Cetacean Evolution

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Mammalian Phylogeny

- Cetaceans
- Pinnipeds, sea otters, polar bears
- Sirenians

http://whozoo.org/mammals/mammalianphylo.htm
Order Cetartiodactyla

Deer, Elk, Moose, Caribou

Giraffidae Giraffe, Okapi

Bovidae
Bison, Buffalo, Antelope, Gazelle, Sheep, Goat

Hippopotamidae
Hippopotami

Mysticeti

Physeteridae
Ziphliidae
Delphinoidea

Gatesy et al. 1999
The Archaeocetes ("ancient whales")

Epochs in the Tertiary Period, Cenozoic Era
Early Eocene (50-60 mya)
Pakicetidae

- Early – Middle Eocene (50 mya)
- Wolf/fox-size
- Predominantly terrestrial
- Partially aquatic?
  - Fossils in modern-day Pakistan, near coastal Tethys Sea
  - Earbones adapted for underwater hearing
Ambulocetidae

- *Ambulocetus natans* “walking whale that swims” (most complete specimen found to date)
- Middle Eocene (45 mya)
- 3 m, 300 kg; thick limbs
- Amphibious (back legs more adapted to swimming than walking)
- Shallow, swampy marine and fresh water environments
- Ecological niche similar to today’s crocodiles

- Cetacean features: early cetacean-like teeth; cetacean-like ear bones; nose adapted for underwater swallowing; no external ears
- Transition: fresh-marine; land-water
Remingtonocetidae

- Middle Eocene (45 mya)
- Amphibious
- Coastal marine environments
- Long, narrow skull and jaw (suggesting diet of fast-swimming prey)
- Small orbits (suggestion vision not important)
- Ears adapted for underwater hearing
Middle Eocene (45 mya)
Protocetidae

- Middle Eocene (45 mya)
- Widespread (fossils from Europe, Africa, Asia, N America) – first Archaeocetes to disperse to all shallow sub-tropical oceans
- Lagoon, coastal, *and* open marine forms
- Nasal openings large and half-way up the snout
- Some possibly with flukes
Basilosaurusidae “king lizard”

- Late Eocene – Early Oligocene (41-35 mya)
- Initially mistaken for a marine reptile
- Oldest known (with Dorudontids) obligate marine forms (no freshwater forms)
- Fully recognizable cetaceans
  - Nostrils close to position of modern-day blowholes
  - Functionally modern cetacean ear structure (incl air-filled sinus between ear bones and skull)
- Small brains (suggesting non-social)
- Tiny external hind limbs but pelvic bones not connected to vertebral column
- Widely distributed in tropical and sub-tropical oceans of the world

- Of note:
  - Large body size (12-25 m!)
  - Extreme elongation of lumbar vertebrae
  - Tail with fluke but likely not the main propulsive organ
- Fish remains found with fossils
Dorudontidae

• Late Eocene – Early Oligocene (41-35 mya)
• Very similar to Basilosaurids *except*:
  – Dolphin-like (~5 m)
  – Tail with fluke that formed main propulsive organ
• Modern mysticetes and odontocetes likely diverged from these forms
Cetacean Phylogeny

35 mya
Oligocene (35 mya)
Early Mysticetes

- **Aetiocetidae**
  - Late Oligocene
  - Toothed

- **Cetotheriidae**
  - Late Oligocene – Late Pliocene
  - Skull similar to Balaenopterids
  - Toothless (some with baleen?)
  - 3-10 m
  - Diverse (>60 species described)
Early Odontocetes

• Mid Oligocene – Mid Miocene (33-14 mya)
• Rostrum of various lengths
• Primitive dentition
• Squalodontidae
  – Telescoping of skull
  – first hypothesized echolocation
Odobenocetops “walrus whale”

- Early Pliocene
- Convergent on walrus
- Asymmetrical tusk length (1.4m vs 25 cm)
Phylogeny of modern cetaceans
Major Features Associated with the Evolution of Cetaceans:

1. Reduction of the hind limbs (adaptive significance: increased hydrodynamic efficiency)
Major Features Associated with the Evolution of Cetaceans:

2. Hyperphalangy (adaptive significance: use of forelimbs for locomotion in water)
   - Increased number of bones in digits

Greyhound, Sperm Whale, Dolphin

Tinker 1988
Major Features Associated with the Evolution of Cetaceans

3. Telescoping of the skull (adaptive significance: nares on top of head)
   - Maxillae - rostrum
   - Pre-maxillae – nares
   - Nasals
   - Occipital
   - Parietals
   - Frontals

Bryden 1988
Major Features Associated with the Evolution of Odontocete Cetaceans:

4. Homodonty and Polydonty (adaptive significance: prey capture)
   - Teeth of the same type
   - Increase in tooth number
Potential Term Paper Topics

• What is the evolutionary history of modern-day sperm whales? Beaked whales? River dolphins?

• What major evolutionary features (changes from terrestrial ancestors to modern-day forms) do cetaceans have in common with other secondary marine forms (marine reptiles, marine birds)?