

Topic 10: Origin of Cetaceans: A Macroevolutionary Case Study



I. Cetaceans

A. What

1. Fully aquatic, mostly marine mammals
Colloquially called dolphins, porpoises, & whales



Harbor Porpoise
Photo by E.Christensen

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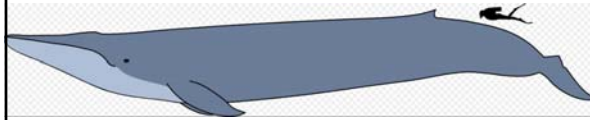


Bottlenose Dolphin
Photo by Pelican

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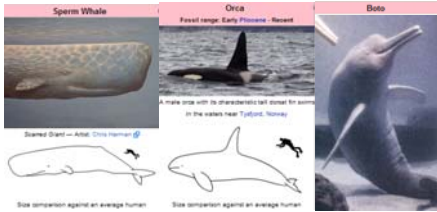
Blue Whale
Illustration by Kurzon

I. Cetaceans

A. What

- 2. Generally called "whales" or "cetaceans" and classified into two main groups:

- a. **Ondontocetes** (toothed whales)

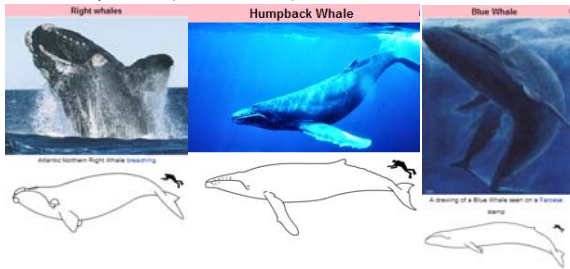


I. Cetaceans

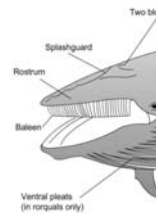
A. What

- 2. Generally called "whales" or "cetaceans" and classified into two main groups:

- a. **Ondontocetes** (toothed whales)
- b. **Mysticetes** (baleen whales)



I. Cetaceans



From upper jaw: fine-comb-like epidermal protrusion of Keratin (stiff, elastic) & hydroxyapatite (bony)

I. Cetaceans



A. What

B. Mammalian Heritage

- Warm-blooded
- Live young*
- Mammary glands

nipples concealed in abdominal mammary slits



I. Cetaceans



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- Hair (snout, chin, behind blow hole)
- Up-down spinal mobility



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Above: Sperm whales: 40 min down, 10 min up, starts to exhale just below surface.

Left: minke whale

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Blowhole (nostrils) in a blue whale.

II. Evolutionary Origins

A. Phylogenetic Evidence



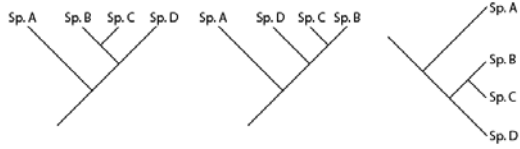
II. Evolutionary Origins



A. Phylogenetic Evidence

1. "Phylogeny" is the evolutionary history of a group
2. Cladograms used to depict phylogeny

Relative recency of common ancestry read from tips.



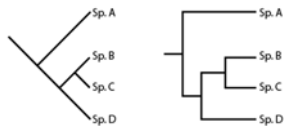
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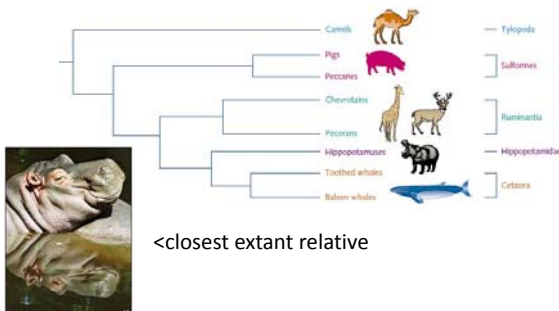


II. Evolutionary Origins



A. Phylogenetic Evidence

3. DNA-based cladograms point to terrestrial origin among ungulate mammals



II. Evolutionary Origins

A. Phylogenetic Evidence

B. Anatomical Evidence

1. Front legs evolved into flippers
2. Hind legs lost

Odontoceti

Mysticeti

Modern cetaceans: vestigial pelvis

II. Evolutionary Origins

A. Phylogenetic Evidence

B. Anatomical Evidence

C. Paleontological Evidence

1. Front legs evolved into flippers
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Valley of the Whales
(150 km S of Cairo)

II. Evolutionary Origins

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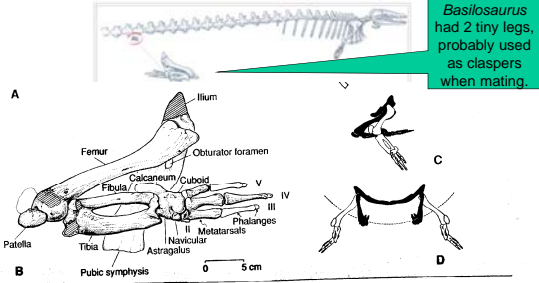
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Basilosaurus (40-34 Ma)

II. Evolutionary Origins

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II. Evolutionary Origins

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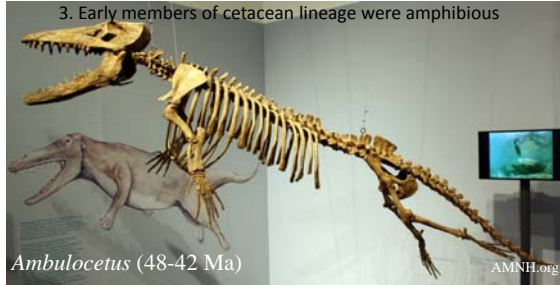
1. Front legs evolved into flippers
2. Hind legs lost
3. Early members of cetacean lineage were amphibious



II. Evolutionary Origins

- A. Phylogenetic Evidence
- B. Anatomical Evidence
- C. Paleontological Evidence

1. Front legs evolved into flippers
2. Hind legs lost



Ambulocetus (48-42 Ma)

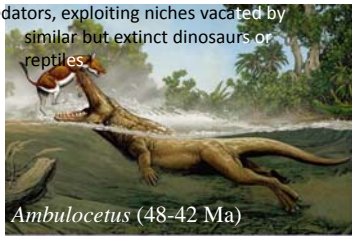


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II. Evolutionary Origins

- A. Phylogenetic Evidence
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1. Front legs evolved into flippers
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3. Early members of cetacean lineage were amphibious ambush predators, exploiting niches vacated by similar but extinct dinosaurs or reptiles.



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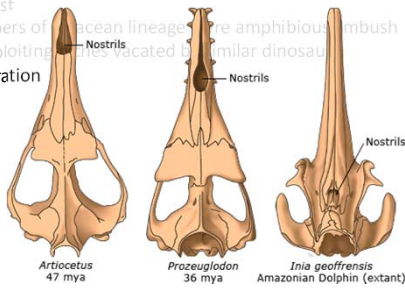
Ambulocetus natans in action. A reconstruction of an early close cousin of whales. Shown here with the kind permission of artist Carl Buell.



II. Evolutionary Origins

- A. Phylogenetic Evidence
- B. Anatomical Evidence
- C. Paleontological Evidence

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4. Nostril migration



III. Analagous Transformations



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- A. Sirenians
- Diverged from protoungulates, related to elephants, aardvarks
 - 40 Ma
 - Manatees (Caribbean, Amazon, West Africa) & Dugongs (Indo-Pacific)



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- Diverged from protoungulates, related to elephants, aardvarks
 - 40 Ma
 - Manatees (Caribbean, Amazon, West Africa) & Dugongs (Indo-Pacific)
 - Hind legs lost
 - Foreflippers dextrous for maneuvering in shallow coastal waters & rivers.



III. Analagous Transformations

- A. Sirenians
- B. Pinnipeds

- Diverged from "bear-like" carnivores 30 Ma
- Seals, Sea lions and Walruses



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- Hindlegs dextrous but highly reduced, toes webbed, claws reduced



III. Analagous Transformations



- A. Sirenians
- B. Pinnipeds
- C. Otters

- Diverged from badgers, weasels, polecat carnivores 5-7 Ma.
- Amphibious
- Least streamlined of marine/aquatic mammals
- Limbs are those of a terrestrial carnivore but with webbed toes.



Pacific sea otter

III. Analagous Transformations



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Northern river otter

III. Analagous Transformations



- A. Sirenians
- B. Pinnipeds
- C. Otters

D. Demonstrate Convergent Evolution

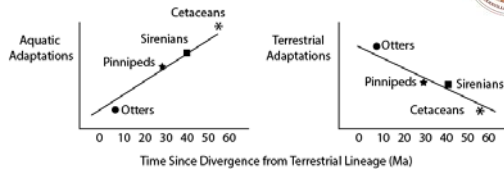
1. Similar adaptations arisen independently.
2. Positive correlation between degree of modification and time since divergence from terrestrial lineage.

III. Analogous Transformations

	Otters (5-7 Ma)	Pinnipeds (30 Ma)	Sirenians (40 Ma)	Whales (50 Ma)
1. Hairiness	Thick coat; whiskers	Very sparse; whiskers	Very sparse; whiskers poorly developed	Very very sparse; no whiskers
2. Nostril position	Front	High Front	High Front	Top
3. Forelimbs (toe/claw development)	Well	Fair	Non-existent	Non-existent
4. Fluke development	Absent	Absent	Present	Present
5. Hind limbs	Well dev.	Reduced	Absent	Absent
6. Blubber	No	Fairly dev.	Well-dev.	Well-dev.



III. Analogous Transformations



IV. Summary

A. Terrestrial origin for cetaceans

Whales evolved from a terrestrial, mammalian ancestor via an amphibious ancestor.

B. Analogous transitions have occurred or are occurring in a variety of lineages.

Sirenians, Pinnipeds, & Otters



IV. Summary



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Sirenians, Pinnipeds, & Otters

C. Degree of modification in various structures depends on age of group

