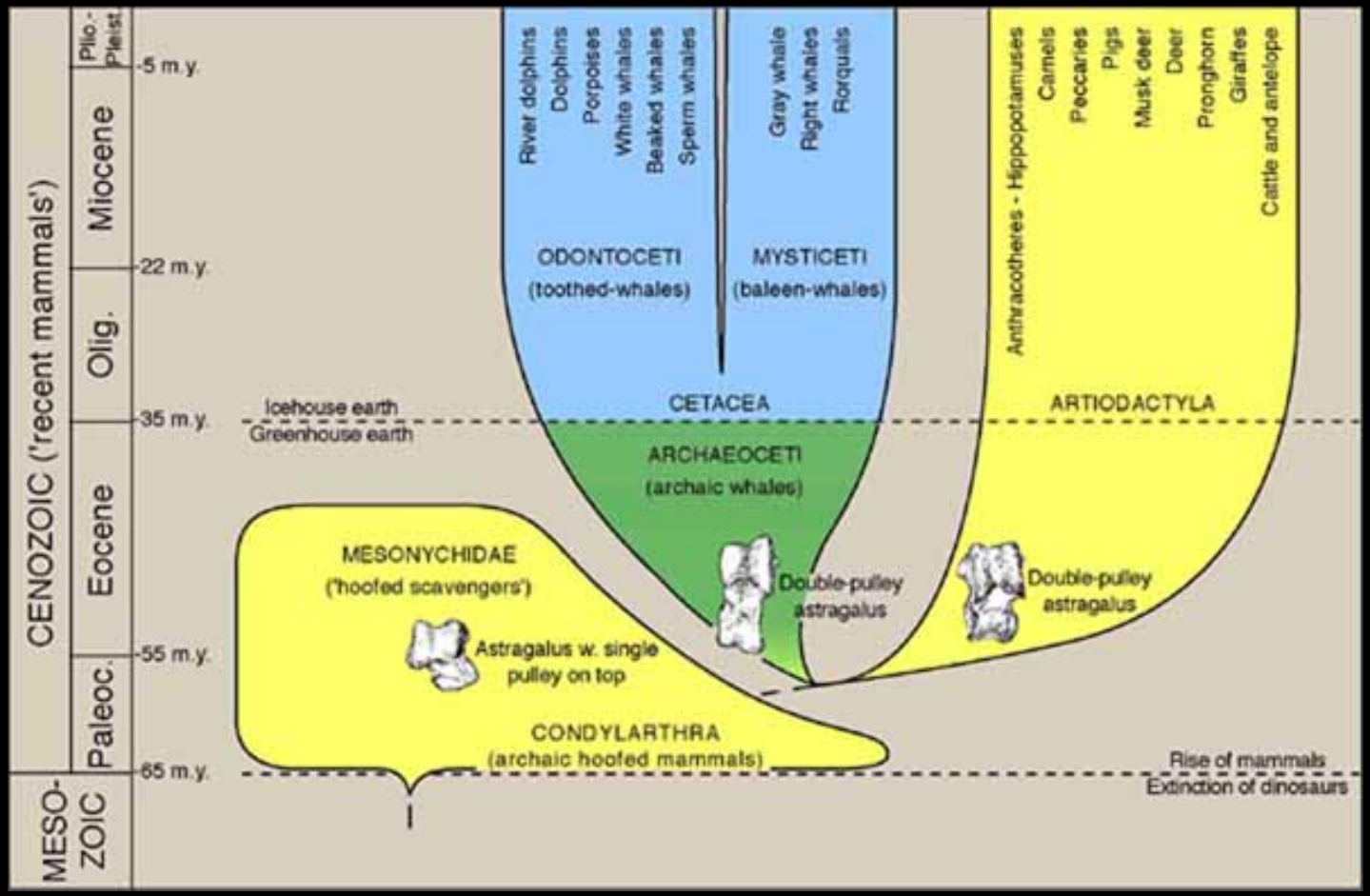
Genetic evidence suggests that hippos (artiodactyls) are the closest living relatives of whales.

Evolution of Whales

2000s



Prothero, 2007



Phylogeny of Cetacea showing a common ancestry shared with Artiodactyla, and the hypothesized evolutionary origin of both from older Paleocene age Condylarthra. Horizontal axis is arbitrary, while the vertical axis is geological time. Our 2000 discovery of distinctively artiodactyl-like double-pulley astragalus bones in articulated skeletons of early archaeocetes is the principal evidence linking whales and artiodactyls as shown here (see Gingerich et al., 2001). The evolutionary origin of both whales and artiodactyls is closely tied to the Paleocene-Eocene boundary, and the transition from archaeocetes to modern whales is related to climatic and ocean circulation changes at the Eocene-Oligocene boundary. Source: University of Michigan Museum of Paleontology.

Evidence for the evolutionary link between cetaceans and artiodactyls